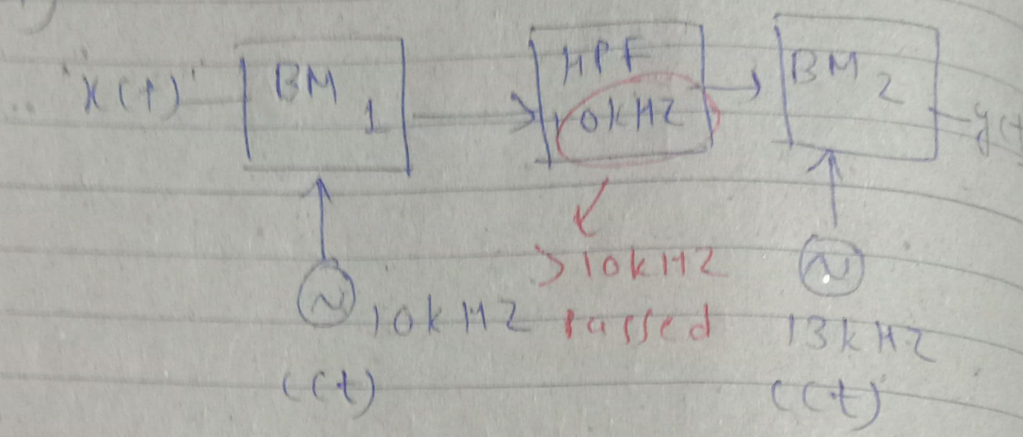
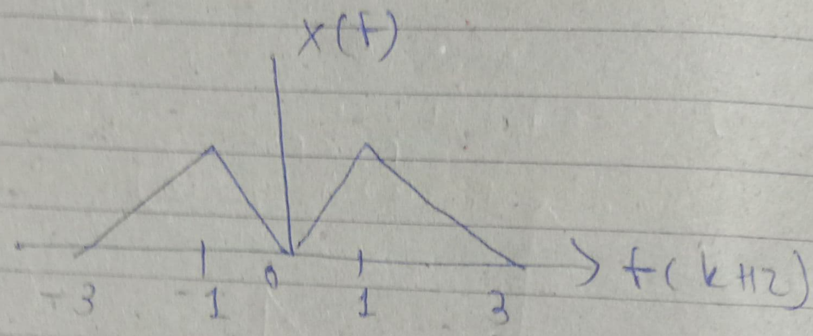
Lec 10 (Demodulation Techniques)

Q1)



Spectrum of x(t) is:



Find out the positive frequencies where Y(f) has peaks?

Soln:

$y(t) \leftrightarrow Y(f)$

$X_f = \begin{matrix} 1\,kHz \\ -1\,kHz \end{matrix}$ > Peaks

Balanced modulator $= x(t)\,c(t)$

$\omega_c \pm \omega_m \quad -\omega_c \pm \omega_m$

O/P of $BM_1 = x(t)\, c(t)$

10 KHZ

= frequencies added & subtracted

f ~~10 ± 1 KHZ~~ 10 KHZ ± 1 KHZ

10 KHZ ± (−1 KHZ)

peaks

= 11 KHZ; 9 KHZ

9 KHZ, 11 KHZ

HPF (>10 KHZ)

11 KHZ passed

O/P of $BM_2 = y(f) = 13\text{ KHZ} \pm 11\text{ KHZ}$

= 24 KHZ

OR

2 KHZ

Peaks

Ans

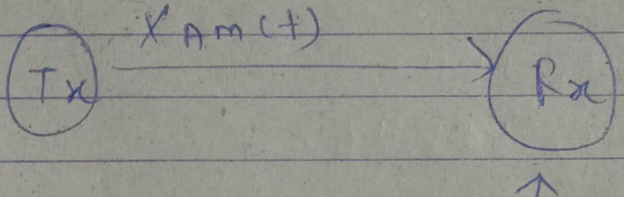
Tx = Transmitter
Rx = Receiver

Amplitude modulation

↳ DSB-C (conventional AM)
⇓
$x_{AM}(t) = c(t) + m(t)c(t)$

↳ DSB-SC
↳ only 2SB $(m(t)c(t))$

↳ SSB-SC = only 1SB, carrier suppressed



Demodulation takes place here

DEMODULATION/DETECTION OF AM SIGNALS

① Envelope detection (Asynchronous / non-coherent detector)

② Synchronous / coherent detection

③ Square law detector

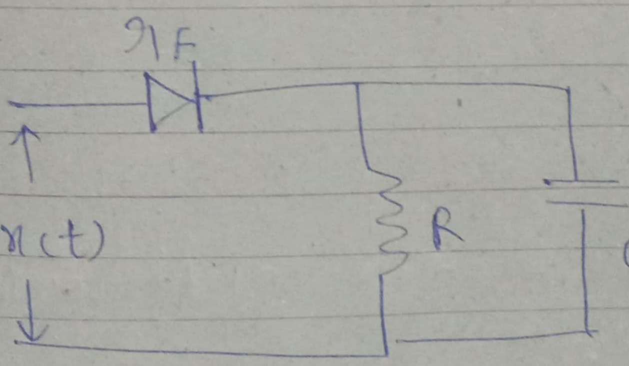
ENVELOPE DETECTION

→ used for conventional AM type of signal

→ non-coherent / Asynchronous
(does not require carrier signal at the receiver for detection)

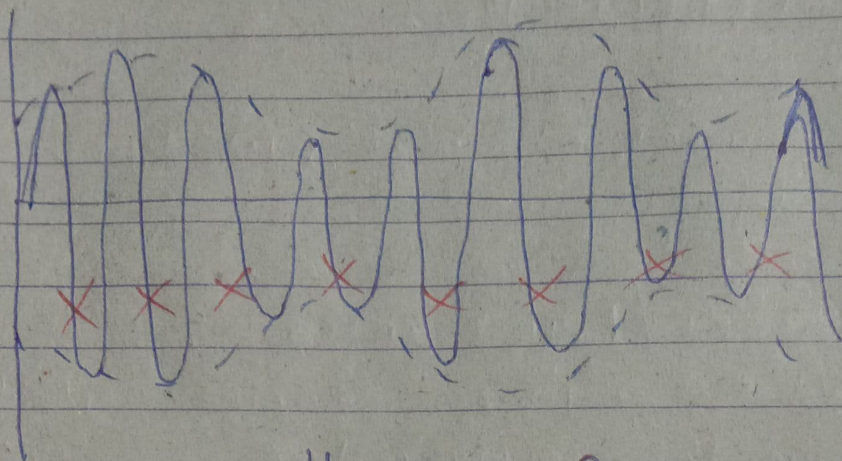
✓ since carrier signal already present in $X_{Am}(t)$

CIRCUIT:

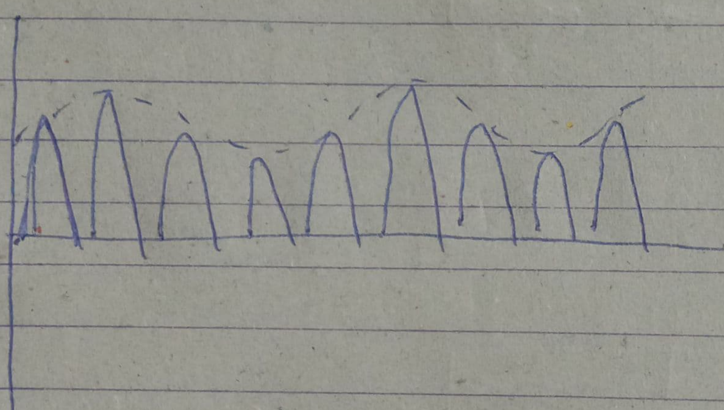


Envelope detector

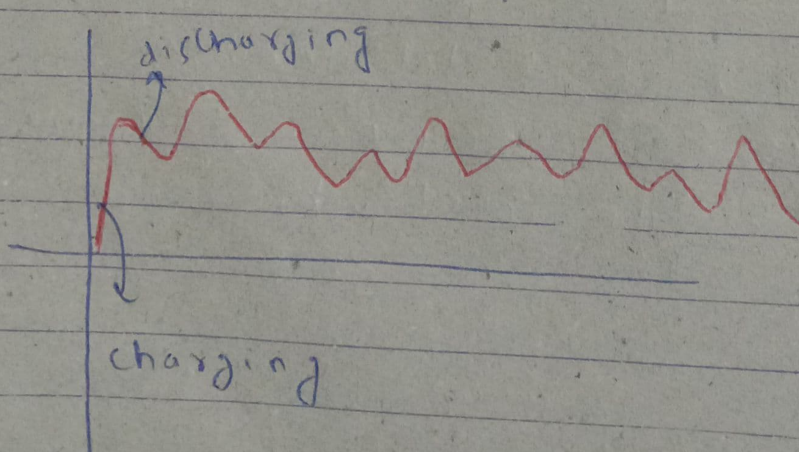
* Simple & cheap detector
* consists of unexpensive discrete elements like diode, R, C.



diode (all negative polarities removed)

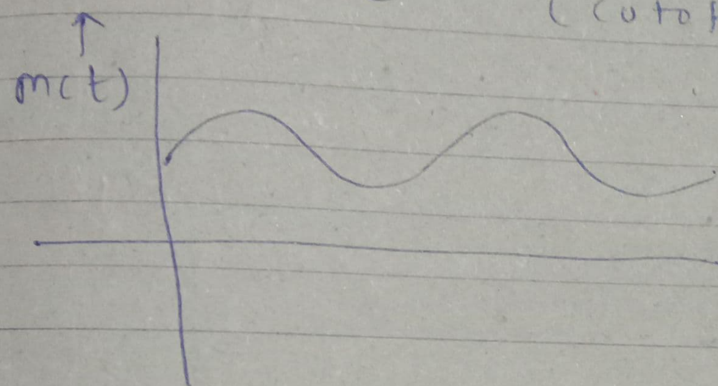


RC = charging / discharging circuit



charging / discharging = leads to distorted envelope consisting of high frequency components

$\Downarrow$ LPF (cutoff = ω_m)



CHARGING TIME CONSTANT

r_f = forward bias resistance

charging through route Diode → C

$\tau_{charging} = r_F C$

$$\boxed{r_F C << \frac{1}{f_c}}$$

DISCHARGING TIME CONSTANT

$$\tau_{discharge} = R \times C$$

discharging through path = $C \rightarrow R$

This cannot be too low / too high to properly detect the envelope.

It should be moderate

$$RC \gg \frac{1}{f_c}$$

$$RC \ll \frac{1}{f_m}$$

$$\boxed{\frac{1}{f_c} \ll RC \ll \frac{1}{f_m}}$$

If not this, then discharge very quickly, may lead to distorted envelope

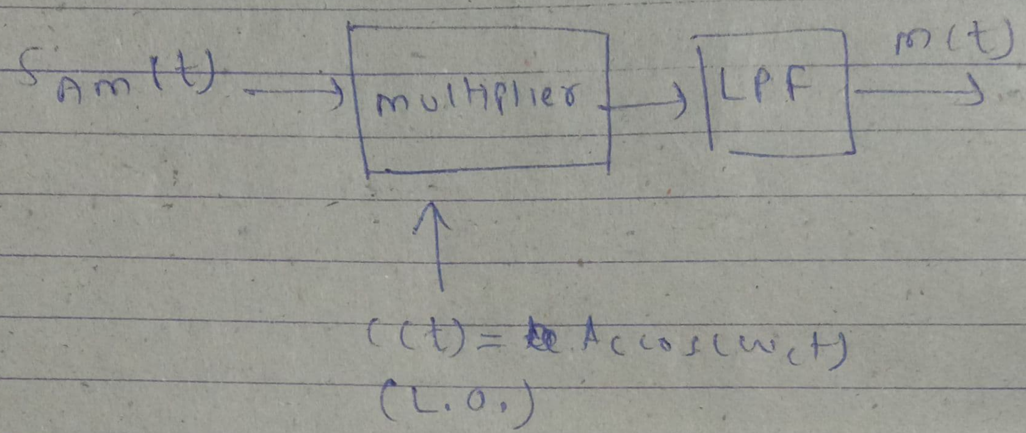
* DSB-C / conventional Am used for ~~broa~~ broadcasting since detection technique very cheap

~~* recur~~

Lec11 (Demodulation techniques)

SYNCHRONOUS DETECTION

(Locally generated carrier signal reqd.)



* $c(t)$ should be perfectly synchronized in phase & frequency to the $c(t)$ at the transmitter end

* generation of carrier signal = complex task

ANALYSIS

Case 1: Perfect synchronization of $c(t)$

$$S_{Am}(t) = A_c \cos(\omega_c t) + A_c m(t) \cos(\omega_c t)$$

$\cos(\omega_c t) = 2\cos^2(\omega_c t) - 1$

$2\cos(\omega_c t) =$

$$S_{AM}(t) \times c(t) = \left[A_c \cos(\omega_c t) + A_c m(t) \cos(\omega_c t)\right]$$

$$A_c \cos \omega_c t$$

$$= A_c^2 \cos^2(\omega_c t) + A_c^2 m(t) \cos^2(\omega_c t)$$

$$\cos(2\omega_c t)$$

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

$$(1 + \cos(2\omega_c t))$$

$\downarrow$ LPF (ω_m)

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

$$\frac{A_c^2 m(t)}{2}$$

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

$\frac{A_c^2 m(t)}{2}$ $\Rightarrow$ required signal $= m(t)$
we are getting
scaled version
of $m(t)$, scaling
factor can be removed.

$L.O.\ c(t)$ = Locally generated carrier signal

Case 2:

$$L.O.\ c(t) = A_c \cos(\omega_c t + \phi)$$

$$S_{AM}(t) \times A_c \cos(\omega_c t + \phi)$$

$$= \left(A_c \cos(\omega_c t + \phi)\ \cancel{m(t)} + A_c\, m(t) \cos(\omega_c t + \phi)\right)$$

$$A_c \cos(\omega_c t + \phi)$$

$$\Big\Downarrow \text{LPF}$$

$$\left(\frac{A_c^2}{2} m(t)\right) \cos\phi$$

→ distortion in demodulated signal ~~varies~~ varied in accordance to ϕ

↓ scaled factor of $m(t)$

if $\phi = 90^\circ$,

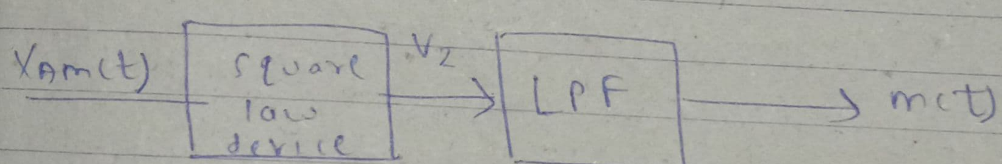
$\cos 90^\circ = 0$, hence total loss of signal.

This condition is called Quadrature null effect

Quadrature → orthagonal phase

null effect → total loss of $m(t)$

SQUARE LAW DETECTOR



$$V_2 = a_1 X_{Am}(t) + a_2 [X_{Am}(t)]^2$$

$\Downarrow$ LPF

eliminates all high frequency components & keeps lower frequency

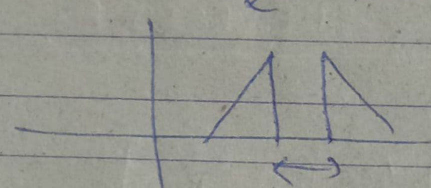
$$\boxed{LPF_{out} = \frac{a_2^2 A_c^2}{2} m(t)}$$

VSB = vestigial side band modulation

SSB-SC = best in case of Power efficiency & Transmission efficiency

demodulation circuit is complex.

limited to voice-signal



f_c

sufficient guard band between USB & LSB, so easier to detect

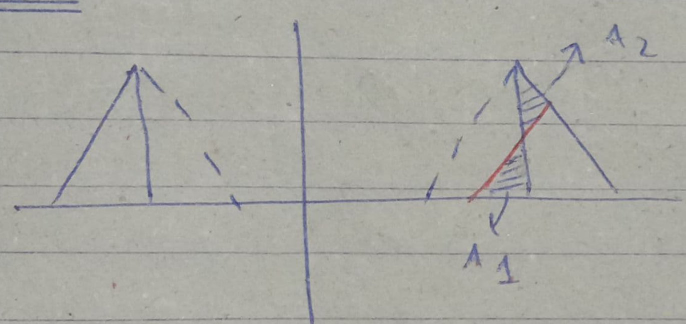
VSB = variation of SSB-SC

VSB

① B.W requirement is almost same as the bandwidth of SSB-SC and also allows video signal transmission

* freq. range = 4.5 MHZ
* no guard band between sidebands

② VSB

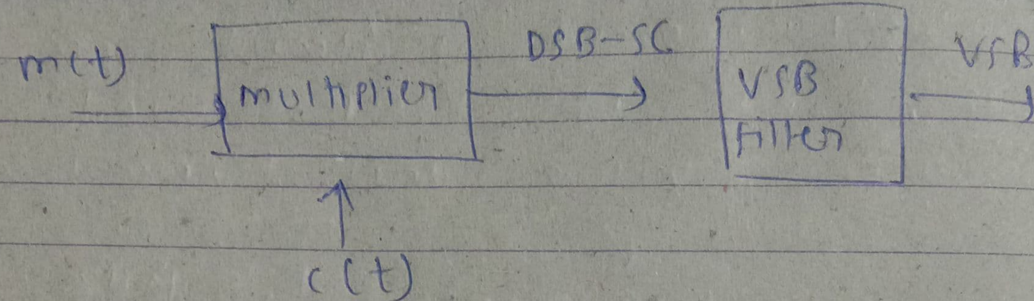


area A_1 = area A_2

* small part of vestige unwanted ~~REAR~~ sideband added & equal amount of desired sideband subtracted. so no loss of information

* helps us to use practical filtering process.

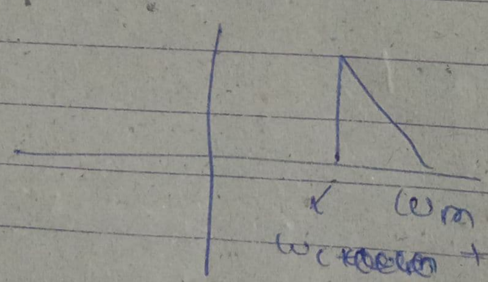
GENERATION OF VSB



Bandwidth requirement

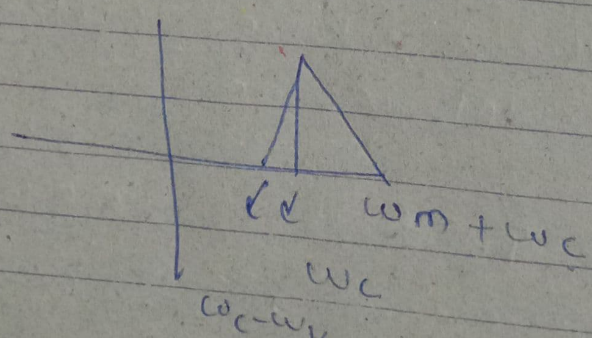
DSB-C & DSB-SC $(2\omega_m)$ > VSB > SSB-SC (ω_m)

but slight difference



$BW = \omega_m$

$= SSB-SC$



$BW = \omega_m + \omega_v$

$\omega_v = small$

Power requirement

DSB-C > DSB-SC > (VSB & SSB-SC)

Power = same

∴ VSB-SC = efficient technique