ASSIGNMENT-1
PCS.

Q. What is modulation?

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

Modulation
- Analog
  - Amplitude modula.
    - SSB
    - DSB
  - Angle modulation
    - F.M
    - P.M
- Pulse
  - Analog
  - Digital

Q2 various advantages of modulation:

Soln: (1) Reduces the size of Antenna
(2) It reduces the cost of wires
(3) It easily multiplex the signals
(4) allows 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 of a carrier signal

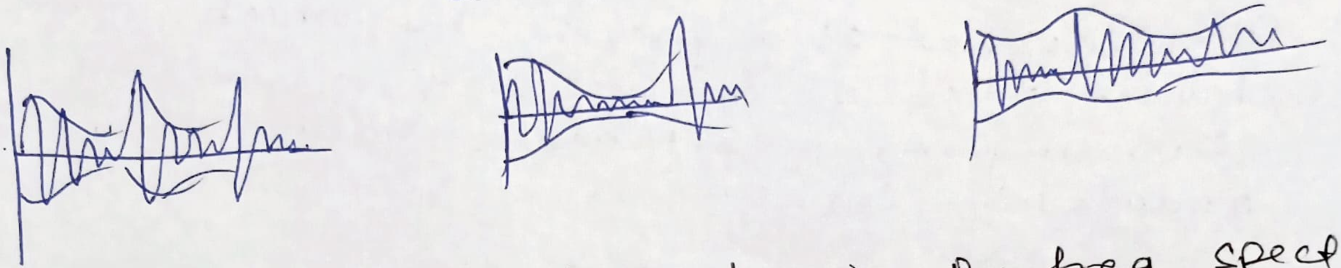
Calculation: $m = \frac{A_m}{A_c}$ or $m = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$

Q4! Various degree of modulation in Am? & m(t)

Sol^n! Degree of modulation are!

1. $m = 1 \rightarrow$ Critical modulation
2. $m > 1 \rightarrow$ over modulation
3. $m < 1 \rightarrow$ Under modulation

1. $m = 1$. 2. $m > 1$ 3. $m < 1$



Q5. Define Am? time domain & freq, spect?

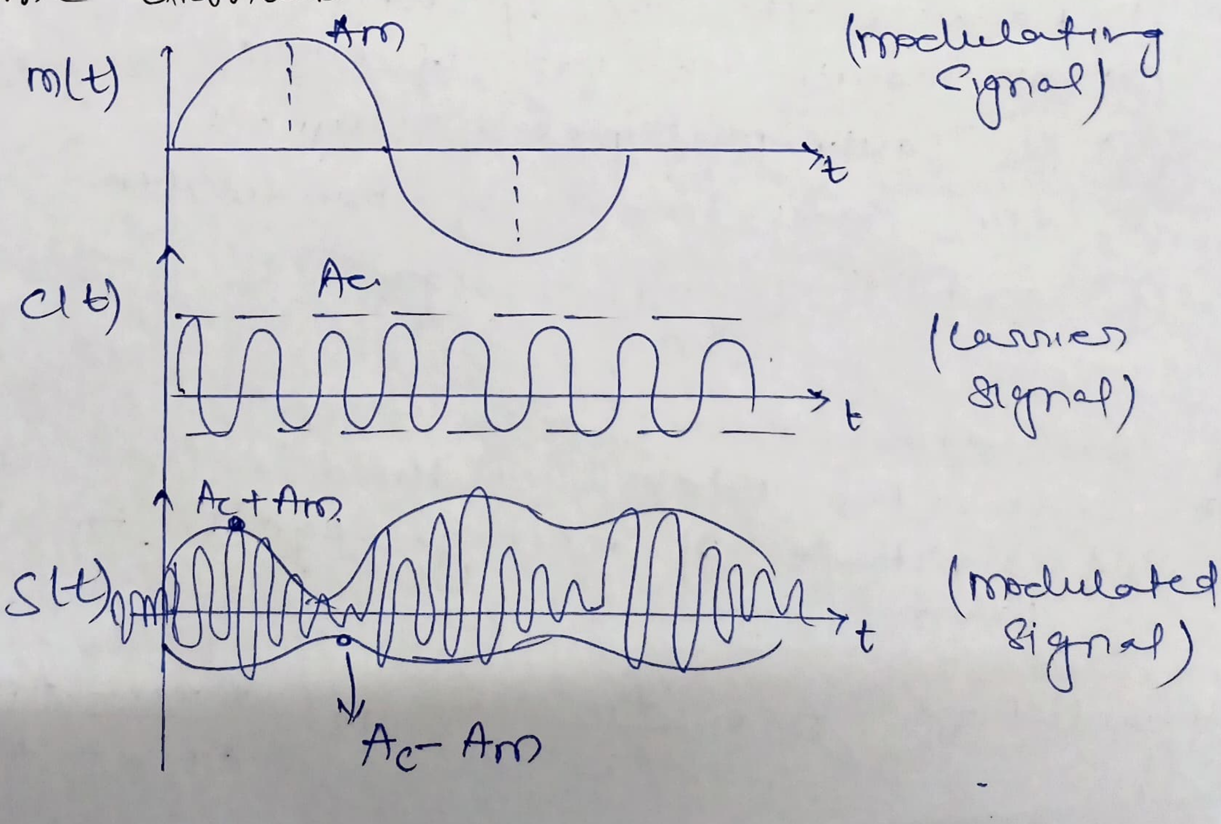
Sol^n! Am! It is the process in which amplitude of carrier signal changes with respect to message (modulating) signal).

$c(t) \rightarrow$ carrier signal $\rightarrow A_c \sin(\omega_c t)$

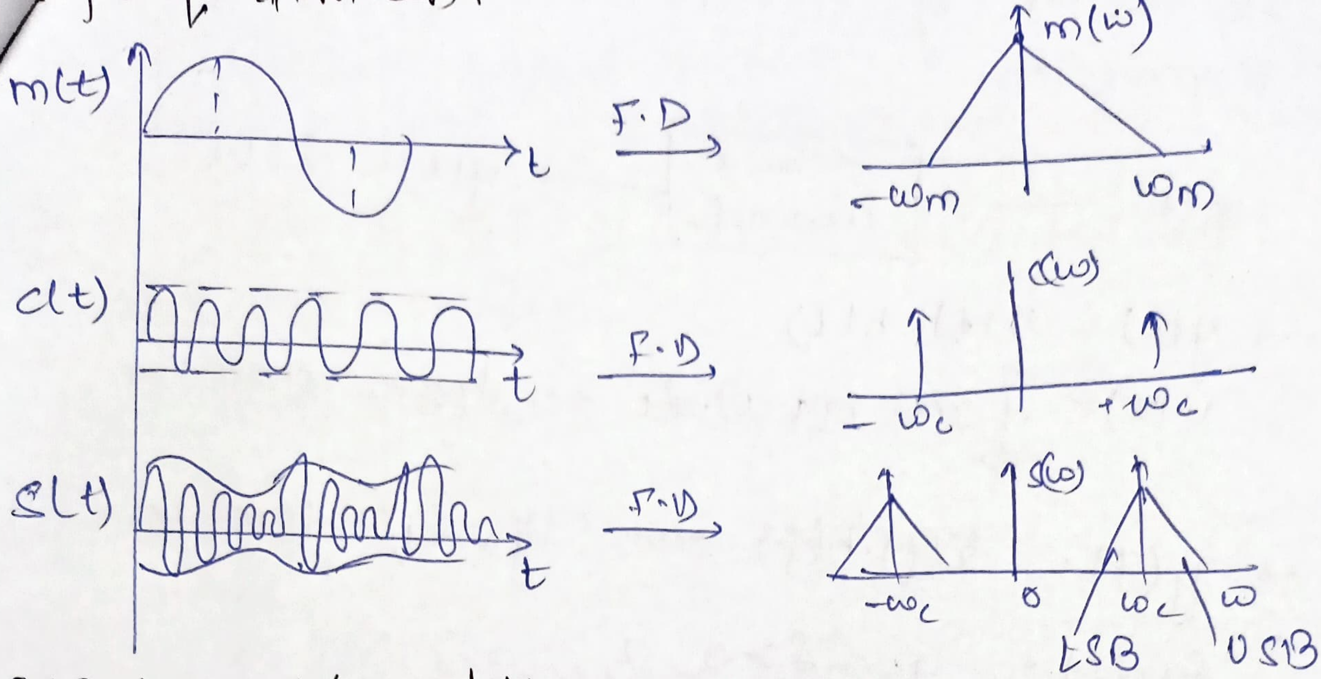
$m(t) \rightarrow$ modulating signal $\rightarrow A_m \sin(\omega_m t)$

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

1 time domain:



freq. domain:



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. Receiver are complex & expensive	6. Receiver are complex & expensive	6. Simpler & cheaper

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

Soln: $f_m = 5\,KHz$, $B.W = 100\,KHz$

$Bw = 2 \times f_m \Rightarrow 2 \times 5 = 10.$

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

Q8: Expression of Hilbert transform & its

Sol^n: Expression:

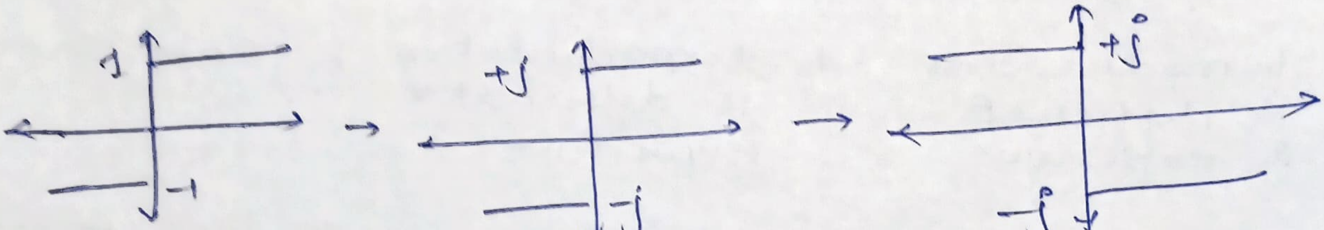
$x(t) \longrightarrow$ [Hilbert Transf] $\longrightarrow y(t) = \hat{x}(t)$.

$\to y(t) = x(t) \circ h(t)$

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

$\to Y(f) \cdot X(f) \cdot H(f) \longrightarrow$ freq. domain

$sgn(f) = \left\{ \begin{matrix} 1 & f>0 \\ -1 & f<0 \end{matrix} \right\}$.



$H(f) = j\,sgn(f)$ $\qquad$ $H(f) = -j\,sgn(f)$

Using duality theorem:

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

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

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

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 transform:

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

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

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.

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

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

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

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

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

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

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

③ $x(t) \xrightarrow{H.T} \hat{x}(t) \xrightarrow{d/dt} \frac{d}{dt}[\hat{x}(t)]$

$$\therefore HT\left[\frac{d(x(t))}{dt}\right] = \frac{d}{dt}\hat{x}(t)$$

Q9! Total Power in a AM having 100 W Pc
$\mu = 0.6$?

Soln! $P_c = 100W$
$\mu = 0.6$

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

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

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

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

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.

- 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

11! Provide Power & current relation AM

Sol^n! (1) Power.

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

& we know that;

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

$$\boxed{\text{Power} = \frac{V^2_{rms}}{R}} \Rightarrow I^2_{rms} \times R$$

∴ ~~I^2_{rms} = Power × R~~

∴

$$P = P_c\left[1+\frac{\mu^2}{2}\right].$$

$$I_T^2 \times \cancel{R} = I_C^2 \times \cancel{R}\left[1+\frac{\mu^2}{2}\right]$$

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

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

Q18! Exp. for efficiency of an AM wave?

Sol^n!

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

we know,

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

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

$$\therefore \eta = \frac{\frac{\cancel{A_c^2}\mu^2}{\cancel{2}4\cancel{R}}}{\frac{\cancel{A_c^2}}{\cancel{2R}}\left[1+\frac{\mu^2}{2}\right]} = \frac{\mu^2/2}{1+\frac{\mu^2}{2}} \times 100$$

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

Let's take, $\mu = 1$

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

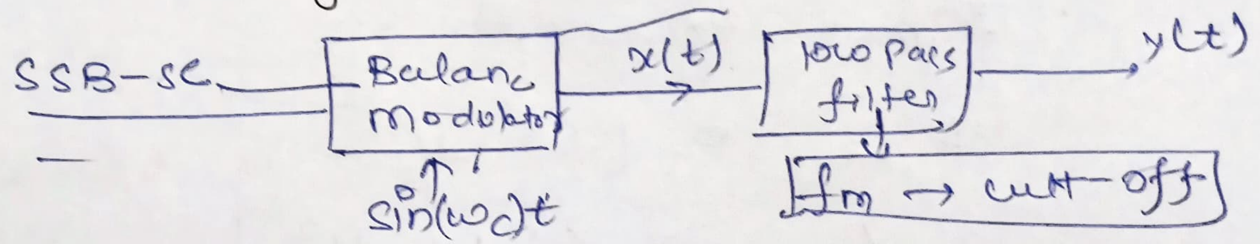
$$\boxed{\eta = 33.33\%}$$

or

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

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

Soln:



• working:

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

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

② $x(t) = s(t).\sin(\omega_c t).$

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

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

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

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

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

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

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

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

$\frac{m(t)}{2}$ → f_m → easily pass by low pass filter

$\frac{m(t)}{2}\cos 2\omega_c t$ → $\boxed{2\omega_c \pm \omega_m}$ → can't pass by low pass filter

$\hat{m}(t).\sin 2\omega_c t$ → $2\omega_c \pm \omega_m$ → can't pass by low pass filter

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

↓

modulating Signal

* ~~Advantages~~: of SSB-SC
1. Bandwidth is half i.e $B = f_m$
2. Power is saved
3. noise is reduced

* Disadvantages: SSB-S
1. Transmission & receiver is complex
2. quality get affected 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

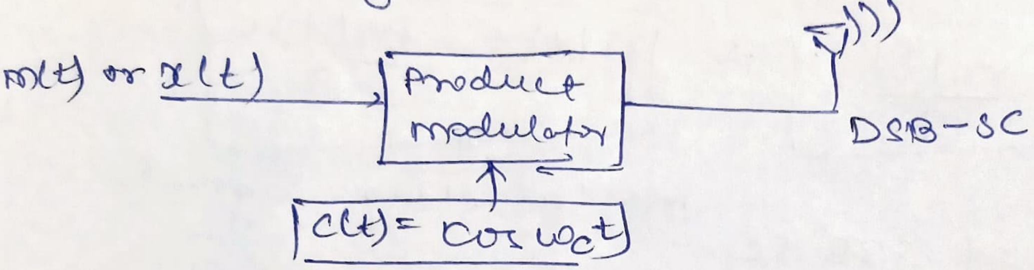
II. Disadv:
1. Requires complex design
2. Higher implementation cost
3. Sensitive to phase noise
4. Need accurate phase info.

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

Sol^n: 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 $2f_m$.

* Block Diagram:



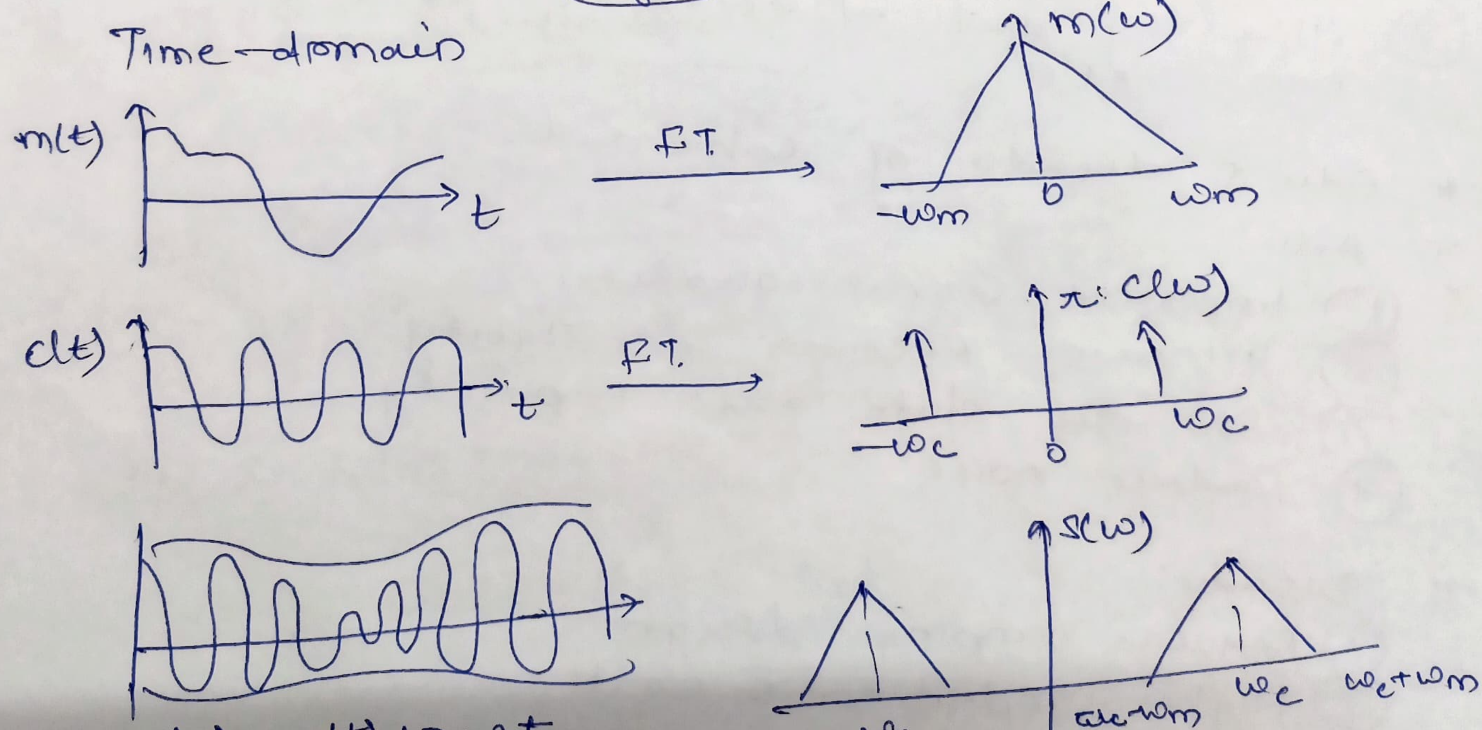
* Eq^n:

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

$$s(t) = A_c \underbrace{\boxed{\cos\omega_c t}}_{\text{carrier wave}} + \underbrace{m(t)\cos\omega_c t}_{\text{DSB-SC}}$$

neglect

Time-domain



$s(t) = m(t). \cos\omega_c t$

$$s(t) = m(t)\cos\omega_c t$$

$$= A_m \cos\omega_m t \cos\omega_c t = \frac{A_m}{2}\left[\underbrace{\cos(\omega_c-\omega_m)t}_{\text{L.S.B}} + \underbrace{\cos(\omega_c+\omega_m)t}_{\text{U.S.B}}\right]$$

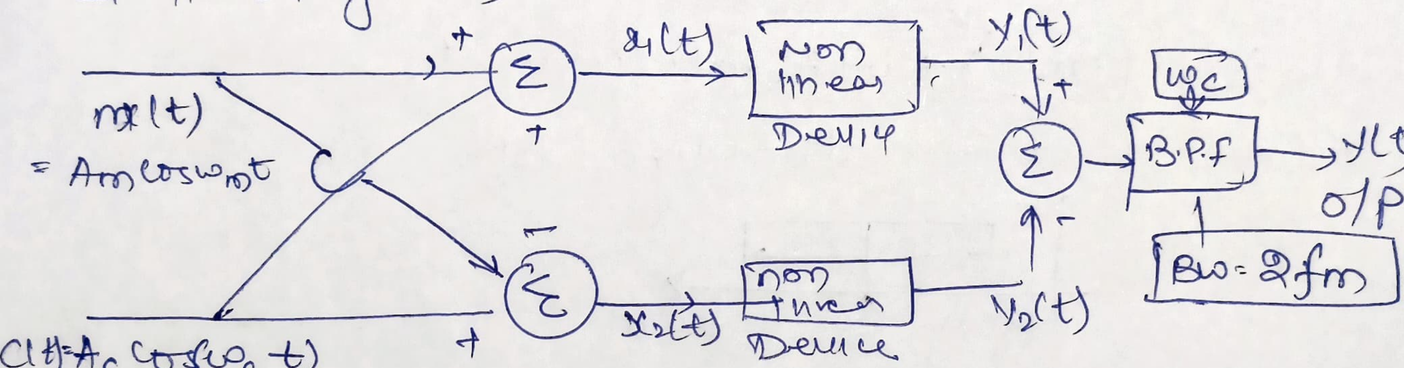
Modulator Types:

1. Balanced modulator
2. Ring Modulator

1. Balanced modulator:

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

* Block Diagram:



V_{in} → Non linear → $V_o = aV_{in} + bV_{in}^2$

$\therefore x_1(t) = m(t) + A_c \cos \omega_c t$

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

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

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

$\therefore Y_o(t) = y_1(t) - y_2(t)$

$\therefore y_1(t) = a(m(t) + A_c \cos \omega_c t) + b(m(t) + A_c \cos \omega_c t)^2$

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

$y_1(t) = a\,m(t) + aA_c \cos \omega_c t + bm^2(t) + bA_c^2 \cos^2 \omega_c t +$
$2m(t) A_c \cos \omega_c t$

$\therefore y_2(t) = a[-m(t) + A_c \cos w_c t] + b[-m(t) + A_c \cos w_c t]^2$

$y_2(t) = -am(t) + aA_c \cos w_c t + b(m^2(t) + A_c^2 \cos^2 w_c t -$

$2 A_c m(t) \cos w_c t$

$\therefore y(t) = y_1(t) - y_2(t)$

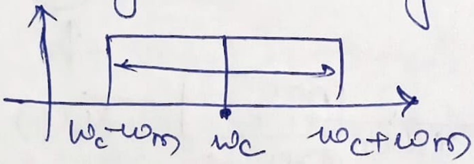
$= am(t) + aA_c \cancel{\cos w_c t} + b\cancel{m^2(t)} + bA_c^2 \cancel{\cos^2 w_c t} +$
$2bA_c m(t) \cos w_c t$

$+$

$am(t) - aA_c \cancel{\cos w_c t} - b\cancel{m^2(t)} - bA_c^2 \cancel{\cos^2 w_c t}$
$+ 2A_c m(t) \cos w_c t$

$y(t) = am(t) + b4A_c m(t) \cos w_c t$ ✓

After passing through BPF



$y(t) = 4bA_c m(t) \cos w_c t$

$\boxed{y(t) = KA_c m(t) \cos w_c t}$ → double side band

$y(t) = KA_c m(t) . \cos w_c t$

$y(t) = A_m \cos w_m t . A_c \cos w_c t$

$y(t) = \frac{A_m . A_c}{2} [\cos(w_c + w_m t)t + \cos(w_c - w_m)t]$

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

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

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