Section 4

* Amplitude Modulation - Single side band [SsB] :: [passband B.W = B]

→ It only Sends one Sideband [Either the upper or the lower].

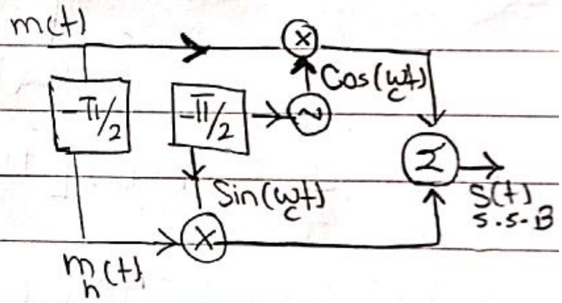
Modulators: ① Selective filtering method: It uses a filter that selects the transmitted sideband.

② phase shift method: It changes the phase of s(t) using hilbert transform

$$S(t) = m(t)\cos \omega_c t \pm m_h(t)\sin(\omega_c t)$$

→ If the ~~first~~ two terms are added → LsB

→ If the two terms are subtracted → usB.



* Amplitude Modulation: Vestigal Sideband :: [VSB] ::

* It Compromises between SsB & DsB in spectrum & power.
  - SsB → Difficult to realize the modulators but power efficient.
  - DsB → Easier to realize the modulators but power inefficient.

* Instead of Sending only one sideband [SsB] or Sending ~~half~~ the two sidebands [DsB], VsB passes one Sideband along with apart of the other Sideband.

Modulators TX

$m(t) \rightarrow \otimes \xrightarrow{ⓐ} \boxed{H_v(f)} \xrightarrow{ⓑ} s(t)$

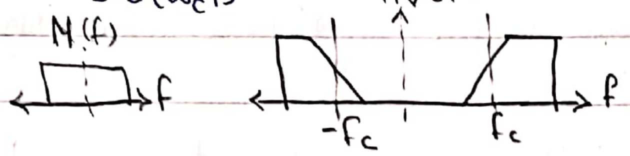
$\uparrow \cos(\omega_c t)$

Recall: $x(t) \rightarrow \boxed{h(t)} \rightarrow y(t)$

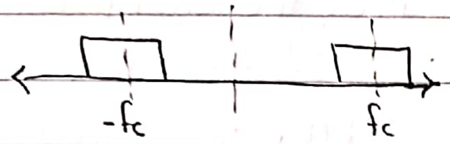
$y(t) = x(t) \circledast h(t)$ Conv.

$y(f) = X(f) \cdot H(f)$ Mult.

Let $\rightarrow M(f)$ be

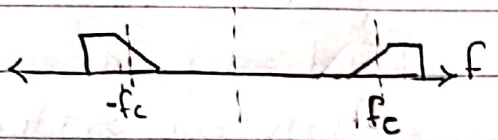


$\rightarrow$ @a:



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

$\rightarrow$ @b:



$\frac{1}{2} H_v(f)[M(f-f_c) + M(f+f_c)]$

DeModulators Rx

$\rightarrow \otimes \xrightarrow{ⓒ} \boxed{LPF} \xrightarrow{ⓓ}$

$\uparrow \cos(\omega_c t)$

$\rightarrow$ @c: $\frac{1}{4} H_v(f-f_c)[M(f-2f_c) + \underline{\underline{M(f)}}] + \frac{1}{4} H_v(f+f_c)[\underline{\underline{M(f)}} + M(f+2f_c)]$

$\rightarrow$ @d: $\frac{1}{4} M(f)[H_v(f-f_c) + H_v(f+f_c)]$.

* $H_v(f-f_c) + H_v(f+f_c) \rightarrow$ must be Constant so that the message doesnot get distorted.

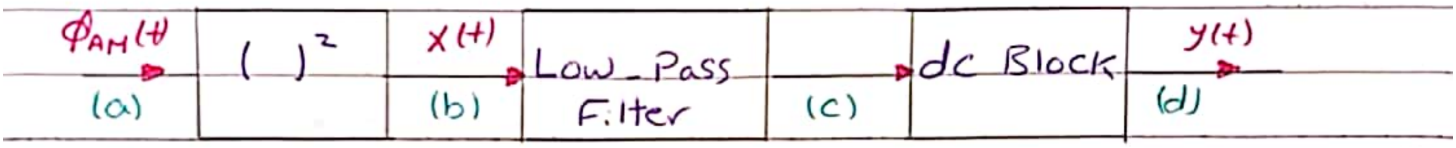
If $[H_v(f-f_c) + H_v(f+f_c)]$ is not Constant, an equalizer should be used. It reverses the effect of the $H_v(f)$.[filter].

So, $H_{v\,\text{Reverse}}(f) = \dfrac{1}{H_v(f-f_c) + H_v(f+f_c)}$ $\leftarrow$ Frequency response of the equalizer

Part Three

Sheet Two Solution

$\boxed{10}$ In The early days of radio, AM signals were demodulated by a crystal detector followed by a low-Pass Filter and a dc blocker as shown in the Figure. Assume a crystal detector to be basically a squaring device. Determine The Signals at Point a, b, c and d. Point out the distortion term in the output $y(t)$. Show That if $A \gg |m(t)|$ the distortion is Small



Solution

at Point (a) $\rightarrow$ $\phi_{AM}(t) = [A + m(t)] \cos(w_c t)$

at Point (b) $\rightarrow$ $(\phi_{AM}(t))^2 = [A^2 + 2A m(t) + m^2(t)] * \frac{1}{2} * (1 + \cos 2w_c t)$

at Point (c) $\rightarrow$ $\frac{1}{2}[A^2 + 2A m(t) + m^2(t)]$

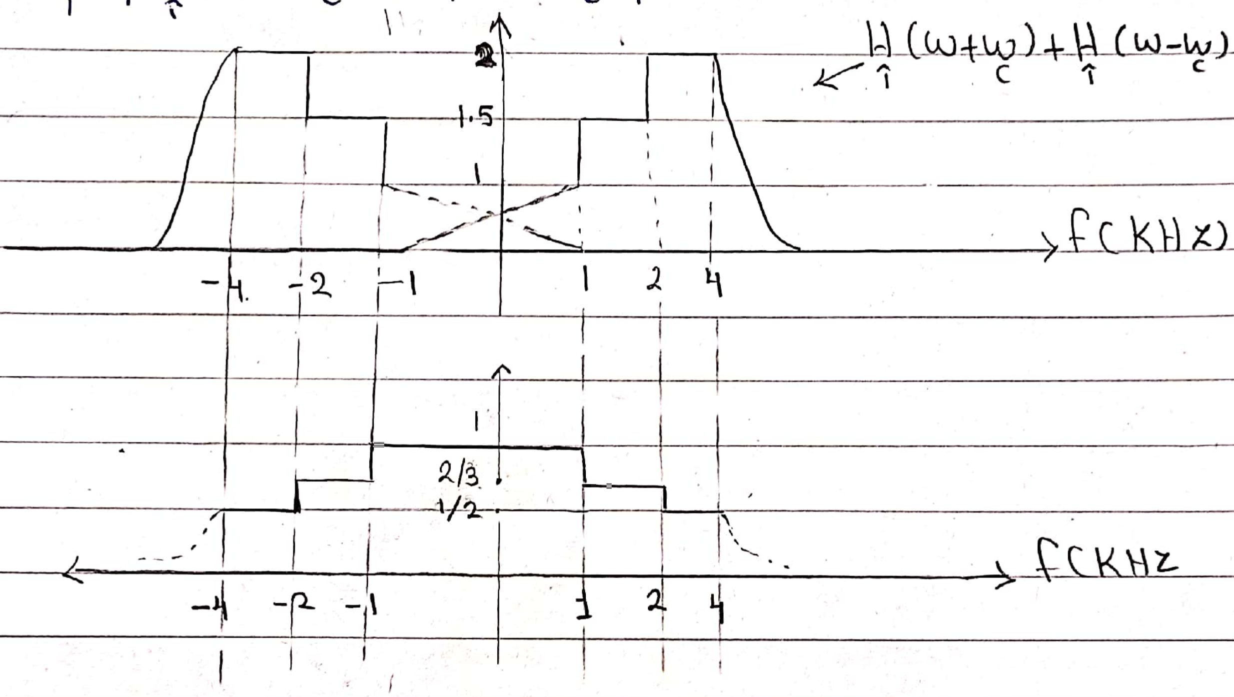
at Point (d) $\rightarrow$ $y(t) = \frac{1}{2}[2A m(t) + m^2(t)] = [m(t) + \frac{m^2(t)}{2A}]$

$\because A \gg |m(t)| \quad \therefore \frac{|m(t)|}{A} \ll 1$

$\therefore y(t) \simeq A\, m(t)$

$\rightarrow$ We see that the distortion Component $\frac{m^2(t)}{2}$

$\boxed{11}$ $$H_0(\omega) = \frac{1}{LPF\{H_{\hat{\imath}}(\omega+\omega_c) + H_{\hat{\imath}}(\omega-\omega_c)\}}$$ where $|\omega| \leq 2\pi B$.



∴ Message Baseband BW = 4 KHz.

∴ Insert LPF after the equalizer with $f_c = 4$ KHz

Note To make sure that you successfully obtained $H_0(\omega)$, Multiply $H_0(\omega)$ by $[H_{\hat{\imath}}(\omega+\omega_c)+H_{\hat{\imath}}(\omega-\omega_c)]$. It should give 1 [Constant].