③ SSB Moudulation: (single side Band Mod.).

→ The BW of the AM and DSB signal is same. In order to multiplex more number of signal the BW of the signal should be as Low as possible. So, in this method only one side Band is transmitted through the channel.

→ $A_c m(t) . \cos 2\pi f_c t$

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

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

⇒ Time domain signal of SSB is,

$$\boxed{\frac{A_c A_m}{2} \cos 2\pi t (f_c \pm f_m)} \swarrow H.B.$$

$+ \rightarrow$ USB

$- \rightarrow$ LSB.

$$\Rightarrow \frac{A_c A_m}{2} \cos 2\pi f_m t . \cos 2\pi f_c t \mp \frac{A_c A_m}{2} \sin 2\pi f_m t . \sin 2\pi f_c t .$$

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

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

= Hilbert transform.

$$\rightarrow \boxed{\frac{A_c}{2} m(t) \cos 2\pi f_c t \mp \frac{A_c}{2} \hat{m}(t) \sin 2\pi f_c t.}$$

H.B

$-$ → USB

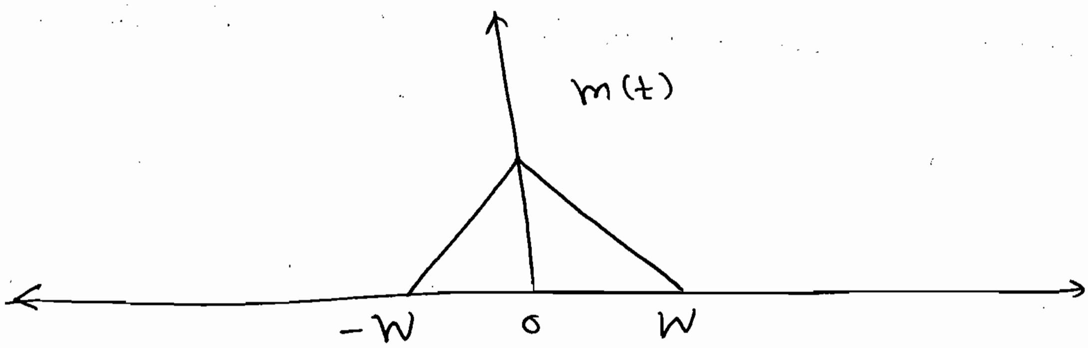
$+$ → LSB.

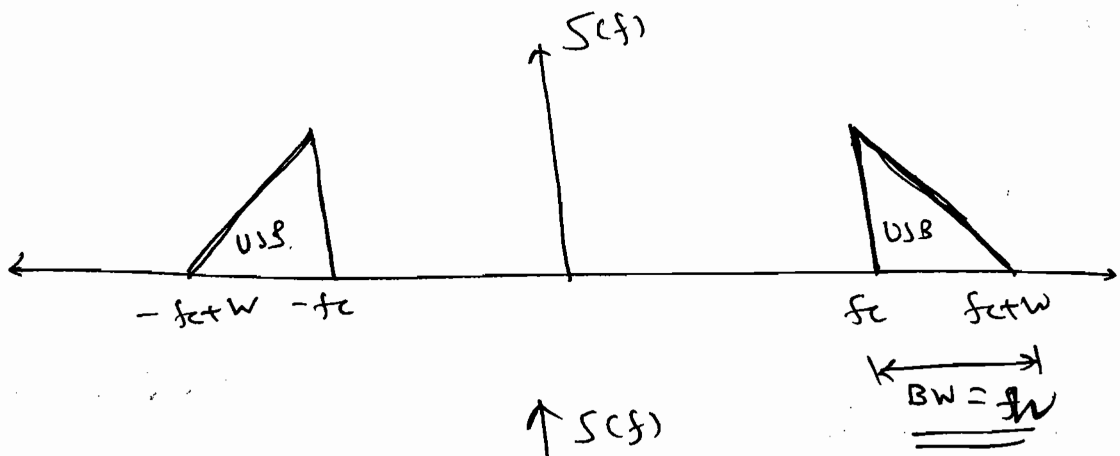
* Power Calculation:

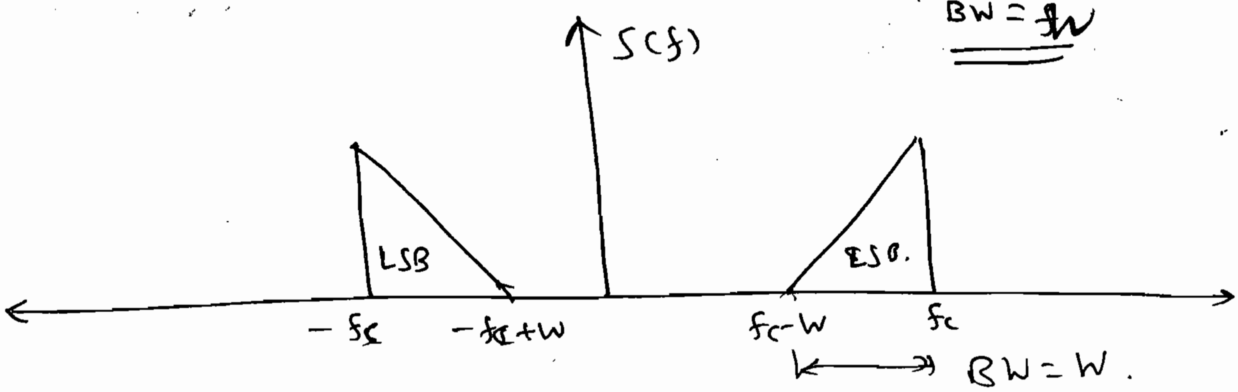
$$\Rightarrow \quad P_t = \frac{A_c^2 A_m^2}{4R}.$$

$$P_t = \underbrace{\frac{A_c^2 A_m^2}{8R}}_{USB} + \underbrace{\cancel{\frac{A_c^2 A_m^2}{8R}}}_{LSB}$$

$$\therefore \quad \boxed{P_t = \frac{A_c^2 A_m^2}{8R}.}$$ ← H.B.





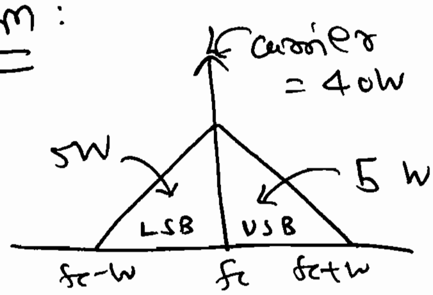


→ The BW & Power are decreasing by 50% when compared with the DSB signal.

⇒ When DSB modulation replace with SSB modulation then the power saving is 50%.

(*)

① **Am :**



BW = 2fm

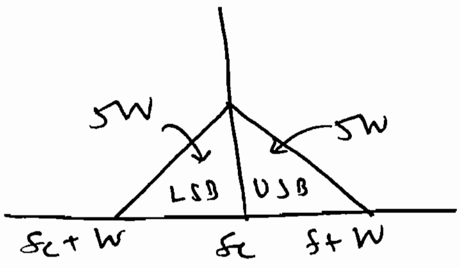
$P_t = 50W = 40W + 5W + 5W$

80%   10%   10%

$\mu = 0.707$

$\eta = 20\%$

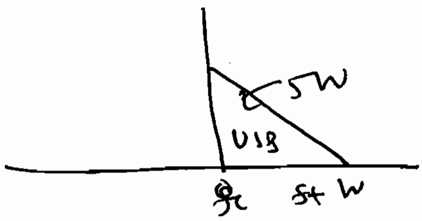
② **DSB :**



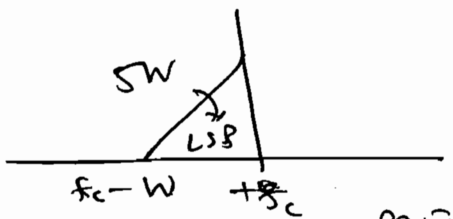
BW = 2fm

$P_t = 10W = 5W + 5W.$

③ **SSB :**



$P_t = 5W.$



BW = fm

* Power Saving: ← H.B

Case-(i): AM to DSB:

$$\therefore \text{Power Saving } (\%) = \frac{\text{Power saved}}{\text{Total power}} \times 100\%$$

$$= \frac{40}{50} \times 100\%$$

$$= \frac{P_c}{P_t} \times 100\%$$

$$= \frac{\cancel{P_c}}{\cancel{P_c}\left[1+\frac{\mu^2}{2}\right]} \times 100\%$$

$$\boxed{\text{Power saving}(\%) = \frac{2}{\mu^2+2} \times 100\%}$$

Case-(ii): AM to SSB.

$$\therefore \text{Power Saving } (\%) = \frac{\text{Power saved}}{\text{total Power}} \times 100\%$$

$$= \frac{40+5}{50} \times 100\%$$

$$= \frac{P_c + \frac{P_c\mu^2}{4}}{P_c\left[1+\frac{\mu^2}{2}\right]} \times 100\%$$

$$\boxed{\text{Power Saving } (\%) = \left[\frac{1+\frac{\mu^2}{4}}{1+\frac{\mu^2}{2}}\right] \times 100\%}$$

Case-(iii): DSB to SSB %.

$$\Rightarrow \boxed{\text{Power saving} = \frac{5}{10} = 50\%}$$

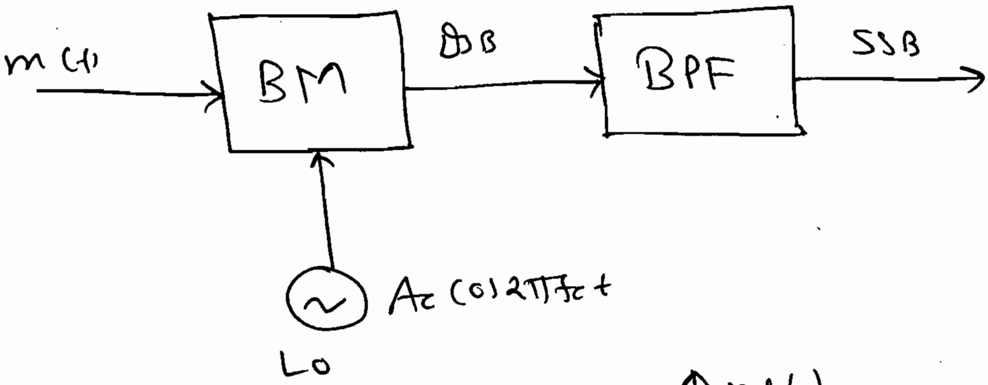
* Generation of SSB signal:

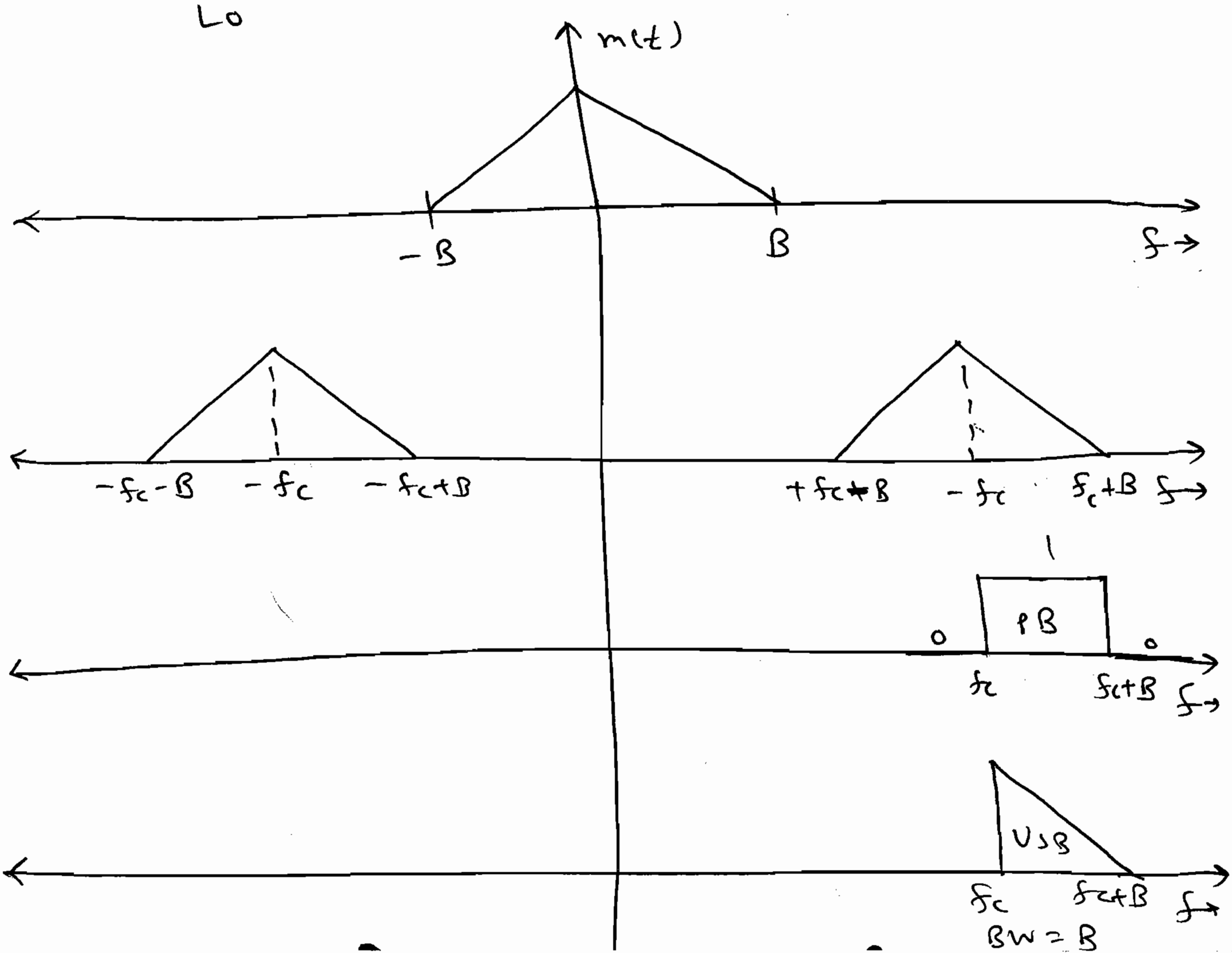
① Frequency discrimination method (or)

(Filtered method)

② Phase discrimination method: H.B.

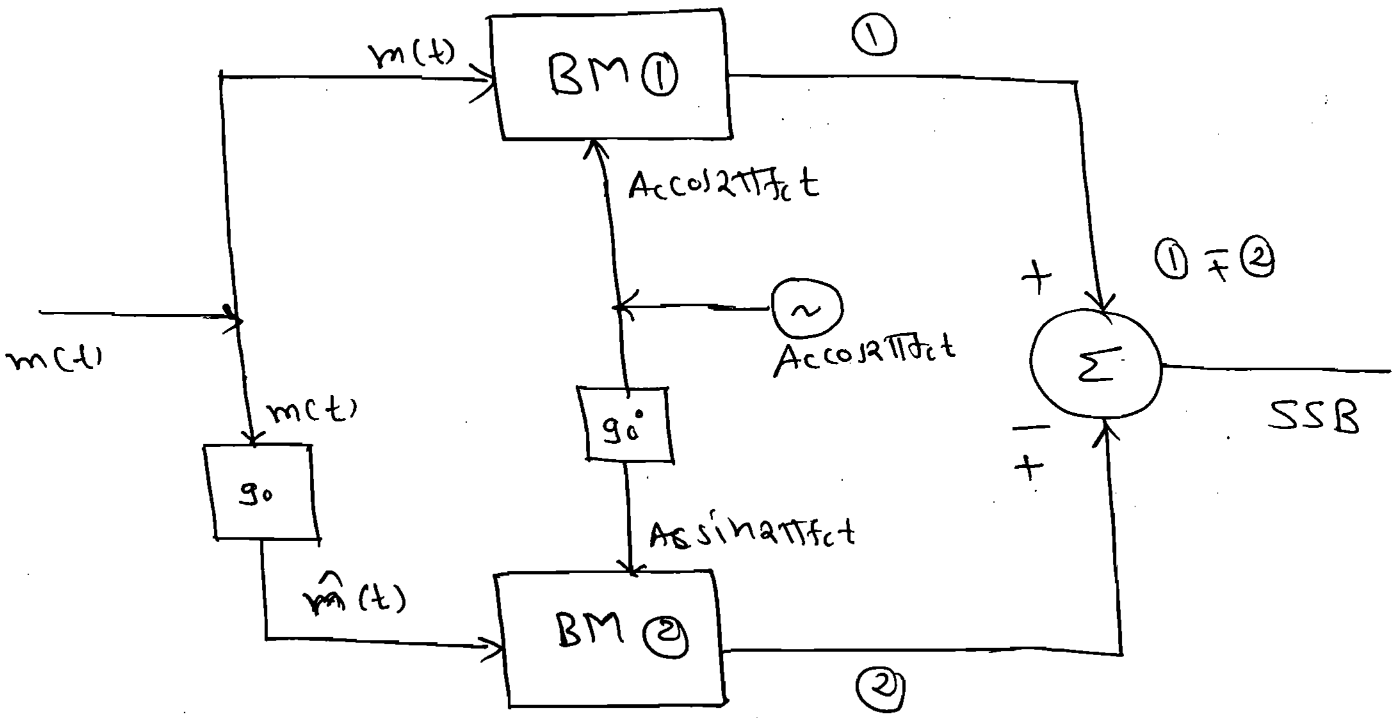
① Frequency discrimination method:





② Phase Discrimination Method :-

$\Rightarrow$ $S(t) = \frac{A_c}{2} \cdot m(t) \cos 2\pi f_c t \mp \frac{A_c}{2} \cdot \hat{m}(t) \cdot \sin 2\pi f_c t.$



disadvantges

$\Rightarrow$ Hardware Complexity is very high.

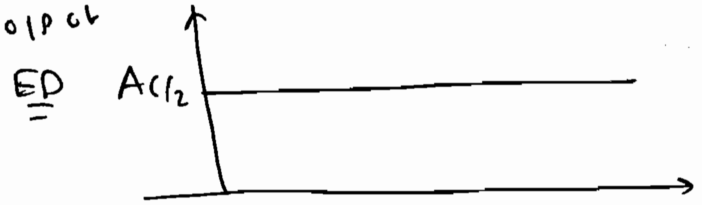
* Demodulation of SSB signals:

$\Rightarrow$ SSB → ED → $O/P = \sqrt{\left(\frac{A_c}{2} m(t)\right)^2 + \left(\frac{A_c \hat{m}(t)}{2}\right)^2}$.

let, $m(t) = \cos 2\pi f_m t.$

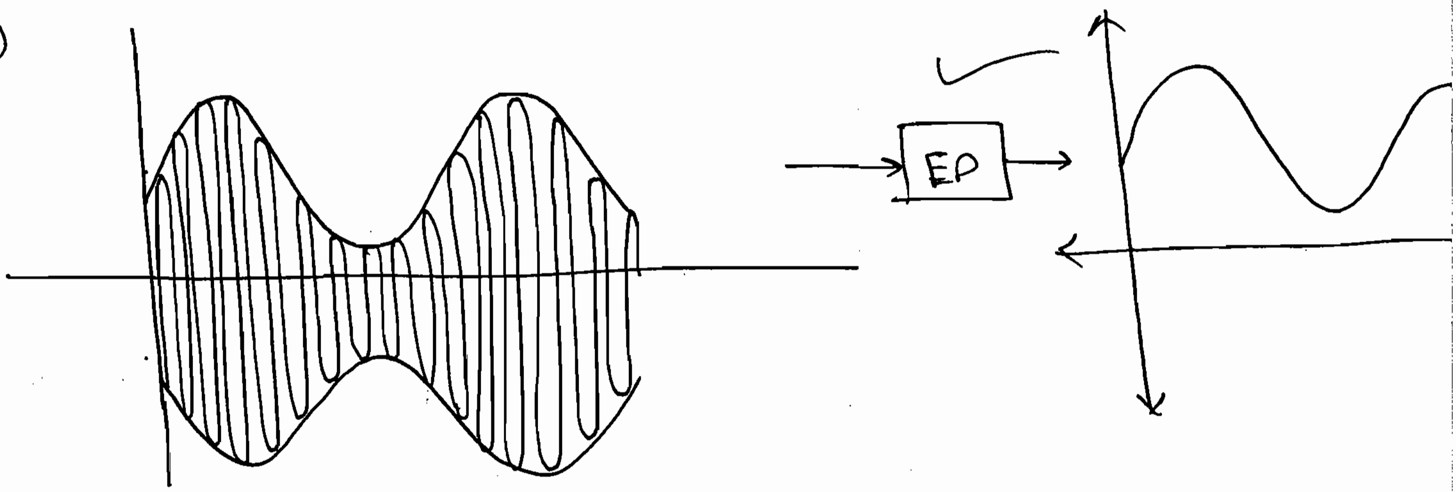
$\therefore O/P = \left(\frac{A_c^2}{4} \cos^2 2\pi f_m t + \frac{A_c^2}{4} \cdot \sin^2 2\pi f_m t\right)^{1/2}$

$O/P = \frac{A_c}{2}.$

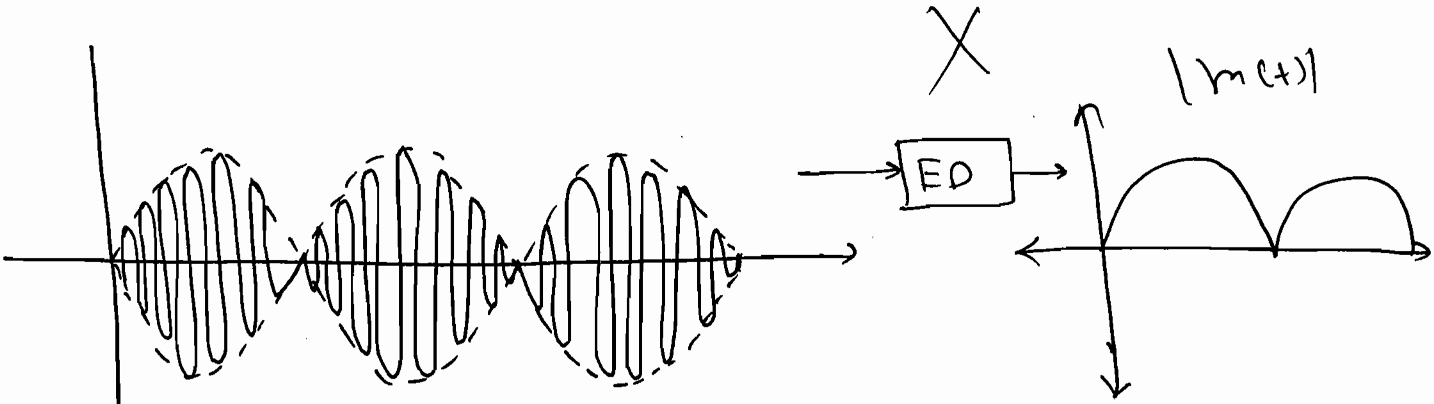


$\Rightarrow$ When the $m(t) = \cos 2\pi f_m t$. The o/p of a envelope detector is constant. So, ED is not used as demodulation for SSB.

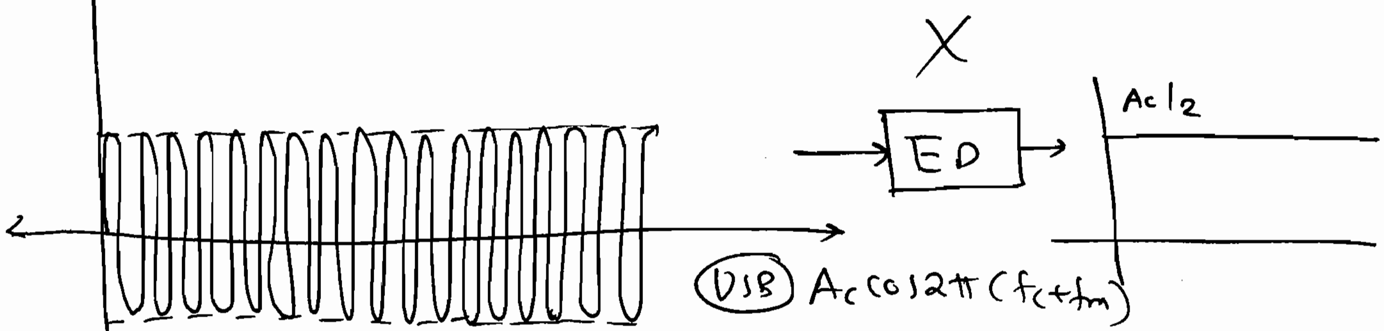
(1)



(2)

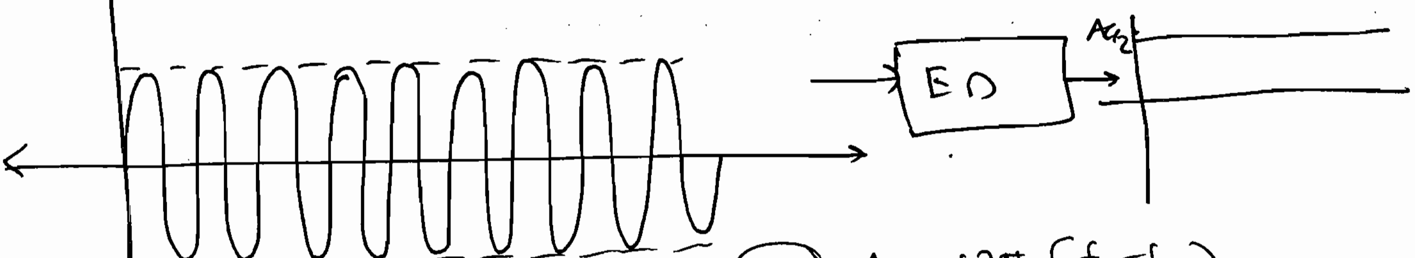


(3)



(USB) $A_c \cos 2\pi (f_c + f_m)$

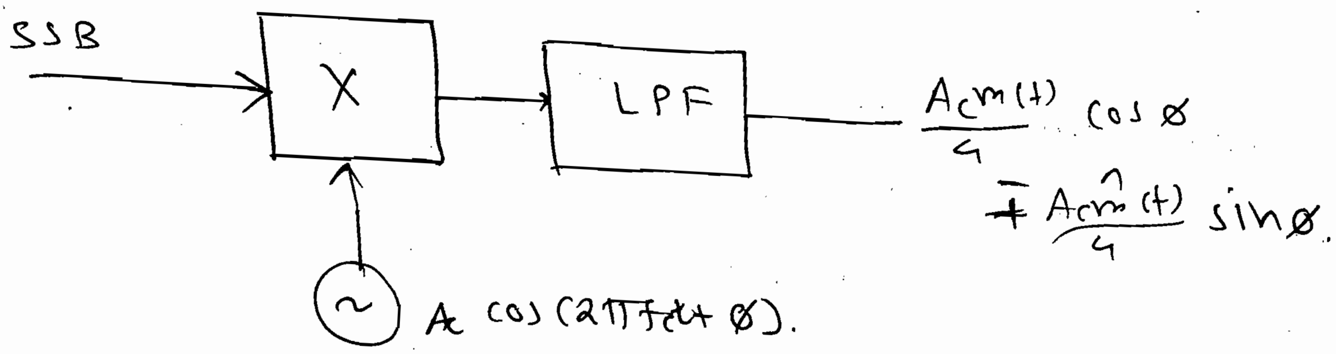
(4)



(LSB) $A_c \cos 2\pi (f_c - f_m)$.

* Synchroneous Demodulator:

✓ H.B.



$\Rightarrow$ O/P of Multiplier:

$$\frac{A_c^2}{2} m(t) \cdot \cos^2 2\pi f_c t \mp \frac{A_c^2}{2} \hat{m}(t) \cdot \cos 2\pi f_c t \cdot \sin 2\pi f_c t$$

$$= \frac{A_c^2}{4} m(t) + \cancel{\frac{A_c^2 m(t)}{4} \cos 2\pi (4 f_c) t} \mp \cancel{\frac{A_c^2}{4} \hat{m}(t) \sin 4\pi f_c t}$$

$$\mp \cancel{\frac{A_c^2}{4} \hat{m}(t) \cdot (0)}.$$

$\Rightarrow$ O/P of LPF

$$O/P = \frac{A_c^2}{4} m(t).$$

if there is phase shift of ϕ then

$$\boxed{O/P = \frac{A_c^2}{4} m(t) \cos\phi \mp \frac{A_c^2}{4} \hat{m}(t) \cdot \sin\phi.}$$

$\Rightarrow$ When $\phi = 0°$ $\Rightarrow$ $\frac{A_c^2}{4} m(t).$

$\phi = 90°$ $\Rightarrow$ $\frac{A_c^2}{4} \hat{m}(t).$

here, No Quadrature null effect.

⇒ When the Phase Shift is betn 0° and 90° the o/p of the demodulator are m(t) and $\hat{m}(t)$ and demodulation is not possible. So, Synchronization required betn Tx and Rx.

* **Advantages of SSB over DSB.** ✓ M.B

① BW is reduced by 50 %.

② Required power for same distance is reduced by 50 %.

③ No Quadrature null effect. ✓

* **Disadvantages of SSB:**

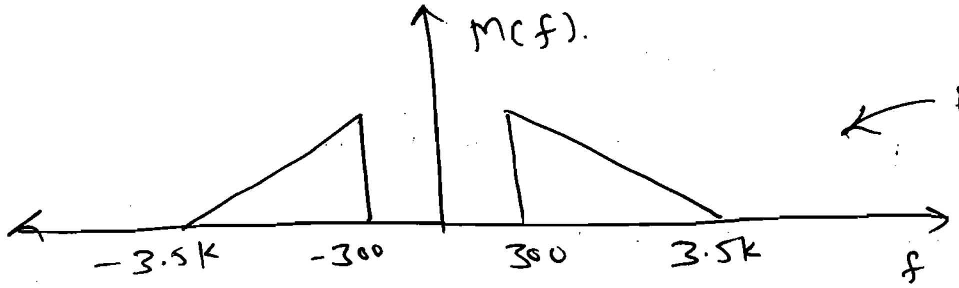
→ As the Practical filter do not have sharp cut-off freq., It is not possible to suppress one side-Band completely.

* **Application: (Most imp Concept):**

⇒ SSB modulation is suitable only for the transmission of Voice signals only.

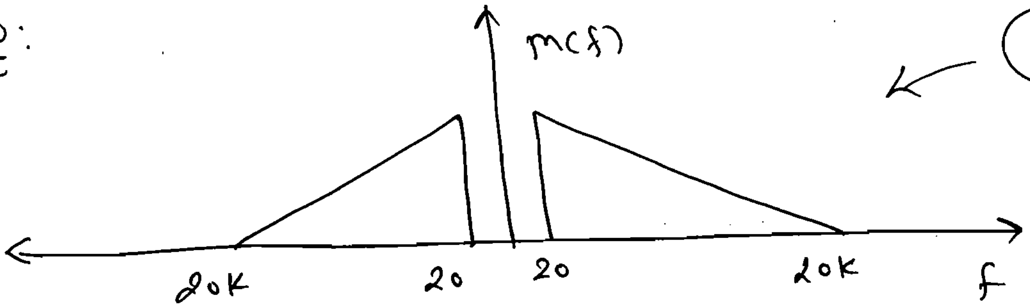
e.g. telephone System.

① Voice:



SSB

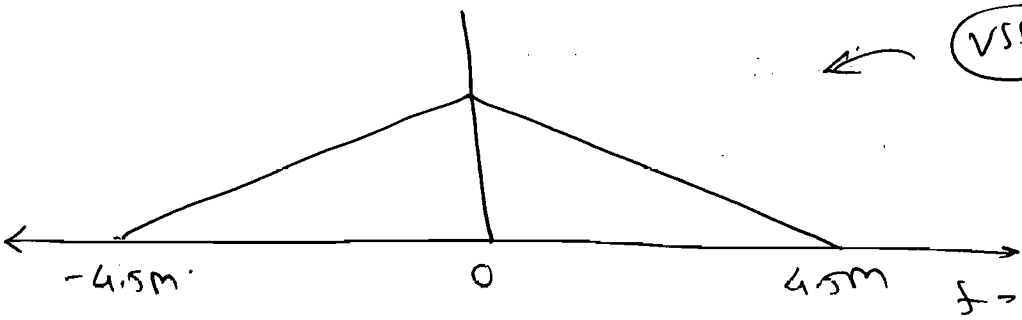
② Audio:



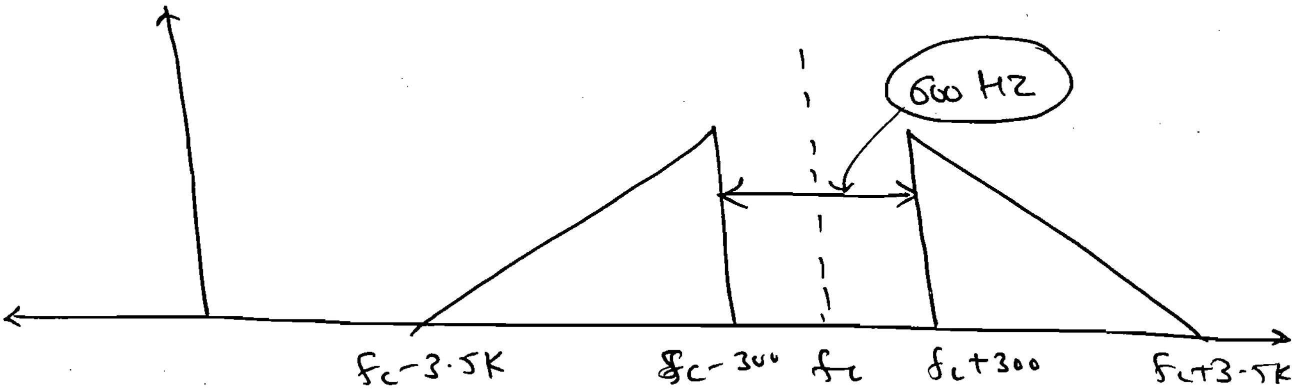
AM &

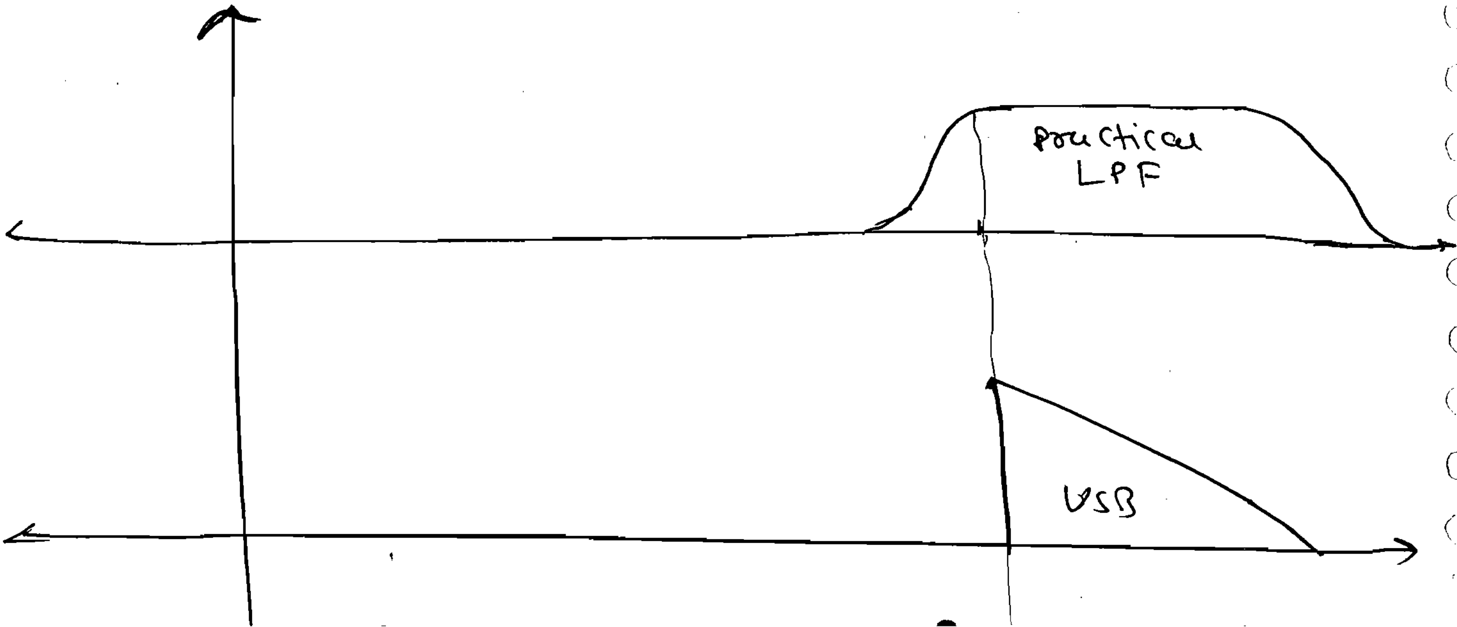
FM

③ Vedio:



VSB

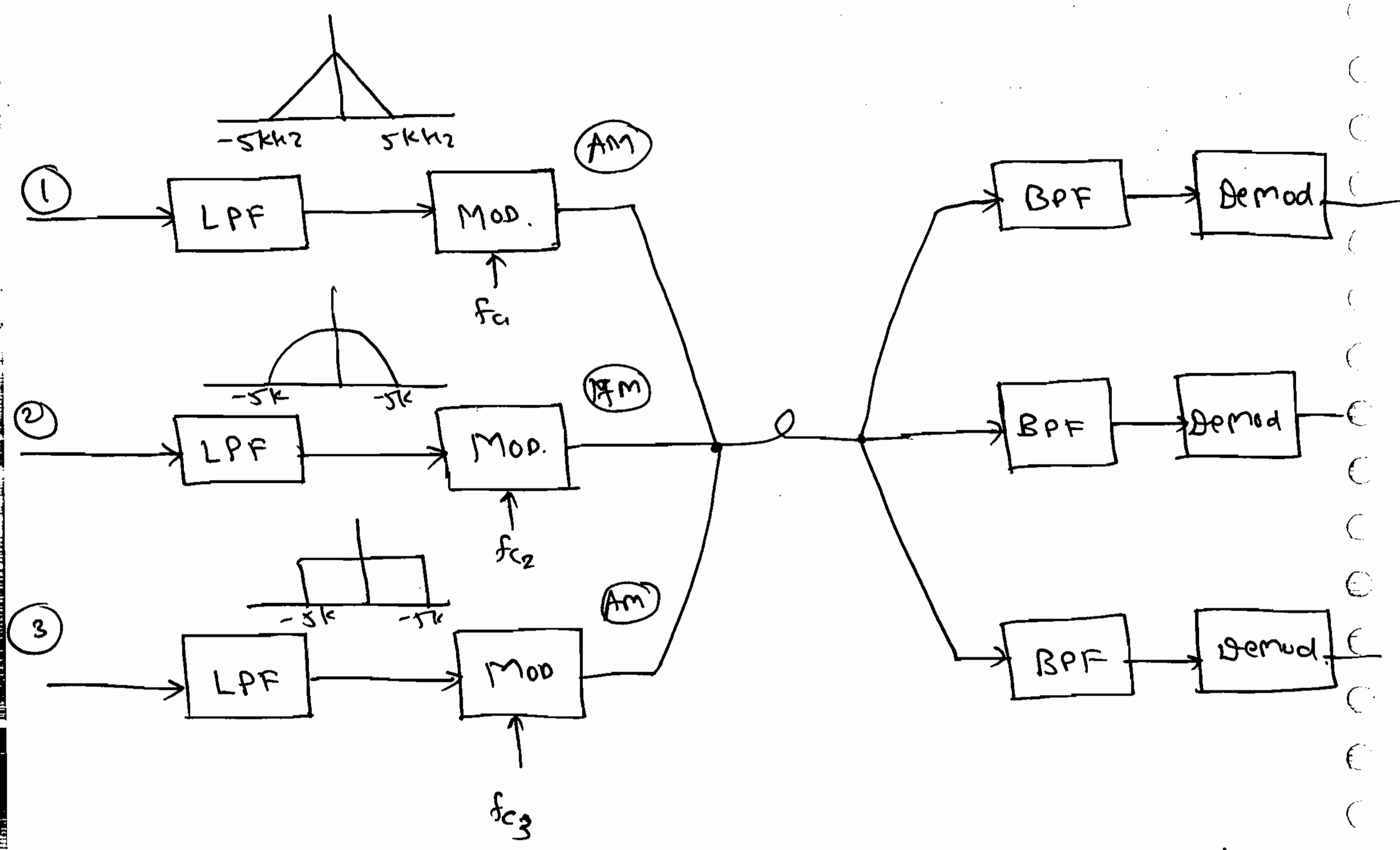




⇒ In the case of voice transmission a spectrum gape of 600 Hz is existing betn USB and LSB. So, it is possible to eliminate one side band completely. even though filter is not having sharp cut-off frequency.

* Frequency Division Multiplexing (FDM):

⇒ Transmission of more than one signal through same ~~transmission~~ ~~line~~ Communication channel is called as Multiplexing.

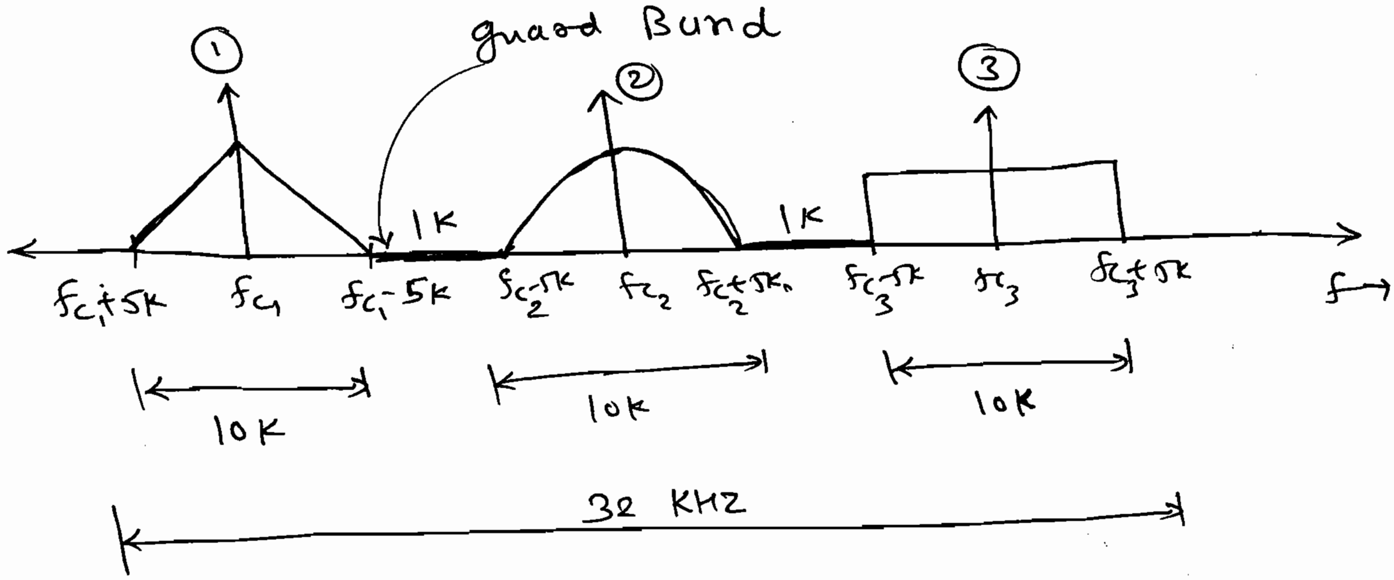


⇒ The LPFs are used to eliminate the insignificant high frequencies and cut-off freq. depends on the application.

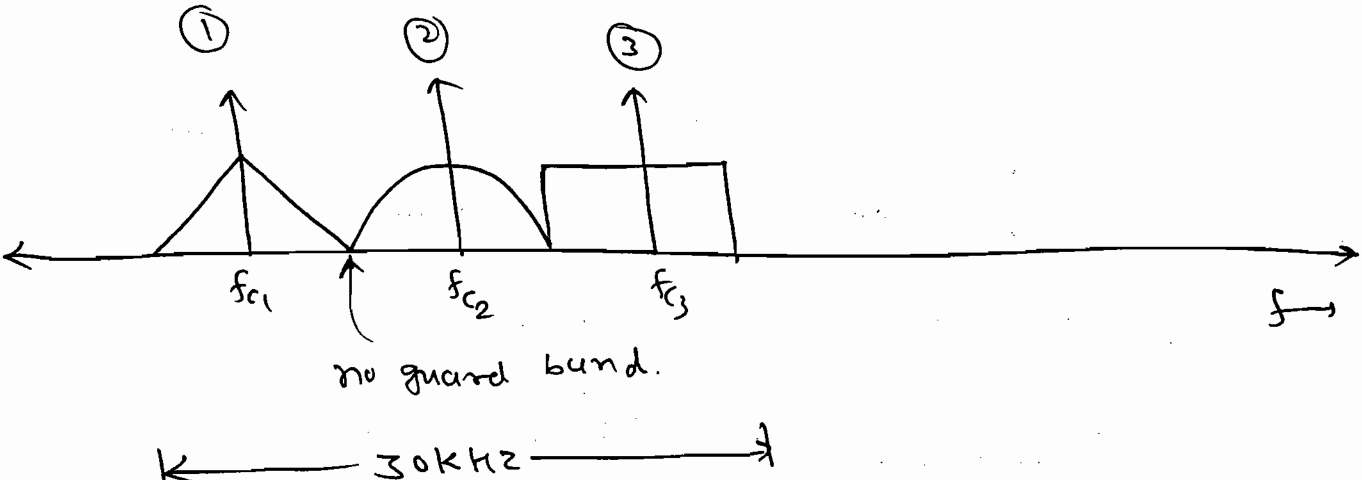
→ Assume that all the signals are band-limited to 5 KHZ.

⇒ Assuming all modulators as AM, the spectrum of the multiplexed signal is as shown in fig.

=>



=>



=> Practically guard band is required. Because BPF will not sharp cut-off frequencies.

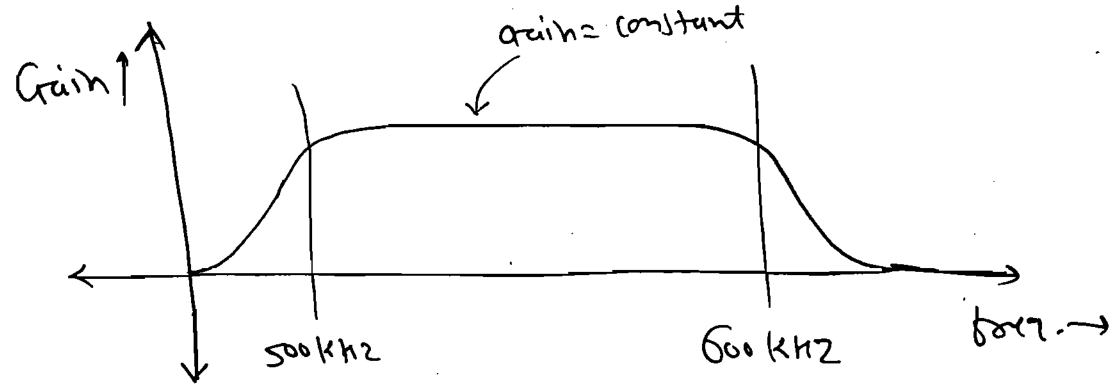
→ Bandpass filters are used at the receiver to select the required signal.

→ The no. of signals which can be multiplexed through a channel is depends on the channel B.W. & signal B.W.

=> Channel BW is defined as the range of freqs. that the channel is capable of transmitting without distortion.

⇒ In order to multiplexed more no. of signals; Channel BW should be as high as possible and signal BW should be as low as low possible.

⇒ For Channel BW.



Freq. response of Channel.

⇒ To transmitt a signal without any distortion the gain of the channel should be constant. For an ideal Channel the gain is constant from 0 to ∞.

⇒ In order to transmit a signal without any distortion BW of Channel should be greater than the BW of the signal.

⇒ Twisted Pair → 500 kHz ← Means the gain of Channel is remain constant through range of 500 kHz frequencies.

Coaxial Cable → 500 MHz.

FOC → GHz.

Ex-1: 10 signals are band limited to 5 KHz are transmitted through a channel after modulation using FDM, the guard band is 2 KHz. Determine the B.W. of the multiplexed signal.

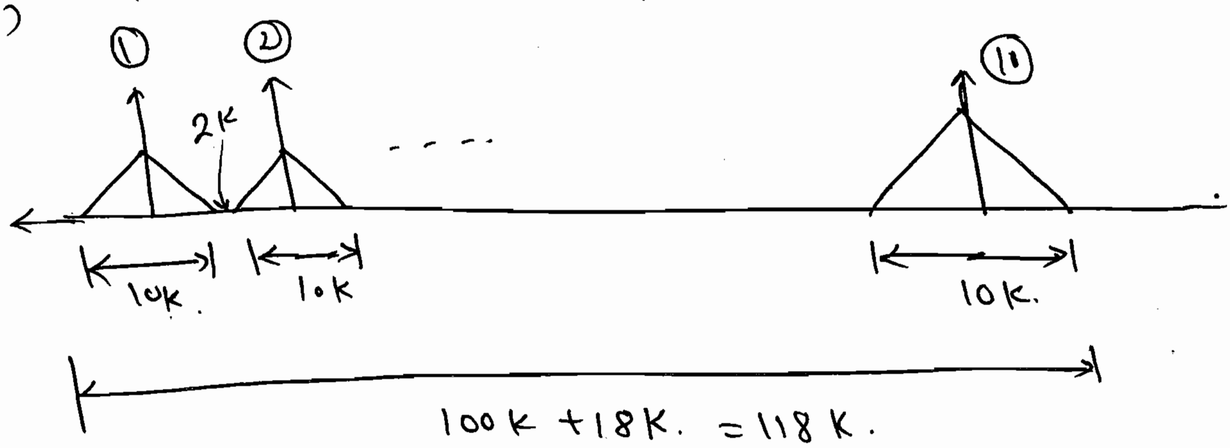
i) If all Modulators are AM.

ii) If all Modulators are DSB.

iii) If all Modulators are SSB.

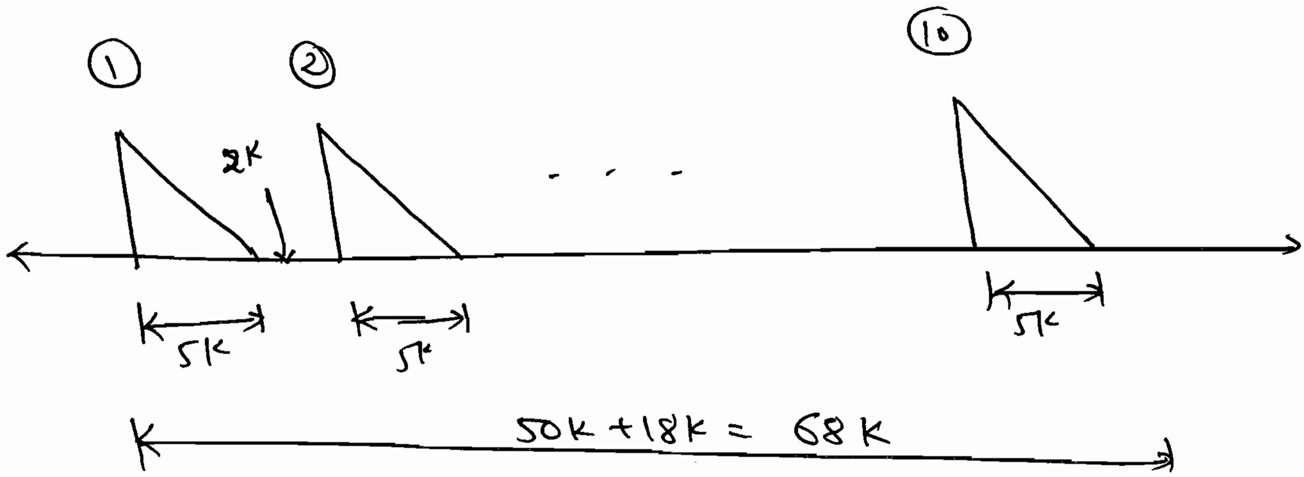
Ans:

(i)



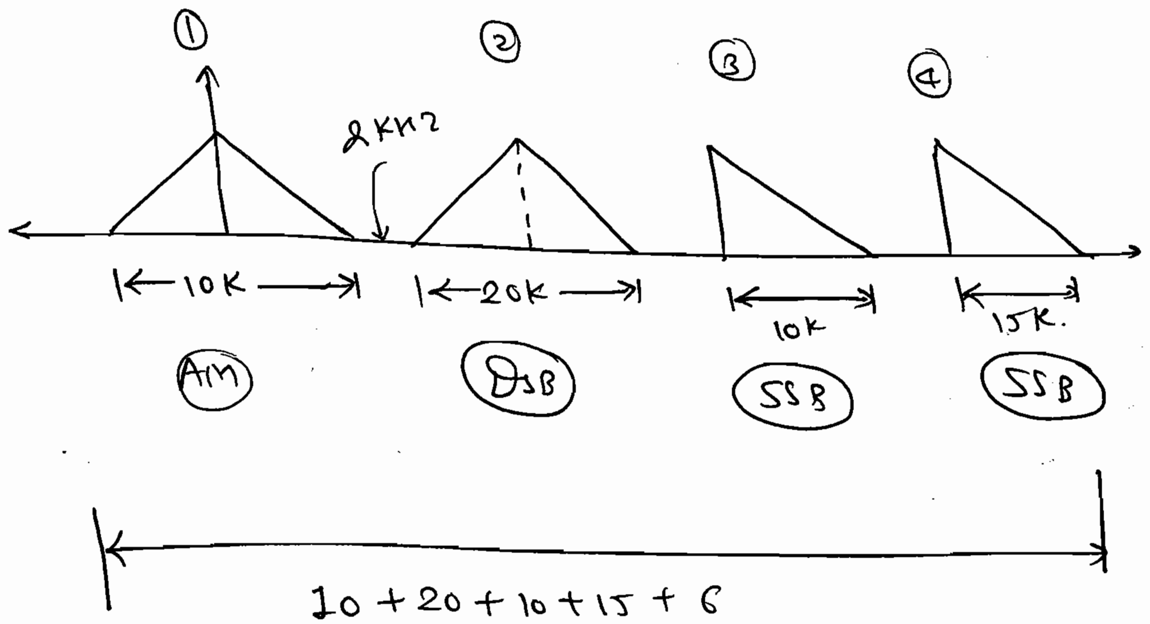
(ii) Same as above but there are no carrier.

(iii)



Q-2 4 signals each bandlimited to 5k, 10k, 10k, 15k, are transmitted through a channel after modulation using FDM. In modulators used are AM, DSB, SSB & SSB respectively. Assuming guard band of 2 kHz. Determine the minimum BW of channel required.

Ans:



$10 + 20 + 10 + 15 + 6$

$= 61 \text{ K Hz}.$