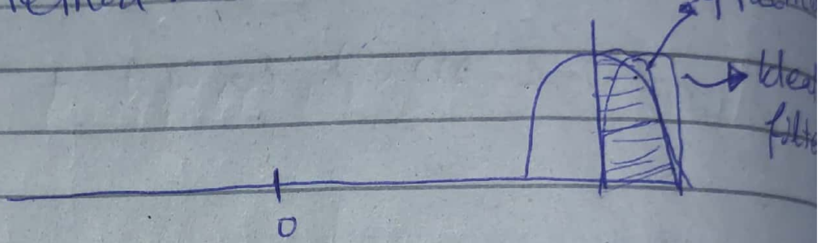
Com Sys After Mids:-

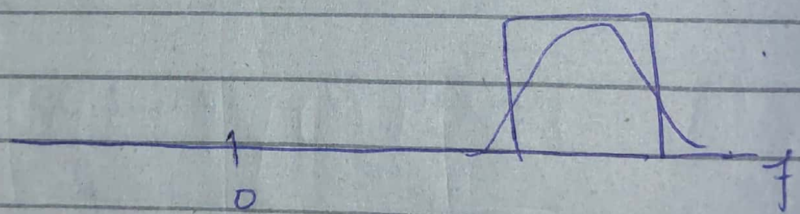
29/11/2023

★ Generation of SSB

(i) Selective Filtering Method:



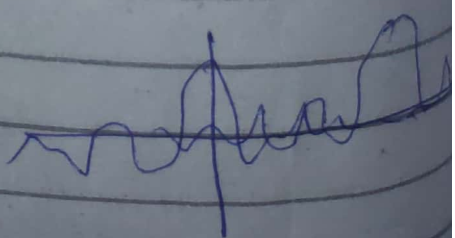
Can we do this?
No.
Why?



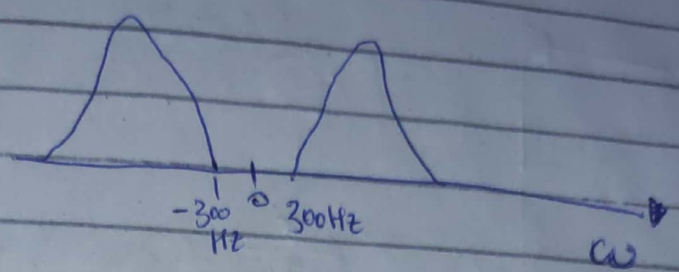
Butterworth filter

$$H(\omega) = \frac{1}{\sqrt{1 + \left(\frac{\omega}{2\pi B}\right)^{2n}}}$$

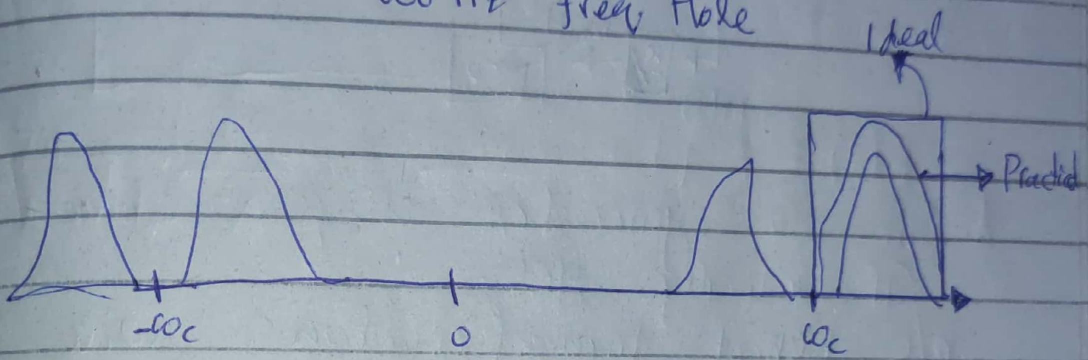
$$\text{rect}\left(\frac{\omega}{2W}\right)$$



★ Speech Signal 0.3 KHz to 3.4 KHZ



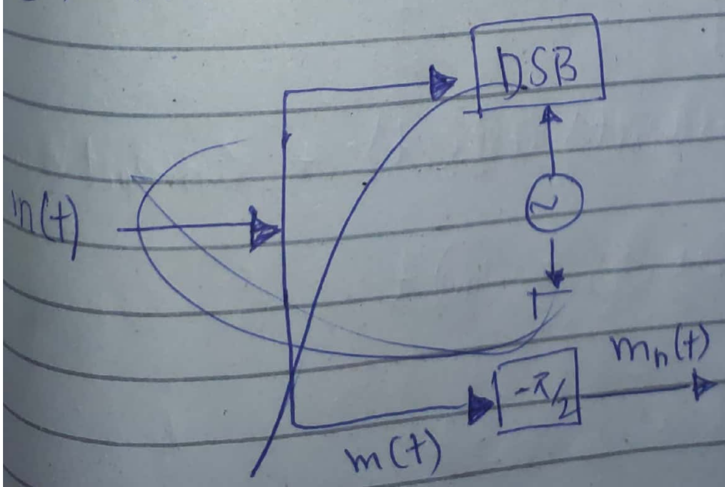
600 Hz freq Hole

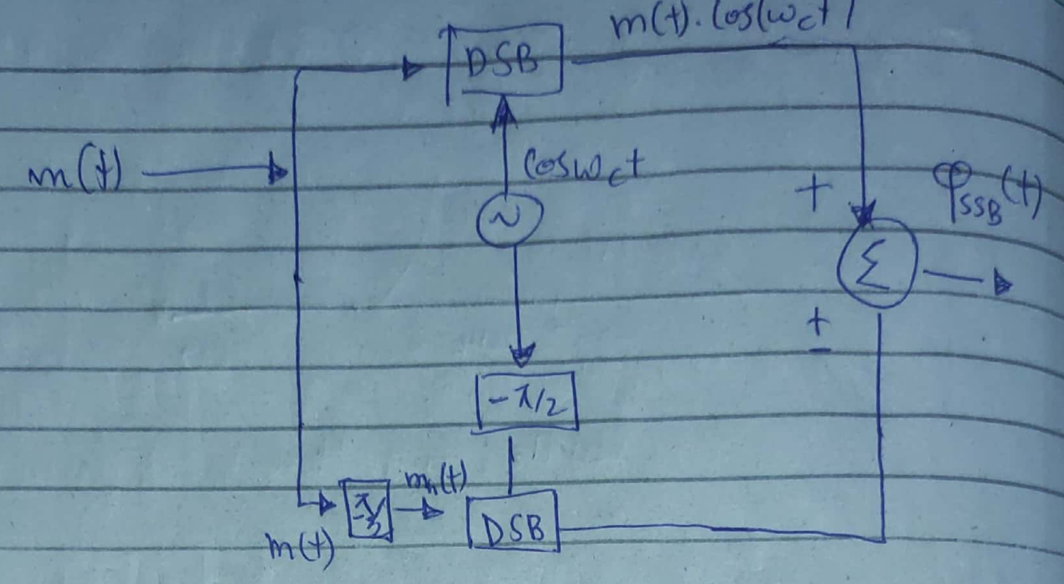


Speech signal can be isolated by practical filter bcoz freq. Hole

Now possible method.

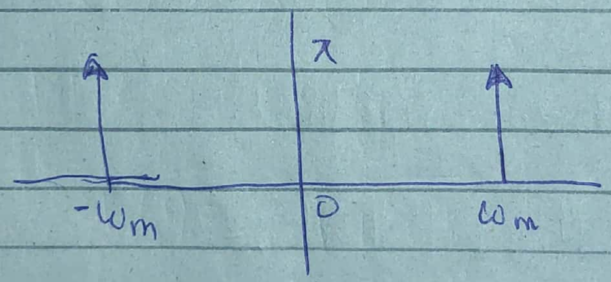
(ii) Phase Shift Method :-





★ Can we generate using above diagram
Theoritically yes.
b/c hilbert transformation will applying constant transformation on every freq. component (ideal case).

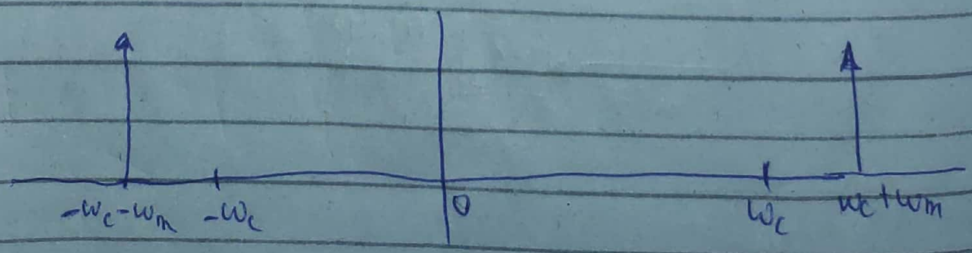
$m(t) = \cos \omega_m t$



$m_h(t) = \cos(\omega_m t - \frac{\pi}{2})$
$= \sin \omega_m t$

$\varphi_{SSB}(t) = \cos(\omega_m t)\cos(\omega_c t) + \sin \omega_m t \sin \omega_c t$

$\quad '' \quad = \cos(\omega_c \pm \omega_m) t$



Multiplying $\varphi_{SSB}(t)$ with $\cos\omega_c t$

$$\varphi_{SSB}(t) = m(t)\cos^2\omega_c t + m_h(t).\sin\omega_c t \cos\omega_c t$$

$$\varphi_{SSB}(t) = \frac{m(t)}{2} + \frac{m(t)\cos(2\omega_c t)}{2} + \frac{m_h(t)\sin 2\omega_c t}{2}$$

$$= M(\omega)$$

Low Pass filter, Coherent Detection

Now we will send carrier along.

$$\varphi_{SSB+C}(t) = \underline{A.\cos\omega_c t} + m(t).\cos\omega_c t + m_h(t).\sin\omega_c t$$

$$'' = (A + m(t)).\cos\omega_c t + m_h(t).\sin\omega_c t$$

$$'' = E(t).\cos(\omega_c t + \theta)$$

as $\dfrac{a+ib}{\sqrt{a^2+b^2}}$

Now if $E(t) = \sqrt{[A+m(t)]^2 + m_h^2(t)}$

Similar to

$a_n \cdot \cos n\omega_0 t + b_n \cdot \sin n\omega_0 t$

$$C_n = \sqrt{a_n^2 + b_n^2}$$

Now $E(t) = \left\{A^2 + m^2(t) + 2 \cdot A \cdot m(t) + m_h^2(t)\right\}^{1/2}$

$$E(t) = A\left[1 + \frac{2\,m(t)}{A} + \frac{m^2(t)}{A^2} + \frac{m_h^2(t)}{A^2}\right]^{\frac{1}{2}}$$

if $m(t) << A$

then

$$E(t) \approx A\left[1 + \frac{2m(t)}{A}\right]^{1/2}$$

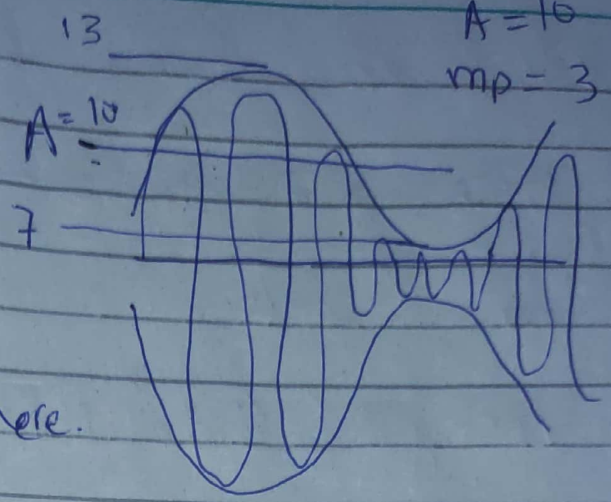
Now using binomial theorem

$$E(t) \approx A\left[1 + \frac{1}{\cancel{2}} \times \frac{\cancel{2}m(t)}{A}\right]$$

$$E(t) \approx A + m(t)$$

Now put in above equations

$$\varphi_{SSB+C}(t) = [A + m(t)]\cos(\omega_c t + \theta)$$



We are using extra power here.

$$\eta = \frac{\mu^2}{2+\mu^2} = \frac{1}{3} \times 100 = 33.33\%$$

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$$\varphi_{DSB-SC}(t) = m(t) \cdot \cos(\omega_c t)$$

$$\varphi_{DSB+C}(t) = [A + m(t)] \cos(\omega_c t)$$

$\Big\}$ 2B Hz

$$\varphi_{QAM}(t) = m_1(t) \cos(\omega_c t) + m_2(t) \sin(\omega_c t)$$

$$\varphi_{SSB}(t) = m(t) \cdot \cos(\omega_c t) \mp m_h(t) \sin \omega_c t$$

i) Selective Filtering Method
ii) Phase shift "

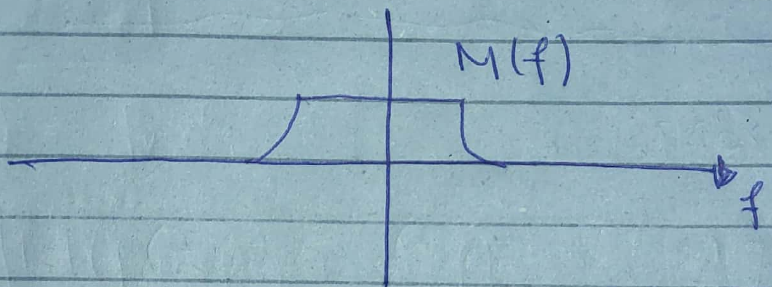
We have two extremes here.

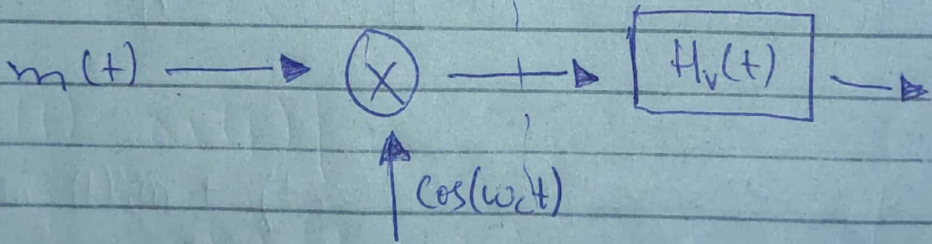
DSB $\rightarrow$ 2 B Hz SSB $\rightarrow$ B Hz

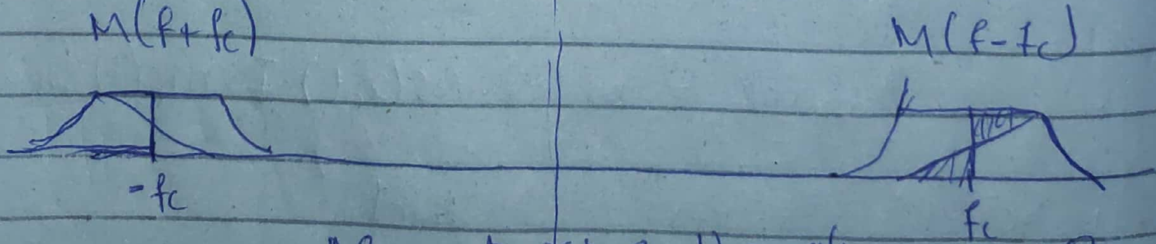
Now comes:

★ Vestigial Side Band Modulation:-

$$B_{Hz} < B_T < 2B\ Hz$$

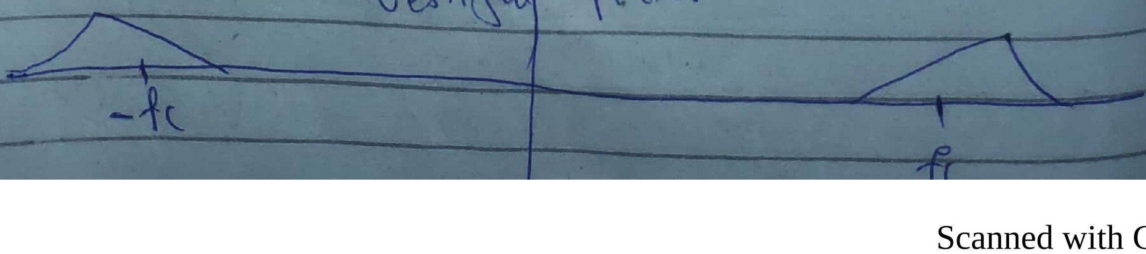






φVSB(f)?

After passing through vestigial filter.



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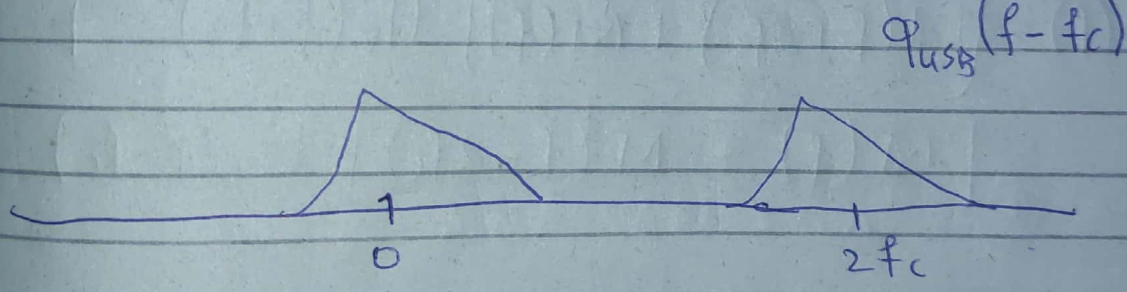
Demodulation

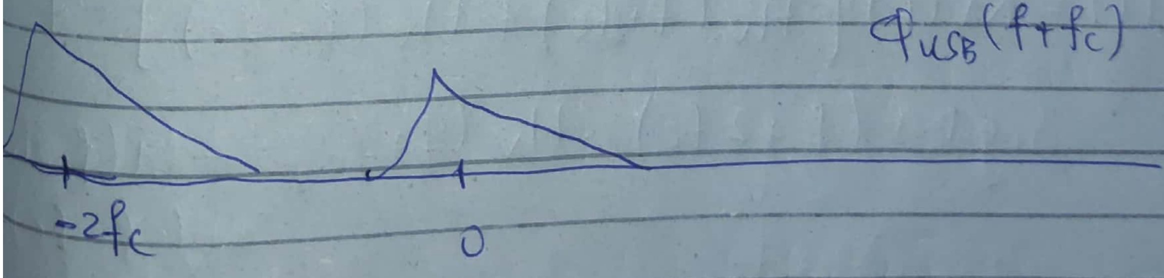
$$\varphi(t)_{DSB-SC} = m(t).\cos(\omega_c t)\Big]\ \text{Modulation}$$

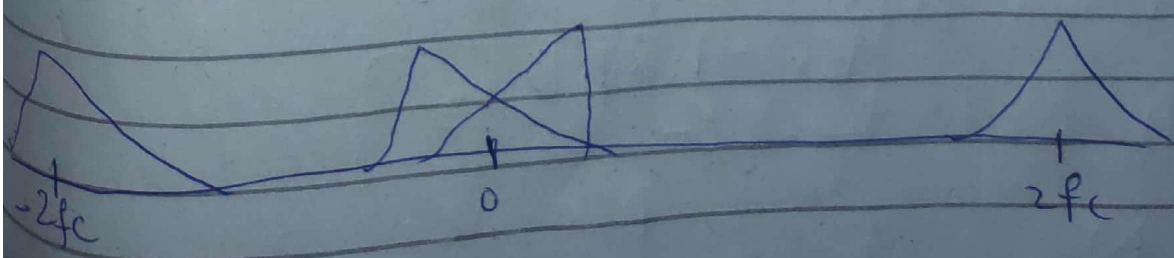
Multipley $\cos(\omega_c t)$ at reciever's end.

$$s(t) = \varphi_{VSB}(t) \cdot \cos(\omega_c t)\Big]\ \text{demodulation.}$$

$$s(f) = \varphi_{VSB}(f - f_c) + \varphi_{USB}(f + f_c)$$







Now at sender's end we have

$$\varphi_{VSB}(f) = [M(f+f_c) + M(f-f_c)]\, H_v(f)$$

Now

$$\begin{cases} \varphi_{VSB}(f+f_c) = \{M(f+2f_c) + M(f)\}\, H_v(f+f_c) \\ \varphi_{VSB}(f-f_c) = \{M(f) + M(f-2f_c)\}\, H_v(f-f_c) \end{cases}$$

Now if we add these two, get

$$S(f) = \varphi_{VSB}(f+f_c) + \varphi_{VSB}(f-f_c)$$

$$S(f) = [M(f+2f_c) + M(f)]\, H_v(f+f_c) + [M(f) + M(f-2f_c)]\, H_v(f-f_c)$$

$$S(f) = M(f)[H_v(f+f_c) + H_v(f-f_c)] + M(f+2f_c)\, H_v(f+f_c) + M(f-2f_c)\, H_v(f-f_c).$$

Typical value fo Bandwidth is;

$$\boxed{B_T = 1.25B \text{ Hz}}$$

Now to recover $M(f)$ we

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will pass it through low pass filter.

$$M(f) = S(f).H_{LPF}(f)$$

Hence.

$$M(f) = \cancel{M}(f)\left[H_v(f+f_c) + H_v(f-f_c)\right] H_{LPF}(f)$$

$$0 = H_v(f+f_c) +$$

$$H_{LPF}(f) = \frac{1}{H_v(f+f_c) + H_v(f-f_c)}$$

* Carrier Acquisition:-

$$m(t).\cos w_c t.\cos\left([\omega_c + \Delta\omega]t + \delta\right)$$

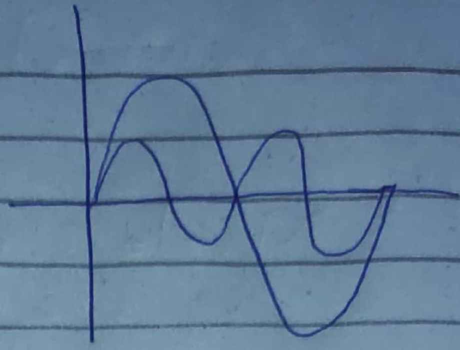
Now $\cos\alpha.\cos\beta = \cos(\alpha+\beta) + \cos(\alpha-\beta)$

$$m(t).\cos(\Delta\omega t + \delta) + m(t).\cos(2\omega_c t + \Delta\omega t + \delta)$$

By passing through LPF

$$m(t).\cos(\Delta\omega t + \delta)$$

$$f = \frac{d\phi(t)}{dt}$$



Case
(1) Now if $\Delta\omega = 0$, $\delta =$ const.

$$m(t) \cdot \cos(\delta)$$

eg

$$0.8 \cdot m(t)$$

Hence, shape of $m(t)$ will not be changed. Hence it is distortionless.

Case (2) $\Delta\omega =$ same value, $\delta = 0$

$$m(t) \cdot \cos(\Delta\omega t)$$

Signal will be distorted.

So, we need carrier aquisition.

Carrier Aquisition :-

(i) Pilot Signal :-

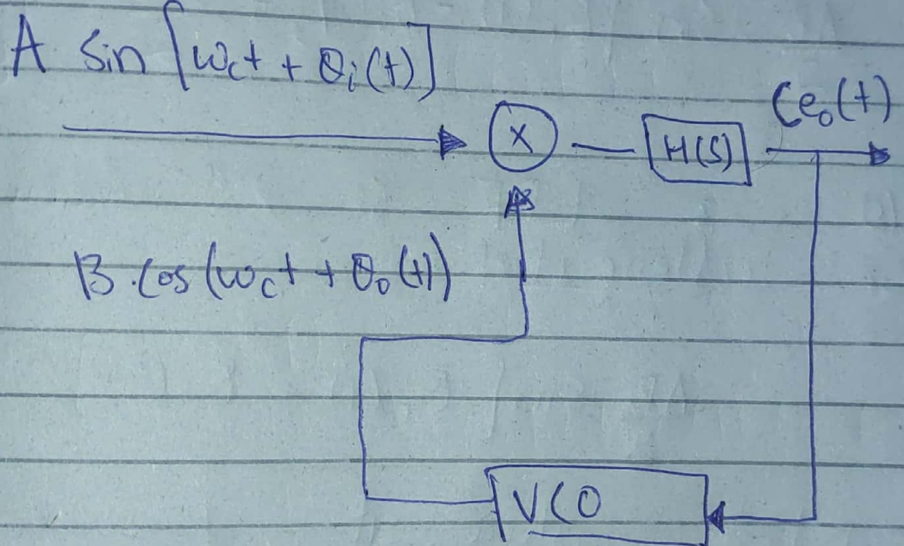
DSB-WC

$\{A + m(t)\} \cos \omega_c t$

(ii) Phase Loop Lock :-
(iii) Squaring Method :-

Phase Loop Lock :-

This is a feedback system.



VCO: Voltage Control Oscillator.

$[\theta_i(t) - \theta_o(t)] \propto \underbrace{e_o}$ will create voltage

$$\omega_i = \omega_c + C \cdot e_o(t) \quad \text{--- (i)}$$

$$\varphi(t) = \omega_c t + \theta_o(t)$$

$$\frac{d}{dt}\varphi(t) = \frac{d}{dt}(\omega_c t) + \frac{d}{dt}(\theta_o(t))$$

$$\omega_i = \omega_c + \dot{\theta}_o(t) \quad \text{---(ii)}$$

Compare (i) and (ii)

$$\dot{\theta}_o(t) = C \cdot e_o(t)$$

Now output of multiplier is:

$$A \cdot \sin(\omega_c t + \theta_i(t)) \cdot B \cdot \cos[\omega_c t + \theta_o(t)]$$

$$\frac{AB}{2} \cdot \sin[\theta_i(t) - \theta_o(t)] + \frac{AB}{2} \sin[2\omega_c t + \theta_i(t) + \theta_o(t)]$$

H(s) is LPF so 2nd term will be attenuated.

$$\frac{AB}{2} \sin[\theta_i(t) - \theta_o(t)]$$

Now when it passes through h(t).

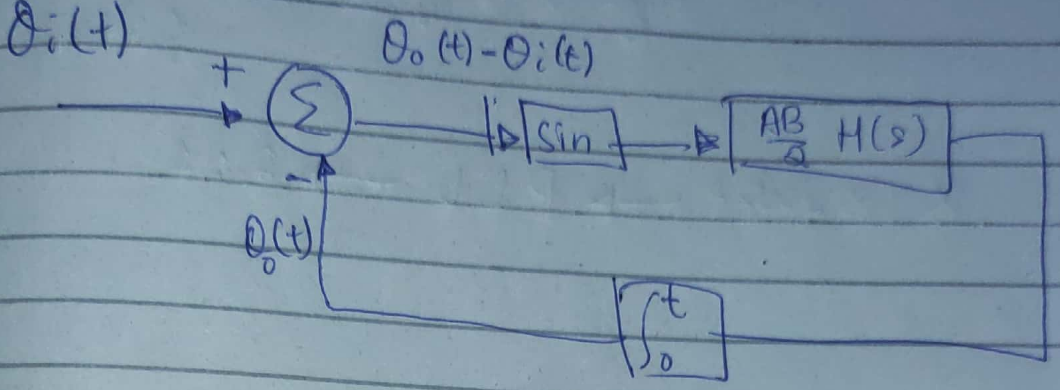
$$\frac{AB}{2}\left[h(t) * \sin[\theta_i(t) - \theta_o(t)]\right]$$

$$C e_o(t) = \frac{AB}{2} \int_0^t h(t-x) \cdot \sin[\theta_i(x) - \theta_o(x)]\, dx$$

Put $C e_o(t) = \dot{\theta}_o(t)$

$$\dot{\theta}_o(t) = \frac{AB}{2} \int_0^t \underline{\hspace{4cm}}\, dx$$

$\theta_o(t) =$



(iii) Squaring Method:-

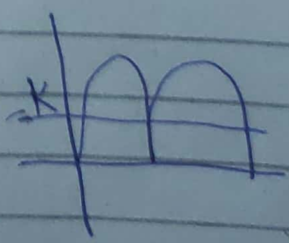
$(m(t))^2 (\cos w_c t)^2$

$$m^2(t) \cdot \left[\frac{1 + \cos(2\omega_c t)}{2}\right]$$

$$\frac{m^2(t)}{2} + \frac{m^2(t)\cos(2\omega_c t)}{2}$$

Let $\frac{m^2(t)}{2} = \underbrace{k}_{\text{Average value}} + \phi(t)$

$\boxed{\text{Average value}}$



$$\frac{m^2(t)}{2} + \frac{\{K + \phi(t)\}\cos(2\omega_c t)}{2}$$

$m(t) \longrightarrow B\ Hz$

$m^2(t) \longrightarrow 2B\ Hz$

$$\frac{m^2(t)}{2} + \frac{K \cos 2\omega_c t}{2} + \frac{\varphi(t) \cos 2\omega_c t}{2}$$

High Quality Q   Narrowband filter

$K \cos 2\omega_c t \longrightarrow PLL \longrightarrow 2:1$

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