18/12/19 # UNIT - 1 AMPLITUDE MODULATION.

Need of modulation :-

(i) * Abel to reduce size of anttena.

antlena length => $h = \lambda/4$

$\downarrow\lambda = \frac{c}{f\uparrow}$ $c = 3\times10^8$ m/sec

f = Hz.

Ex :- if f = 10KHZ

height = $\frac{\lambda}{4}$ $\lambda = \frac{3\times10^8}{10^4} = 3\times10^4$

$h = \frac{3\times10^4}{4} \Rightarrow \frac{30000}{4} = 7.5$K m.

⇒ Increasing the frequency with modulation and could be able in reality. to reduce height of anttena, which is possible

if f = 1MHz

then h = 75mt.

* (ii) frequency translation. (Base band → Band pass).
without modulating / no freq shift — shifts the signal

* (iii) Multiplexing. (transmitting more than one signal through a channel, help of modulation shifting frequencies and transmitting).

* (iv) Reduction in noise & interference (

* The primary resources of any communication are power and Bandwidth. These should be used effectively.

* SNR > 1; Bandwidth ; Power.

signal to noise ratio.

Amplitude Modulation & demodulation :-

The carrier amplitude will be varied linearly in accordance with the amplitude of message signal is called as Amplitude Modulation.

Superposition theorem holds good for amplitude modulation.

let c(t) - carrier signal ; m(t) - message signal ;

s(t) - modulated signal.

$$* \boxed{c(t) = A_c \cos 2\pi f_c t} \quad -(1) *$$

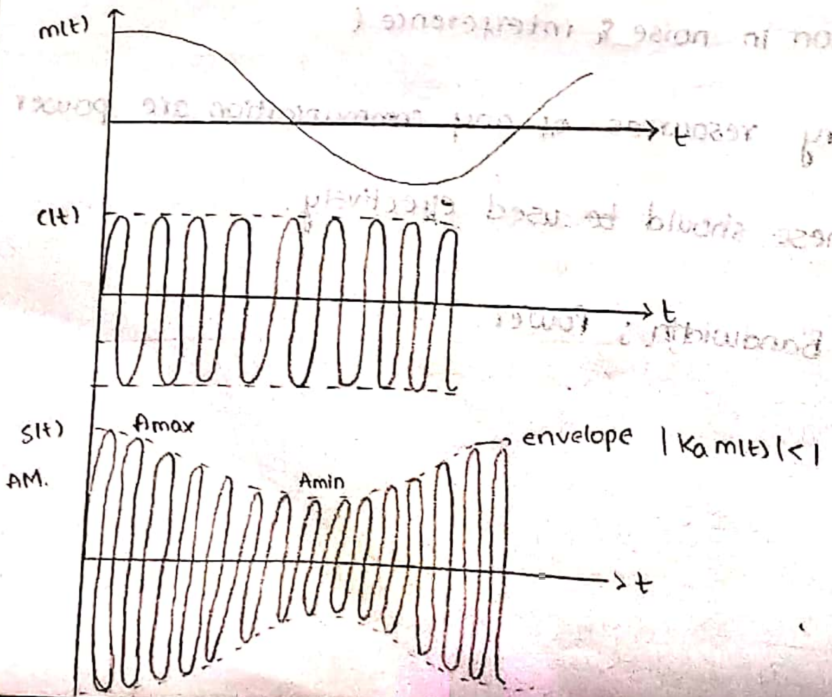
A_c - amplitude of carrier signal.

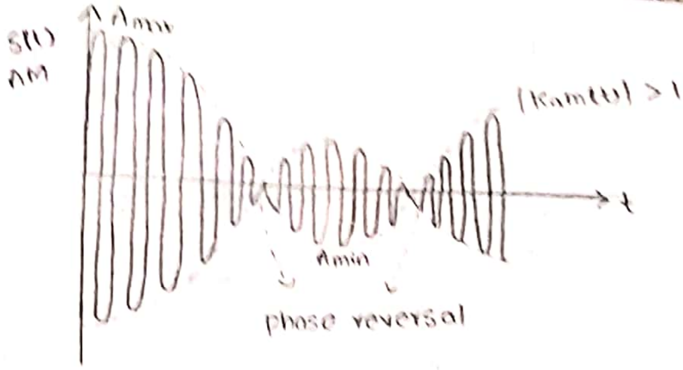
f_c - frequency of carrier signal.

The amplitude modulated signal for a given base band signal m(t) is given as $\boxed{s(t) = A_c[1 + K_a m(t)] \cos 2\pi f_c t}$ — (2)

where K_a = amplitude sensitivity

m(t) = base band signal.

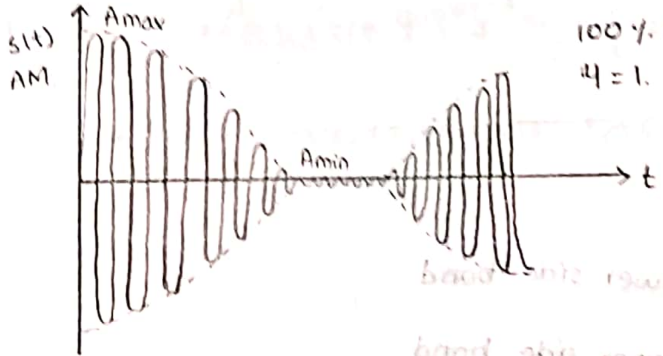




$\boxed{\mu = |K_a m(t)|}$

$$\boxed{\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}}$$

μ is depth of modulation.



* modulation index / depth of modulation (μ) is depend only on the amplitude of signal. $\mu \le 1$ always. to preserve envelope.

* If $\mu > 1$ envelope distortion takes place, over modulation.

19/12 Spectrum of Amplitude modulation wave :-

$S(t) = A_c[1 + K_a m(t)] \cos 2\pi f_c t$

to obtain spectrum convert to frequency domain using frequency property / modulation property.

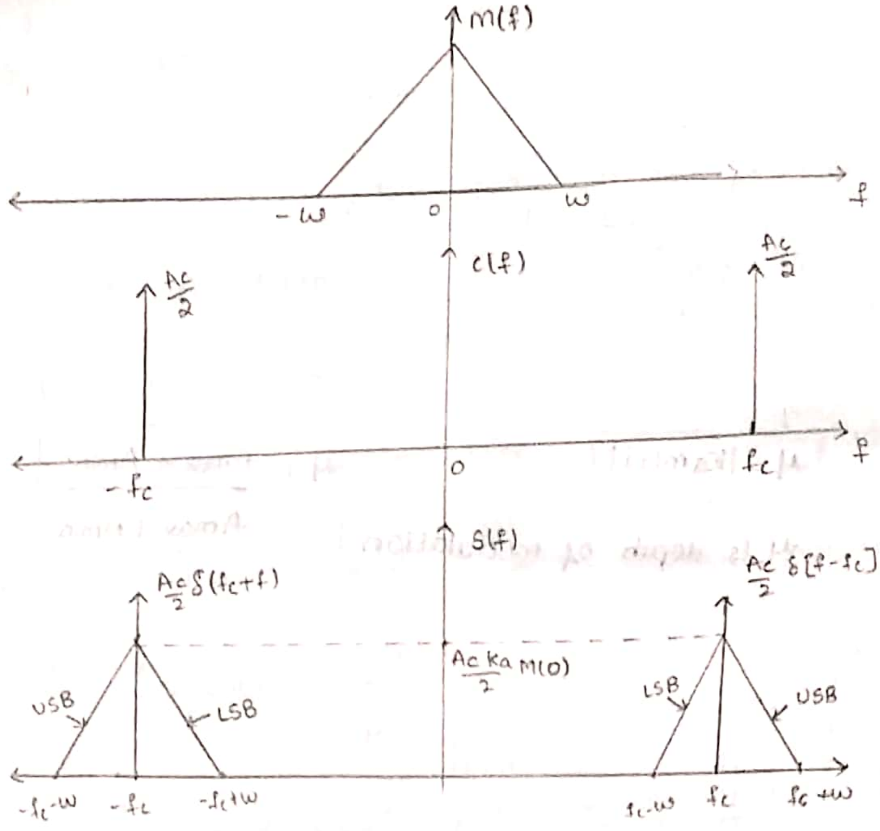
we obtain

$$S(f) = \frac{A_c}{2}[\delta(f+f_c) + \delta(f-f_c)] + \frac{A_c K_a}{2}[m(f+f_c) + m(f-f_c)]$$

$m(t) = m(f)$. bandlimited to ω Hz.

$$c(f) = \frac{A_c}{2}[\delta(f+f_c) + \delta(f-f_c)].$$

$f_c >> W$



LSB - lower side band

USB - upper side band

→ AM - contains 3 components LSB, USB, carrier.

→ Bandwidth required is $f_c + W - f_c + W = 2W$.

Bandwidth required for transmition of AM wave is twice the frequency bandwidth of the message signal.

***Single tone modulation of Amplitude modulation :-**

consider $S(t) = A_c[1 + K_a m(t)] \cos 2\pi f_c t$

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

then, $s(t) = A_c[1 + K_a A_m \cos 2\pi f_m t] \cos 2\pi f_c t$

$S(t) = A_c[1 + \mu \cos 2\pi f_m t]$

where $\mu = K_a A_m$

$A_{max} = 1 + \mu$

$A_{min} = 1 - \mu$

$$\boxed{\frac{A_{max}}{A_{min}} = \frac{A_c[1+\mu]}{A_c[1-\mu]}}$$

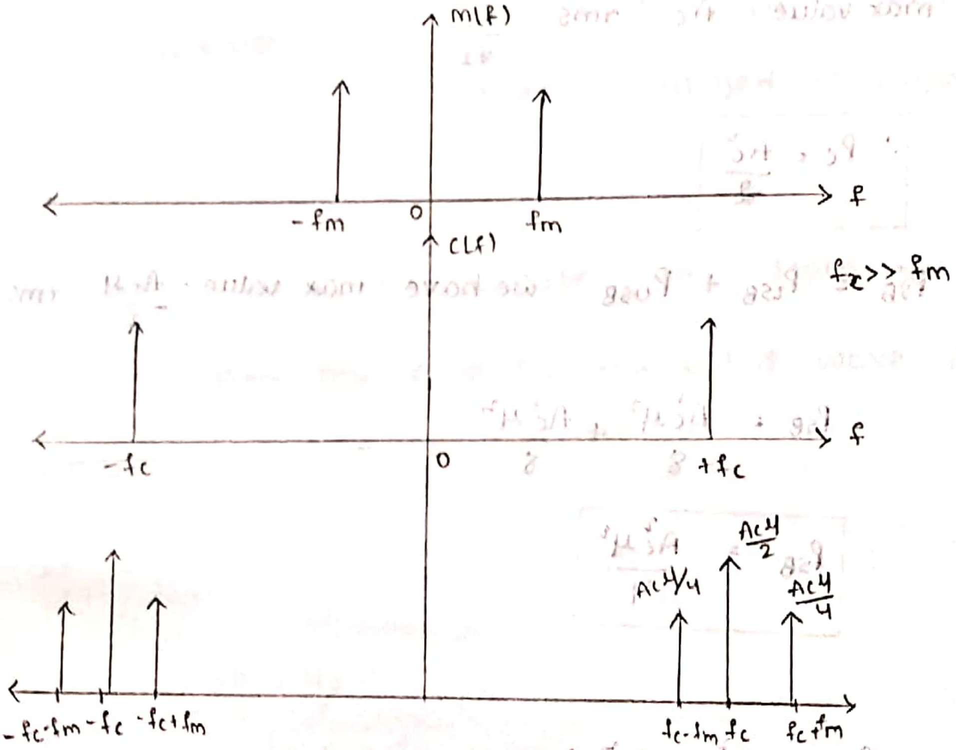
$$\mu = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

Now, consider $s(t) = A_c \cos 2\pi f_c t + A_c k_a A_m \cos 2\pi f_m t \cos 2\pi f_c t$

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

$$s(t) \Rightarrow A_c \cos 2\pi f_c t + \frac{A_c \mu}{2}\left[\cos 2\pi (f_c - f_m) + \cos 2\pi (f_c + f_m)\right]$$

$$S(f) = \frac{A_c}{2}\left[\delta(f+f_c) + \delta(f-f_c)\right] + \frac{A_c \mu}{4}\left[\delta(f+f_c+f_m) + \delta(f-f_c-f_m)\right] + \frac{A_c \mu}{4}\left[\delta(f+f_c+f_m) + \delta(f-f_c+f_m)\right].$$



20/12 Bandwidth of single tone modulation :-

$BW \Rightarrow f_c + f_m - (f_c - f_m)$

$\Rightarrow f_c + f_m - f_c + f_m$

$BW \Rightarrow 2 f_m$

Scanned by CamScanner

Power calculations of AM signal:- (single tone modulation)

power required for transmission of amplitude modulation signal $(P_t) = P_c(1+\frac{\mu^2}{2})$

we have $s(t) = A_c\cos 2\pi f_c t + \frac{A_c\mu}{2}[\underbrace{\cos 2\pi(f_c+f_m)t}_{USB} + \underbrace{\cos 2\pi(f_c-f_m)t}_{LSB}]$

from single tone modulation

$$\boxed{P_t = P_c + P_{SB}}$$

P_t = total power

P_c = carrier power

P_{SB} = side band power.

$R = 1\Omega \therefore P = \frac{V^2}{R} = I^2R$

$P = V^2 = I^2$

max value = A_c rms = $\frac{A_c}{\sqrt{2}}$.

$$\boxed{\therefore P_c = \frac{A_c^2}{2}}$$

$P_{SB} = P_{LSB} + P_{USB}$ we have max value = $\frac{A_c\mu}{2}$ rms = $\frac{A_c\mu}{2\sqrt{2}}$

$$P_{SB} = \frac{A_c^2\mu^2}{8} + \frac{A_c^2\mu^2}{8}$$

$$\boxed{P_{SB} = \frac{A_c^2\mu^2}{4}}$$

$$P_t = \frac{A_c^2}{2} + \frac{A_c^2\mu^2}{4}$$

$$P_t = \frac{A_c^2}{2}\left[1+\frac{\mu^2}{2}\right]$$

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

$\because P_c = \frac{A_c^2}{2}$

Efficiency calculations of AM signal:- (single tone modulation):

$$\text{Efficiency} = \frac{P_{SB}}{P_t} = \eta$$

$$\eta = \frac{A_c^2 \mu^2 \times \cancel{2} \times \cancel{2}}{\cancel{4} \times \cancel{A_c^2} \times (2+\mu^2)}$$

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

$$\boxed{\text{redundancy} = 1-\eta}$$

case (i). If $\mu = 1$. (critical modulat^n)

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

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

$$= 33.33\%$$

* only 33% is untilized by the side bands where as rest of the power is utilized by carrier.

Q) A 400 watts carrier is modulated to a depth of 75%. Calculate the total power in the modulated wave. Assume the modulated signal to be sinusoidal.

we know that. $P_t = P_c\left[1+\frac{\mu^2}{2}\right]$

$\% \mu = 75\%$

$\mu = 0.75$

$$P_t = 400\left[1+\frac{0.75^2}{2}\right]$$

$$= 200[2.75]$$

P_t = 5[5]0 watts

2Q) A broadcast radio transmiter radiates 5k watts of power when the modulation % = 60%. what is the carrier power.

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

$$2 \times 5 \times 10^3 = P_c\,(2 + (0.6)^2)$$

$$\frac{10^4}{2.36} = P_c$$

$$4.23K \text{ watts} = P_c$$

* Multitone Modulation of amplitude modulation:-

$$m(t) = A_{m_1}\cos 2\pi f_{m_1}t + A_{m_2}\cos 2\pi f_{m_2}t + \cdots\cdots$$

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

$$s(t) = A_c\left[1 + k_a\{A_{m_1}\cos 2\pi f_{m_1}t + A_{m_2}\cos 2\pi f_{m_2}t + \cdots\}\right]\cos 2\pi f_c t$$

$$s(t) = A_c\cos 2\pi f_c t + \left[A_c\mu_1\cos 2\pi f_{m_1}t + A_c\mu_2\cos 2\pi f_{m_2}t + \cdots\right]$$

$$\Rightarrow A_c\cos 2\pi f_c t + \frac{A_c\mu_1}{2}\left[\cos 2\pi(f_c + f_{m_1})t + \cos 2\pi(f_c - f_{m_1})t\right] + \frac{A_c\mu_2}{2}$$

$$\left[\cos 2\pi(f_c + f_{m_2})t + \cos 2\pi(f_c - f_{m_2})t\right] + \cdots\cdots$$

Power for multitone modulation of AM signal:-

$$P_t = P_c + P_{SB}$$

$$P_c = \frac{A_c^2}{2}$$ same as single tone.

$$P_{SB} = \frac{A_c^2\mu_1^2}{4} + \frac{A_c^2\mu_2^2}{4} + \frac{A_c^2\mu_3^2}{4} + \cdots\cdots$$

$$P_{SB} = \frac{A_c^2}{4}\left[\mu_1^2 + \mu_2^2 + \mu_3^2 + \cdots\cdots\right]$$

$$P_t = \frac{A_c^2}{2}\left[1+\frac{1}{2}\left[\mu_1^2+\mu_2^2+\cdots\right]\right]$$

$$\boxed{P_t = P_c\left[1+\frac{\mu_t^2}{2}\right]}$$

where μ_t is effective modulation index

$$\mu_t^2 = \mu_1^2+\mu_2^2+\mu_3^2+\cdots$$

$$\mu_t = \sqrt{\mu_1^2+\mu_2^2+\mu_3^2+\cdots}$$

$$\boxed{\mu_t \le 1}$$

current calculations of multitone modulation :-

$$\frac{P_t}{P_c} = \frac{I_t^2 R}{I_c^2 R}$$ we have $R = 1\Omega$ $\Rightarrow \frac{P_c\left[1+\frac{\mu^2}{2}\right]}{P_c}$

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

$$\boxed{I_t = I_c\left[1+\frac{\mu^2}{2}\right]^{1/2}}$$

Q) A 300 watts carrier is simultaneously modulated by 2 audio waves with modulation % of 50 and 60 respectively. What is the total side band power radiated.

Given $P_c = 300$ watts

$$P_{SB} = \frac{P_c}{2}\left[\mu_t^2\right]$$

$$\mu_t^2 = (0.5)^2+(0.6)^2 = 0.61$$

$$P_{SB} = \frac{0.61}{2} \times 300$$

$$P_{SB} = 150 \times 0.61 = 91.5 \text{ watts}$$

23/12

Q) The antenna current of an AM transmitter is 8A when only carrier is sent. But it increases to 8.96A when the carrier is modulated by a single tone sinosoidal. Find the % modulation and also the antenna current when depth of modulation changes to 0.8.

$$I_t = I_c\left[1+\frac{\mu_a^2}{2}\right]^{1/2}$$

$I_c = 8A$

$I_t = 8.6A$

(i) $8.96 = 8\left[1+\frac{\mu^2}{2}\right]^{1/2}$

$\frac{8.96}{8} = \left[1+\frac{\mu^2}{2}\right]^{1/2}$

$(1.12)^2 = 1+\frac{\mu^2}{2}$

$2(1.12)^2 - 2 = \mu^2$

$2\times1.25 - 2 = \mu^2$

$2.508 - 2 = \mu^2$

$0.508 = \mu^2 \Rightarrow \mu = 0.713.$

(ii) $\mu = 0.8$; $I_c = 8A$

$I_t = 8\left[1+\frac{(0.8)^2}{2}\right]^{1/2}$

$I_t = 8\left[2+\frac{0.64}{2}\right]^{1/2} \Rightarrow 8\left[\frac{4+64}{2}\right]^{1/2}$

$I_t = 8\times(1.32)^{1/2}$

$I_t = 8\times(1.52)^{1/2}$

$I_t = 9.19A$

Q) A transmitter radiates 10KWatts with carrier un modulated and 12KW when carrier is sinosouidally modulated. Calculate the modulation index if another sinwave corresponding to 50%. modulation is transmitted simultaneously. Determine the total radiation power.

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

Given, 1. $P_t = 12KW$ $P_c = 10KW$ $\mu_1 = ?$

2. $\mu_2 = 0.5$ $P_t = ?$

1. $12 = 10\left[1 + \frac{\mu_1^2}{2}\right]$

$\frac{12 \times \cancel{2}}{\cancel{10}_5} = \left[2 + \mu_1^2\right]$

$\mu_1^2 = \frac{12}{5} - 2 \Rightarrow \frac{2}{5} = 0.63$

2. $P_t = ?$ $P_c = 10KW$, $\mu_2 = 0.5$

$P_t = 10\left[1 + \frac{(0.5)^2}{2}\right] KW$

$P_t = 10\left[\frac{2 + 0.25}{2}\right]$

$P_t = 5\left[2.25\right] KW$

$P_t = 11.25 KW$

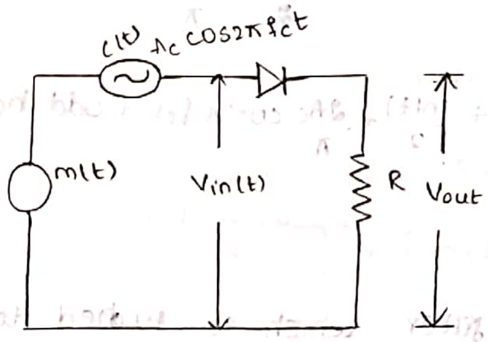
3. $\mu_t = \sqrt{\mu_1^2 + \mu_2^2} = \sqrt{(0.63)^2 + (0.5)^2}$

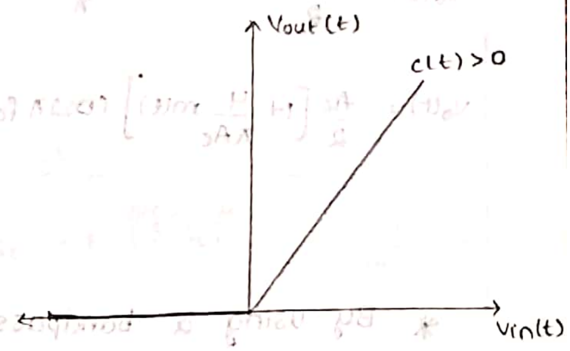
$= \sqrt{\cancel{0.16} + \cancel{0.25}} = \sqrt{0.396 + 0.25}$

$= \sqrt{\cancel{0.41}} = 0.84.$

Scanned by CamScanner

Switching Modulator :- Generation of AM wave.





Vout(t) = Vin(t) c(t) > 0
= 0. c(t) < 0

$V_{in}(t) = m(t) + A_c \cos 2\pi f_c t$

$A_c >> |m(t)|$.

For $V_{out}(t) = V_{in}(t) g_p(t) \Rightarrow \boxed{V_o(t) = V_i(t)\, g_p(t).}$ — ②

where $g_p(t)$ is the periodic pulse train of duty cycle equal to one half of the carrier freqency & period $T_0 = 1/f_c$ as shown in below figure, representing this $g_p(t)$ by its FS we have

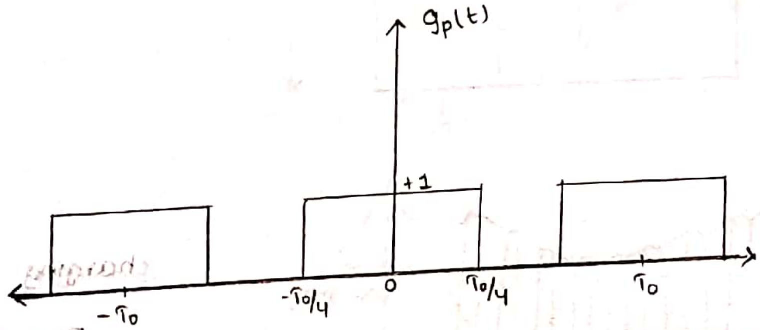
$$g_p(t) = \frac{1}{2} + \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2n-1} \cos[2\pi f_c t (2n-1)]$$

$$\boxed{g_p(t) = \frac{1}{2} + \frac{2}{\pi} \cos 2\pi f_c t + \text{odd hormonic component}} \text{ — ③}$$

ideal diode

R → 0 → FB

R → ∞ - RB



24/12

we know that $V_{out}(t) = V_{in}(t) + g_p(t)$

$$V_o(t) = [m(t) + A_c \cos 2\pi f_c t] \left[\frac{1}{2} + \frac{2}{\pi} \sum_{n=1}^{\infty} \frac{(-1)^{n-1}}{2n-1} \cos[2\pi f_c (2n-1)]\right]$$

$$V_o(t) = (m(t) + A_c \cos 2\pi f_c t) \left[\frac{1}{2} + \frac{2}{\pi} \cos 2\pi f_c + \text{odd harmonic}\right.$$

$$V_o(t) = \frac{m(t)}{2} + \frac{2}{\pi} m(t) \cos 2\pi f_c t + \frac{A_c}{2} \cos 2\pi f_c t + \frac{2A_c}{\pi} \cos^2 2\pi f_c t + \text{odd harmonics.}$$

$$V_o(t) = \frac{A_c}{2}\cos 2\pi f_c t + \frac{2}{\pi} m(t)\cos 2\pi f_c t + \frac{m(t)}{2} + \frac{2A_c}{\pi}\cos^2 2\pi f_c t + \text{odd har...}$$

$$V_o(t) = \underbrace{\frac{A_c}{2}\left[1+\frac{4}{\pi A_c}m(t)\right]\cos 2\pi f_c t}_{\text{AM wave}} + \underbrace{\frac{m(t)}{2} + \frac{2A_c}{\pi}\cos^2 \pi f_c t + \text{odd harmonics}}_{\text{unwanted terms.}}$$

$$k_a = \frac{4}{\pi A_c}$$

* By using a bandpass filter which is tuned to f_c frequency can extract the required AM wave from $V_o(t)$.

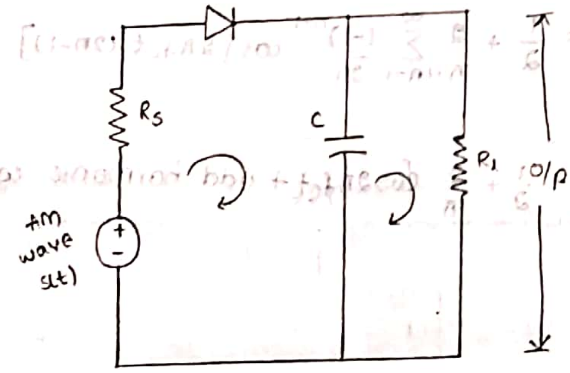
Detection of AM wave :- (Demodulation of AM wave):

Envolope detection :-

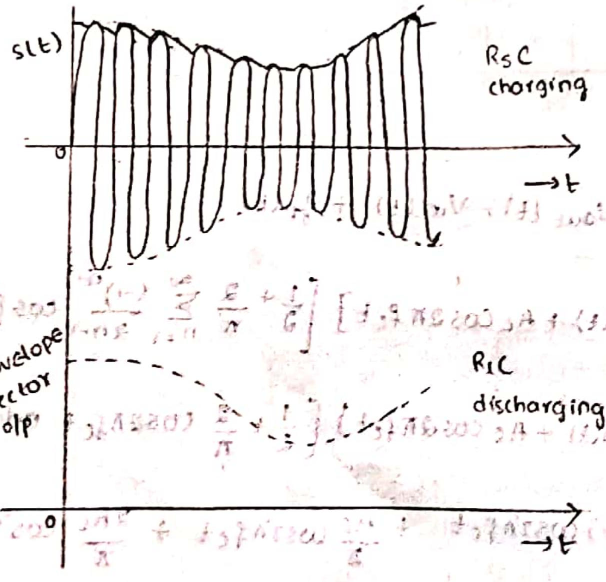
diode followed by LPF is envolope detector.

rectifier followed by LPF is envolope detector.

Envolope detection comes under uncoherent detection (in which carrier is used only once)



$|\mu| \le 1$



charging time constant

$$R_sC \ll \frac{1}{f_c}$$

$$\frac{1}{f_c} \ll R_LC \ll \frac{1}{W}$$

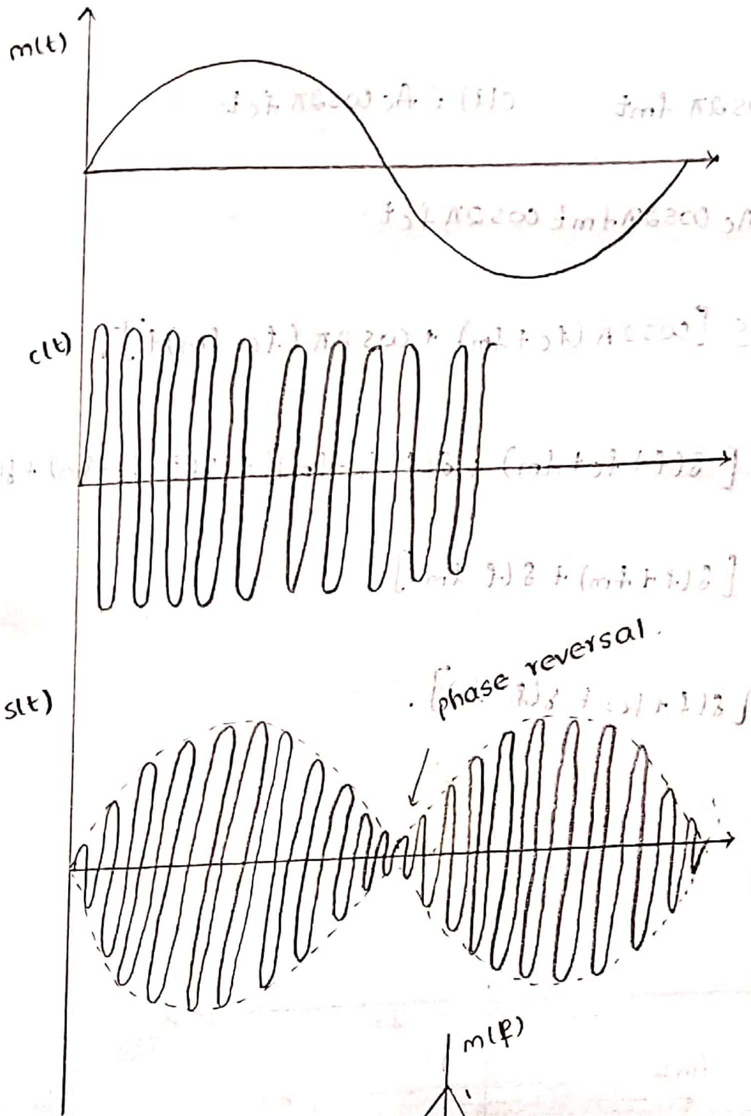
Peaks $\rightarrow$ LPF $\rightarrow$ envolope

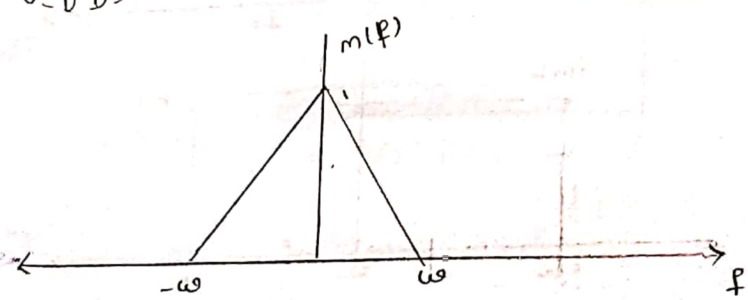
31/12/19 DSBSC [Double side Band Supressed Carrier] :-

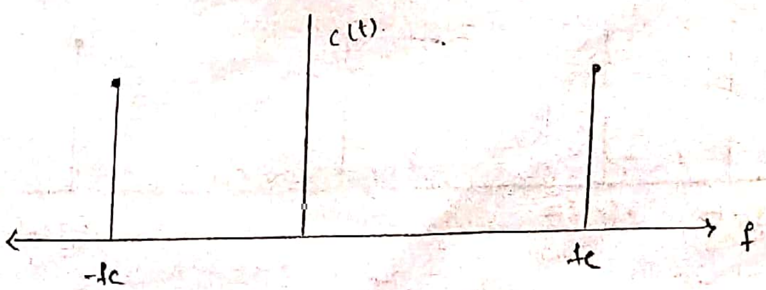
$$S_{DSBSC}(t) = m(t)\,c(t)$$

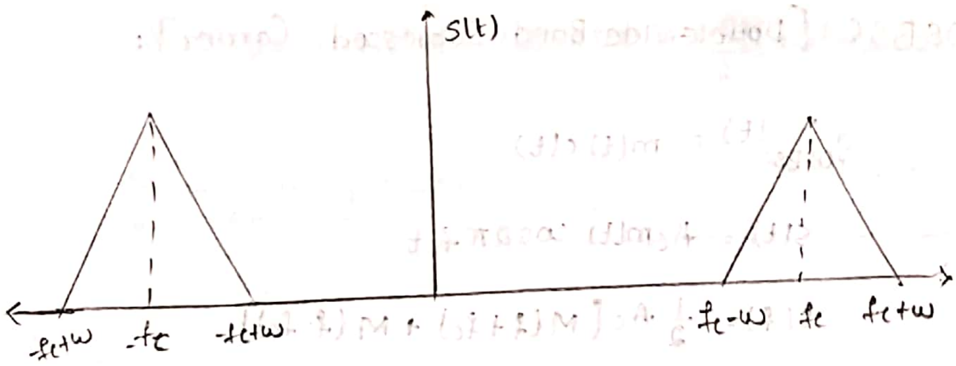
$$s(t) = A_c m(t) \cos 2\pi f_c t.$$

$$S(f) = \frac{1}{2} A_c [M(f+f_c) + M(f-f_c)].$$









Single tone modulation :-

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

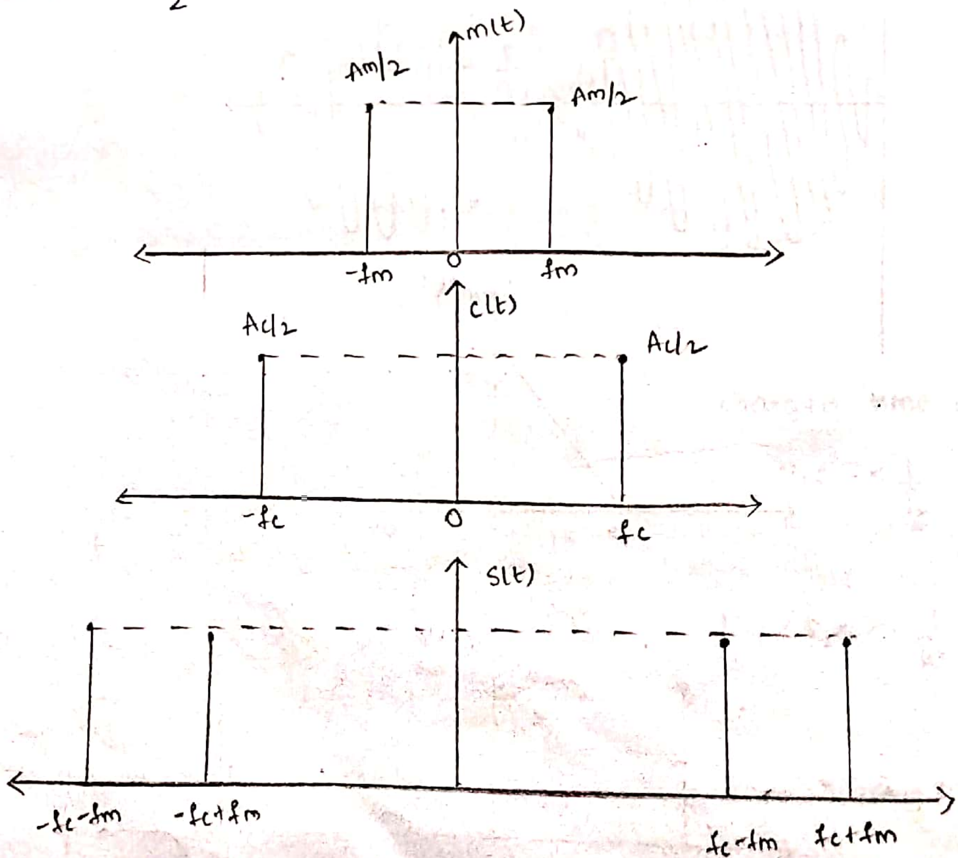
$s(t) = A_m A_c \cos 2\pi f_m t \cos 2\pi f_c t.$

$$s(t)_{DSBSC} = \frac{A_m A_c}{2} [\cos 2\pi (f_c + f_m) + \cos 2\pi (f_c - f_m) t].$$

$$S(f) = \frac{A_m A_c}{4} [\delta(f + f_c + f_m) + \delta(f - f_c - f_m)] + \delta(f + f_c - f_m) + \delta(f - f_c + f_m)$$

$$M(f) = \frac{A_m}{2} [\delta(f + f_m) + \delta(f - f_m)].$$

$$C(f) = \frac{A_c}{2} [\delta(f + f_c) + \delta(f - f_c)].$$



$$P_t = P_{SB}$$

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

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

$$P_{LSB} = \frac{A_m^2 A_c^2}{8} + \frac{A_m^2 A_c^2}{8} \Rightarrow \frac{A_m^2 A_c^2}{4}$$

$$P_t = P_{USB} + P_{LSB} \Rightarrow \frac{A_m^2 A_c^2}{4}$$

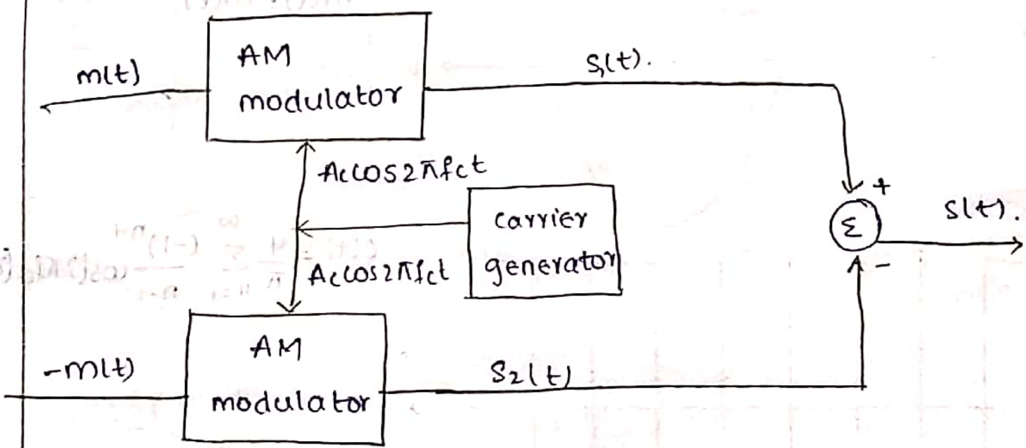
$$P_t = \frac{A_m^2 P_c}{2}$$

$$\eta\% = \frac{P_t}{P_{USB} + P_{LSB}}$$

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

Generation of DSBSC

Balanced modulator :- (Product modulator)



$$s_1(t) = A_c[1 + k_a m(t)] \cos 2\pi f_c t.$$

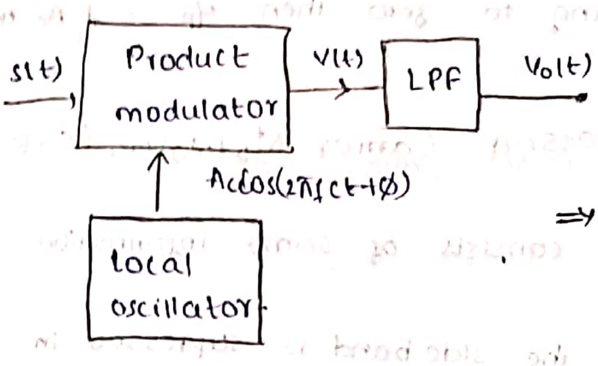
$$s_2(t) = A_c[1 - k_a m(t)] \cos 2\pi f_c t.$$

$$s(t) = s_1(t) - s_2(t).$$

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

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

Coherent detection of DSBSC:-



$$\Rightarrow v(t) = s(t) * A_c\cos(2\pi f_c t+\phi).$$

$$= m(t).A_c\cos 2\pi f_c t * A_c\cos(2\pi f_c t+\phi)$$

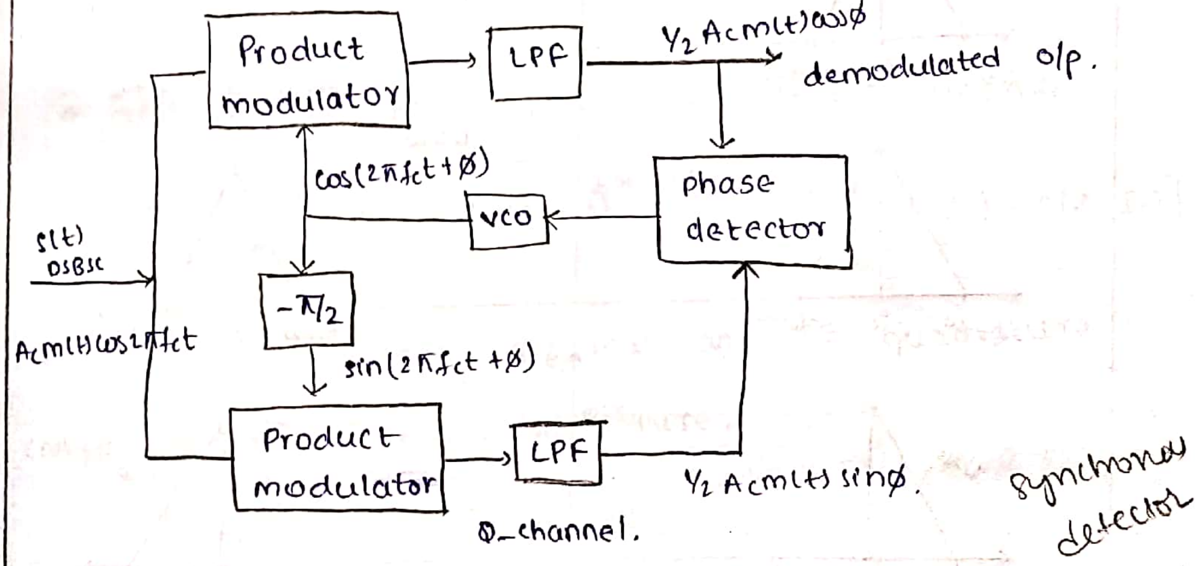
$$= \frac{A_c^2}{2} m(t) \cos 2\pi f_c t \cos(2\pi f_c t+\phi)$$

$$= \frac{A_c^2}{2} m(t)[\cos\phi + \cos(4\pi f_c t+\phi)].$$

* ϕ is phase angle which vary from $\pm\pi/2$.

* If $\phi = 0°$ $V_o(t) = \frac{1}{2}A_c^2 m(t)$ if $\phi = 90°$ $V_o(t) = 0$.

coastas loop :- (proper phase detection)



output of I-channel

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

$$= \frac{A_c}{2} m(t)\cos\phi + \frac{A_c m(t)}{2}\cos 4\pi f_c t$$

$$V_m(t) = \frac{A_c m(t)}{2}\cos\phi$$

|||ly $V_{o2}(t) = \frac{A_c}{2} m(t)\sin\phi.$

$$v(t) = \frac{A_c}{2} m(t)\sin\phi \frac{A_c}{2} m(t)\cos\phi. \Rightarrow v(t) = \frac{A_c^2}{4} m^2(t)\cos\phi\sin\phi$$

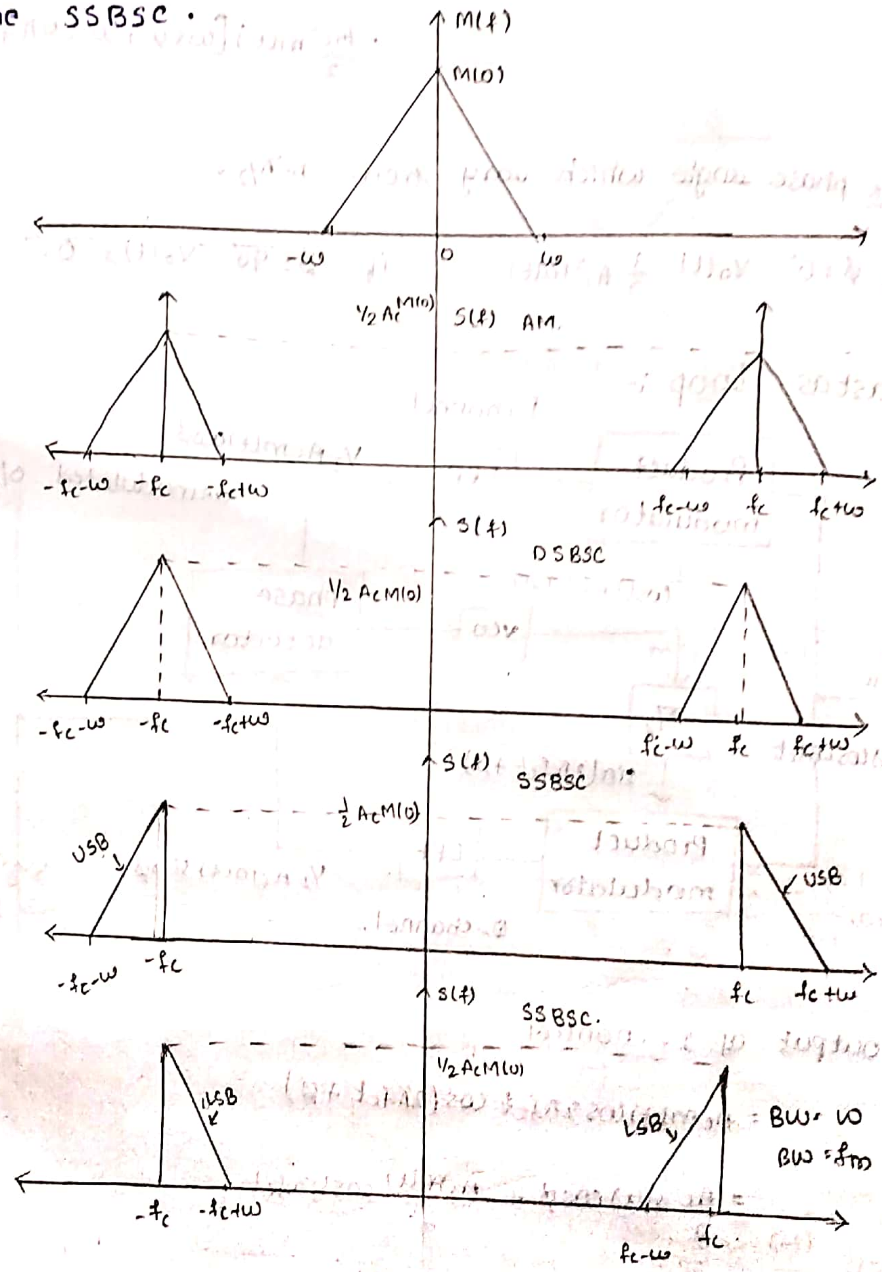
Scanned by CamScanner

03/01/18

* If phase angle is tending to zero then o/p = $\frac{1}{2} A_c m(t)$

Single Side Band Supressed Carrier Modulation (SSBSC):

* Both the side bands consists of same information ∴ carrier signal, one of the side band is supressed in the SSBSC.



* The canonical form of bandpass signal is given as

$$\boxed{S(t) = S_c(t)\cos 2\pi f_c t - S_s(t)\sin 2\pi f_c t} \quad -①$$

$S_c(t)$, $S_s(t)$ are inphase & quadrate comp of BPS.

⇒ The inphase component can be obtained by multiplying $s(t)$ with $\cos 2\pi f_c t$ and passing through a lowpass filter.

⇒ Except the scaling factor the $S_s(t)$ can be obtained by multiplying $s(t)$ with $\sin 2\pi f_c t$ & passing through lowpass filter.

Finally we obtain

$S_c(t) = \frac{s(t)}{2} \cos 2\pi f_c t$ $S_s(t) = \frac{s(t)}{2} \sin 2\pi f_c t$

but except scaling factor except scaling factor

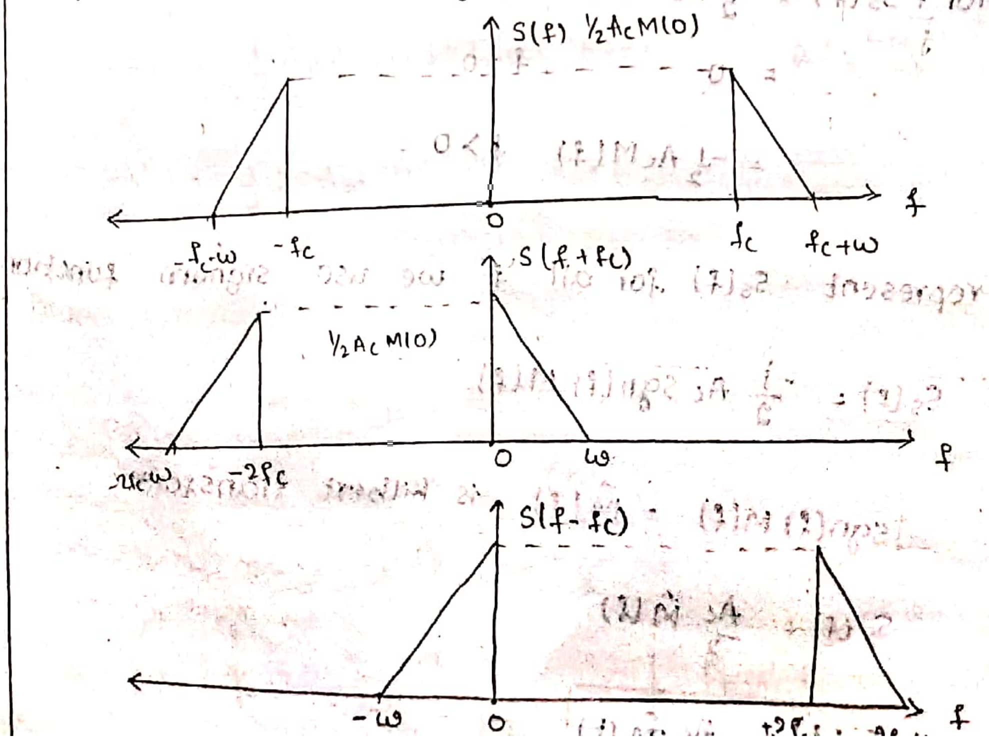
$\boxed{\therefore S_c(t) = s(t) \cos 2\pi f_c t}$ $\boxed{\therefore S_s(t) = s(t) \sin 2\pi f_c t}$

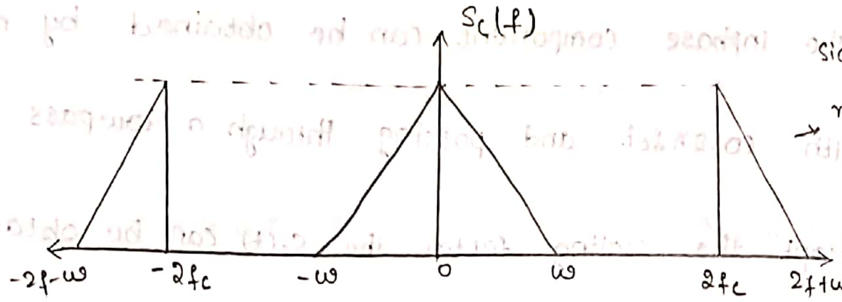
04/0 Fourier transform of $S_c(t)$ and $S_s(t)$

⇒ $S_c(t) = s(t) \cos 2\pi f_c t$ ⇒ $S_s(t) = s(t) \sin 2\pi f_c t$

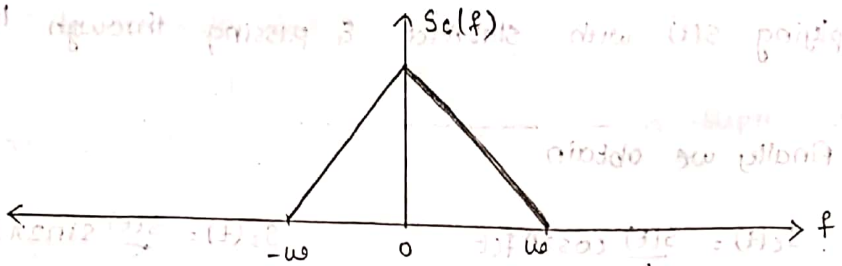
$S_c(f) = \frac{1}{2}[S(f+f_c) + S(f-f_c)]$ $S_s(f) = \frac{j}{2}[S(f-f_c) - S(f+f_c)]$.

The inphase components are real and the quadrature component is imaginary in nature.





→ side bands are removed during LPF. bcz they are of low frequ...



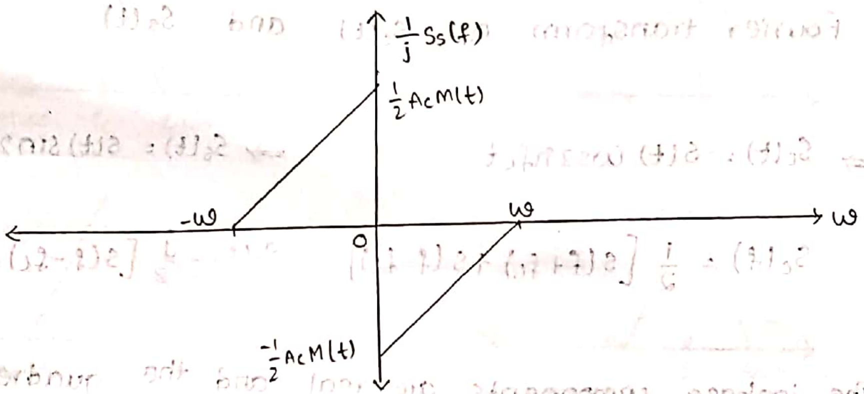
→ $S_c(f) = \frac{1}{2} A_c M(f)$

$$\boxed{S_c(t) = \frac{1}{2} A_c m(t)} \quad -ⓐ$$

→ consider

$$S_s(f) = \frac{j}{2}\left[S(f-f_c) - S(f+f_c)\right]$$

$$\frac{1}{j} S_s(f) = \frac{1}{2}\left[S(f-f_c) - S(f+f_c)\right].$$



for $\frac{1}{j} S_s(f) = \frac{1}{2} A_c M(f) \qquad f<0$

$= 0 \qquad f=0$

$= -\frac{1}{2} A_c M(f) \qquad f>0.$

To represent $S_s(f)$ for all 'f' we use signum function:

$$\boxed{S_s(f) = \frac{-j}{2} A_c \, \mathrm{sgn}(f) \, M(f).}$$

$-j\,\mathrm{sgn}(f)\, M(f) = \hat{M}(f)$ is hilbert transform.

90° phase shift without mag change

$$S_s(f) = \frac{A_c}{2} \hat{M}(f)$$

$$\boxed{S_s(t) = \frac{A_c}{2} \hat{m}(t)} \quad - ⓑ$$

Scanned by CamScanner

substitute a, b in ① we obtain

$$s(t) = s_c(t)\cos 2\pi f_c t - s_s(t)\sin 2\pi f_c t$$

substituting :

$$\boxed{S_{SSB}(t) = \underbrace{\frac{1}{2}A_c m(t)\cos 2\pi f_c t}_{USB} \mp \underbrace{\frac{1}{2}A_c \hat{m}(t)\sin 2\pi f_c t}_{LSB}}$$

The above expression is the time domain expression of the single side Band supressed carrier.

Single tone modulation :-

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

$$\hat{m}(t) = A_m \sin 2\pi f_m t$$

substitute m(t) and $\hat{m}(t)$ in standard equation we obtain

$$S_{SSB}(t) = \frac{1}{2}A_c A_m \cos 2\pi f_m t \cos 2\pi f_c t - \frac{1}{2}A_c A_m \sin 2\pi f_m t \sin 2\pi f_c t$$

$$s(t)_{USB} = \frac{1}{2}A_c A_m \cos 2\pi(f_c + f_m)t$$

$$s(t) = \frac{1}{2}A_c A_m \cos 2\pi f_m t \cos 2\pi f_c t + \frac{1}{2}A_c A_m \sin 2\pi f_m t \sin 2\pi f_c t$$

$$s(t)_{LSB} = \frac{1}{2}A_c A_m \cos 2\pi(f_c - f_m)t.$$

Power calculations :-

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

$$P_t = \left(\frac{A_c A_m}{2\sqrt{2}}\right)^2 = \frac{A_c^2 A_m^2}{8}$$

$$\boxed{P_t = \frac{A_c^2 A_m^2}{8}} \qquad \boxed{P_t = \frac{P_c A_m^2}{4}}$$

Scanned by CamScanner

* The bandwidth required for the single tone modulation in SSB is 'ω'.

LPF
BPF

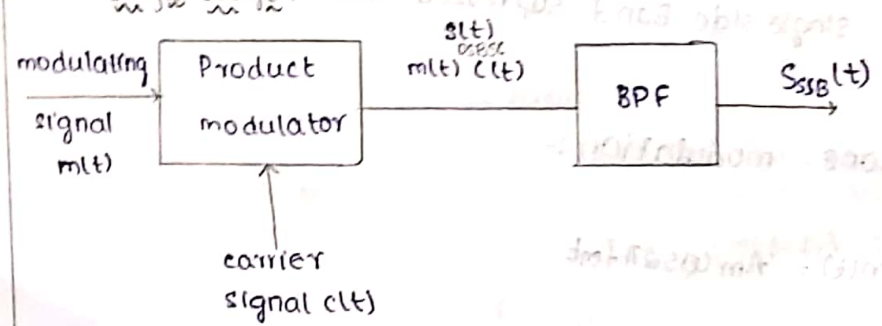
Generation Methods :-

(i) Frequency discrimination method

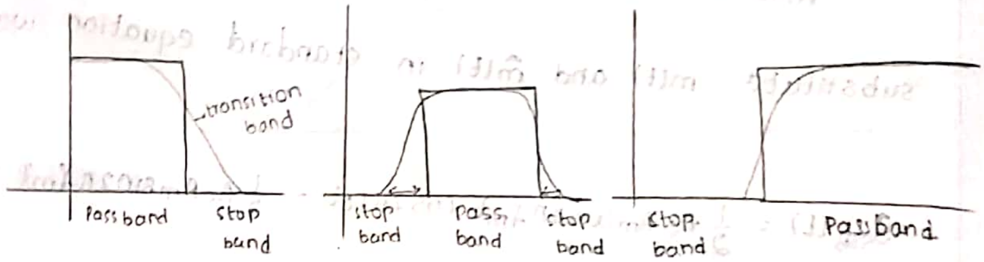
(ii) Phase discrimination method.

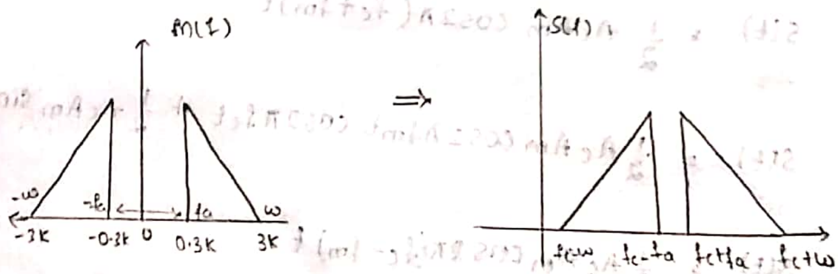
(i) frequency discrimination method :-

single stage :-

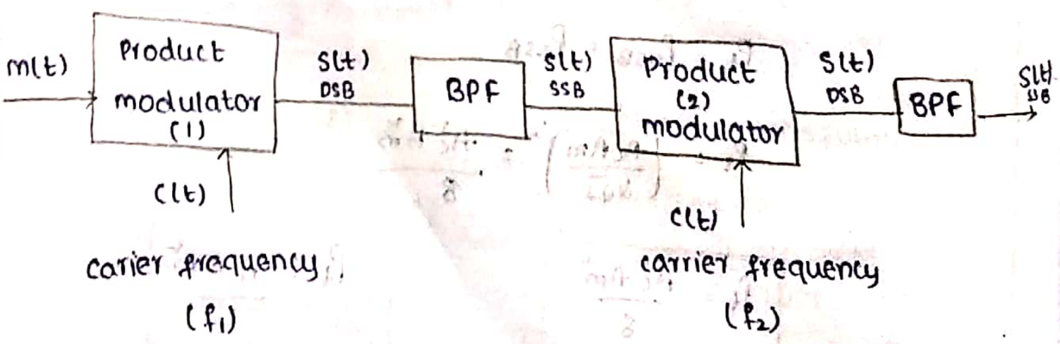


Filters





multistage modulator :-



Application of frequency discrimination methods, requires the message signals satisfy 2 conditions :-

(i) message should not have low frequency content i.e the message spectrum M(f) has "holes" at zero frequency.
no message

Ex: An important type of message signal with such a property is an audio / voice (speech, music).

(ii) The highest frequency component 'W' of the message signal is much less than carrier frequency 'f_c'.

In designing the BPF in SSB modulation we must satisfy 2 basic requirements, they are :-

(i) The passband of the filter occupies the same frequency range as the spectrum of desired SSB modulated wave.

(ii) The width of the transition band (Broad band) of the filter separating the PB from stop band is twice the lowest frequency of component of message signal.

SSB (voice signals).
VSB (TV signals).

06/10

Q) Consider the use of 2 stage modulation scheme to generate SSB. Assuming i/p signal m(t) consists of a voice signal occupying a frequency of 0.3 to 3.4KHz, the oscillator frequencies $f_1 = 100$KHZ and $f_2 = 10$MHz calculate the USB and LSB frequecies in the 1st and 2nd stage of Modulator.

Sol

Stage 1 :-

$f_1 = 100 \text{ kHz}$ $f_m = (0.3 \text{ to } 3.4)K$

USB : 100.3K to 103.4K.

LSB : 96.6K to 99.7K

This becomes i/p to next stage.

Stage 2 :-

(i) let us consider USB as i/p

$f_{m_2}' = 100.3K$ to $103.4K$.

USB : 10100.3K to 10103.4K
10.1003M 10.1034M.

LSB : 9896.6K to 9899.7K
9.8966M 9.8997M

(ii) let us consider LSB as i/p

$f_m'' = 96.6K$ to $99.7K$

USB : 10096.6K to 10099.7K
10.0966M 10.0997M

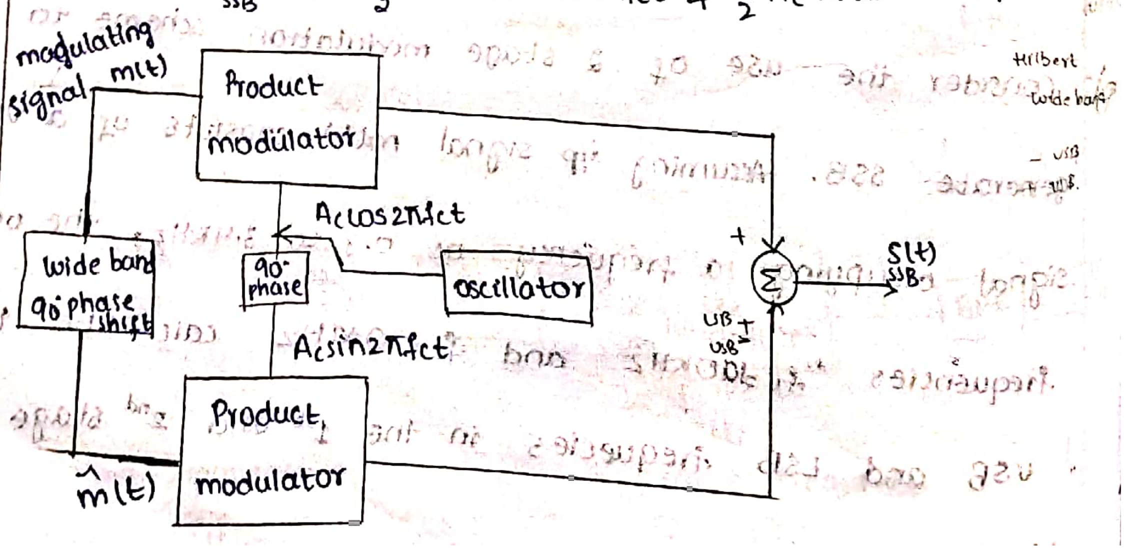
LSB :

(ii) Phase discrimination method :-

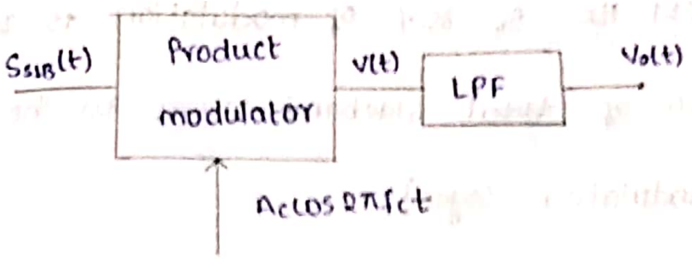
⇒ In frequency discrimination method filter disgining is problem, in phase discrimination method without changing amplitude it is diffucult to phase shift.

* Hence, SSB is generated using third method.

$$S(t)_{SSB} = \frac{1}{2} A_c m(t) \cos 2\pi f_c t \mp \frac{1}{2} A_c \hat{m}(t) \sin 2\pi f_c t$$



Coherent detection of SSBSC :-



(i) assuming a perfect synchronised.

$$v(t) = s(t) * A_c \cos 2\pi f_c t$$

$$v(t) = \left[\frac{1}{2} A_c m(t) \cos 2\pi f_c t \pm \frac{1}{2} A_c \hat{m}(t) \sin 2\pi f_c t\right] A_c \cos 2\pi f_c t$$

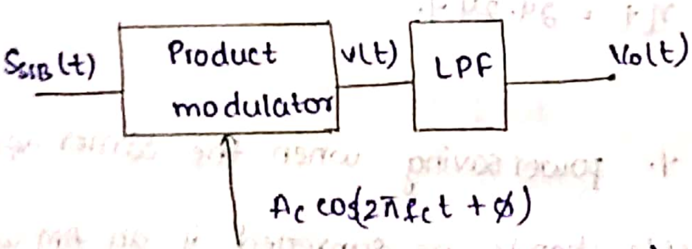
$$v(t) = \frac{1}{2} A_c^2 m^*(t) \cos^2 2\pi f_c t \pm \frac{1}{2} A_c^2 \hat{m}(t) \sin 2\pi f_c t \cos 2\pi f_c t.$$

$$v(t) = \frac{1}{2} A_c^2 m^*(t) \cos^2 2\pi f_c t \pm \underbrace{\frac{1}{4} A_c^2 \hat{m}(t) \sin 4\pi f_c t}_{\text{attenuated.}}$$

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

$$V_o(t) = \frac{1}{4} A_c^2 m^*(t)$$

(ii) assuming not a perfect synchronised :



$$V(t) = s(t) * A_c \cos(2\pi f_c t + \phi).$$

$$v(t) = \left[\frac{1}{2} A_c m(t) \cos 2\pi f_c t \pm \frac{1}{2} A_c \hat{m}(t) \sin 2\pi f_c t\right] [A_c \cos(2\pi f_c t + \phi)]$$

$$v(t) = \frac{1}{2} A_c^2 m(t) \cos 2\pi f_c t \cos(2\pi f_c t + \phi) \pm \frac{1}{2} A_c^2 \hat{m}(t) \sin(2\pi f_c t) \cos(2\pi f_c t + \phi)$$

$$v(t) = \frac{1}{4} A_c^2 m(t) [\cos 4\pi f_c t + \cos\phi] \pm \frac{1}{4} A_c^2 \hat{m}(t) [\sin 4\pi f_c t - \sin\phi].$$

$$v(t) = \frac{1}{4} A_c^2 m(t) \cos\phi \pm \frac{1}{4} A_c^2 \hat{m}(t) \sin\phi + \underbrace{\frac{1}{4} A_c^2 [m(t) \cos 4\pi f_c t \pm \hat{m}(t) \sin 4\pi f_c t]}_{\text{attenuated.}}$$

$$V_o(t) = \frac{1}{4} A_c^2 [m(t) \cos\phi \pm \hat{m}(t) \sin\phi].$$

Q) In an AM system the modulating signal is sinusoidal with frequency FM Hz If 80% of modulation is used then find the ratio of total sideband power to the total power of the modulated signal.

Sol Given, 80% of modulation is used.

we know $\eta = \frac{P_{SB}}{P_t}$

$80\% \Rightarrow \frac{\mu^2}{2+\mu^2} \times 100 = \eta$

$\mu = 0.8$

$\eta = \frac{0.8 \times 0.8}{2 + 0.8 \times 0.8} \times 100$

$\eta\% = \frac{0.64}{2+0.64} \times 100$

$\eta\% = 0.2424 \times 100$

$\eta\% = 24.24\%$

Determine the % power saving when the carrier wave and one of the side bands are supressed in an AM wave modulated to a depth of 50%..

$\mu_2 = 0.5$ $\mu_1 = 1$ $\frac{\cancel{A_c^2} \mu^2 / 4}{8_2 \cancel{A_c^2} (2+\mu^2)}$

$\eta_2\% = \frac{11.11\%}{2} = 5.5\%$ $\mu_1 = 1$ $= \frac{\mu^2}{(2)(2+\mu^2)}$

$\%\eta_1 = 33.3\%$

% power saving $= \frac{P_t - P_{SB}}{P_t}$

$P_t = P_c [1 + 1/2] = \frac{3}{2} P_c$ $P_{SB} = \frac{P_c \mu^2}{4} = \frac{P_c}{4}$.

$P_{SB} = P_c \frac{\mu^2}{4}$ $P_t = P_c\left[1+\frac{\mu^2}{2}\right]$

case (i) $\mu = 1$ case (ii) $\mu_2 = 0.5$

$P_{SB} = \frac{P_c}{4} +$ $P_{SB} = P_c \times 0.06.$

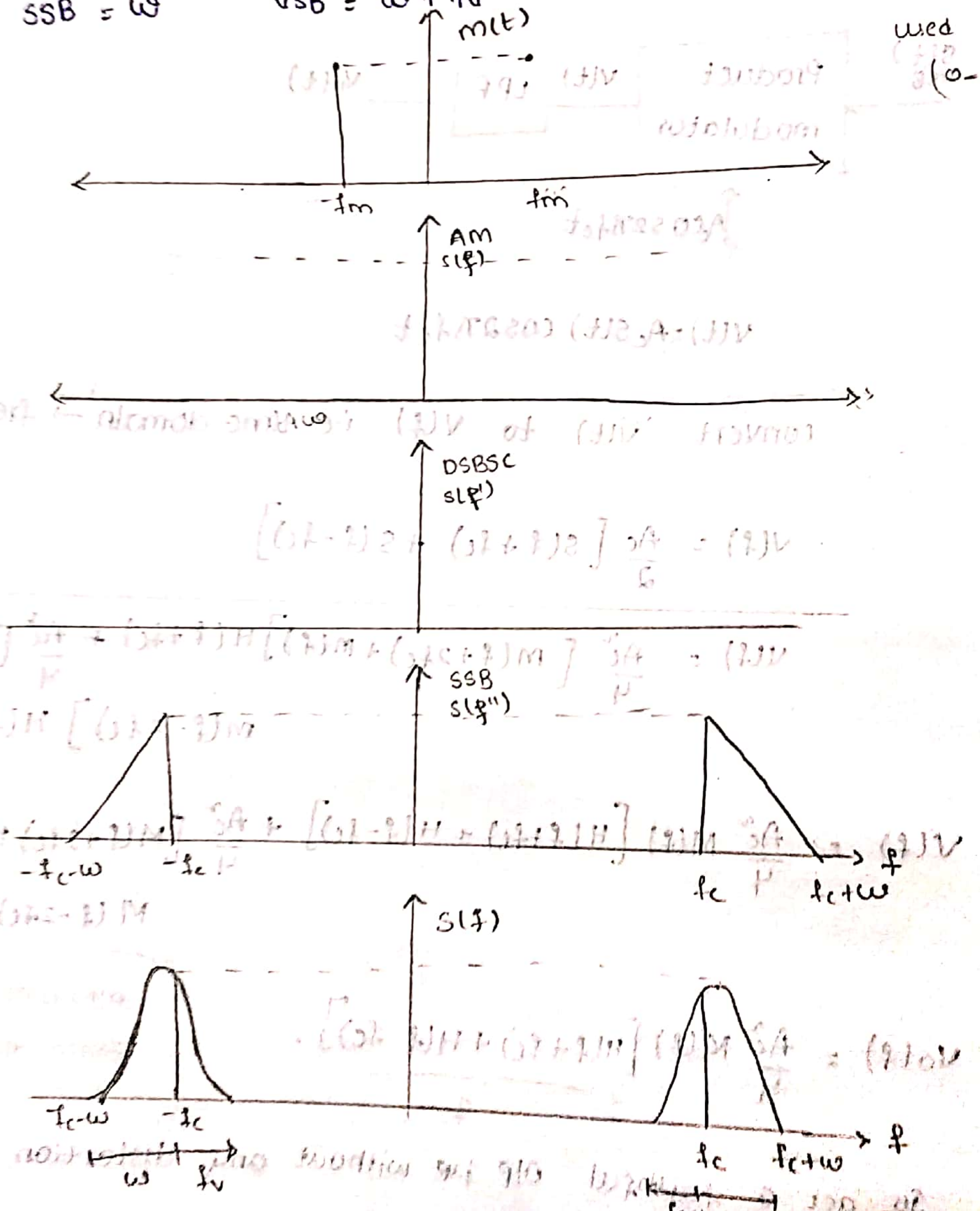
$P_t = P_c\left[1+\frac{0.25}{2}\right]$

$P_t = 1.125\, P_c$

VSB modulation :- [vestigial side band] :-

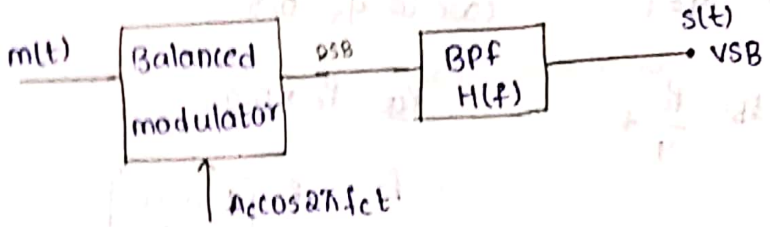
SSB: fc
0 → few Hz
signals can't be
used ∴ VSB.
(0–4.5 MHz)

SSB = ω VSB = $\omega + f_v$ DSB = 2ω



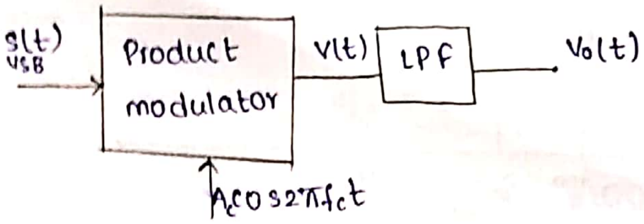
07/01

Generation of VSB :-



$$s(f) = \frac{A_c}{2}\left[m(f+f_c) + m(f-f_c)\right] H(f)$$

coherent detection.



$$v(t) = A_c s(t) \cos 2\pi f_c t$$

convert $v(t)$ to $V(f)$ i.e time domain → freq domain

$$V(f) = \frac{A_c}{2}\left[s(f+f_c) + s(f-f_c)\right]$$

$$V(f) = \frac{A_c^2}{4}\left[M(f+2f_c) + M(f)\right] H(f+f_c) + \frac{A_c^2}{4}\left[M(f) + M(f-2f_c)\right] H(f-f_c).$$

$$V(f) = \frac{A_c^2}{4} M(f)\left[H(f+f_c) + H(f-f_c)\right] + \underbrace{\frac{A_c^2}{4}\left[M(f+2f_c) H(f+f_c) + M(f-2f_c) H(f-f_c)\right]}_{\text{attenuated when passed through LPF}}.$$

$$V_0(f) = \frac{A_c^2}{4} M(f)\underbrace{\left[H(f+f_c) + H(f-f_c)\right]}_{1}.$$

To get a faithful o/p i.e without any distortion.

$$H(f+f_c) + H(f-f_c) = 2H(f_c)$$

$2H(f_c) = 1$

$H(f_c) = 0.5$