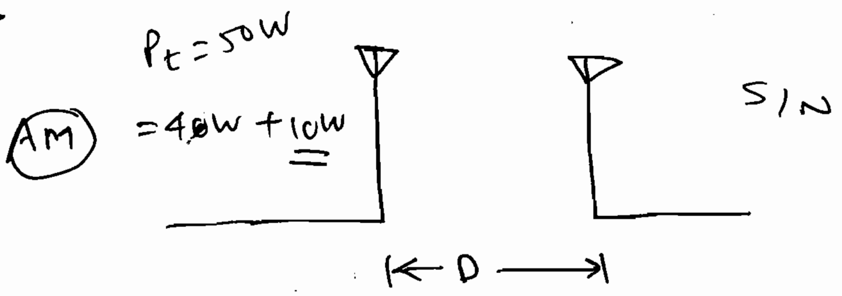
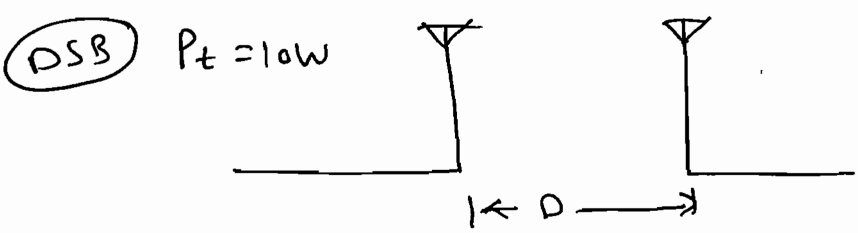
② DSBSC Modulation:- (Double side Band Suppressed Carrier)

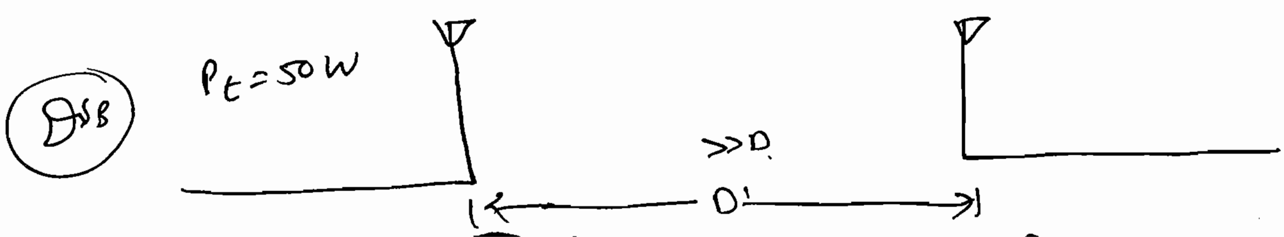
⇒ In AM the maximum efficiency possible is 33.3%, in the case of singletone Modulation. So, the maximum sideband power is only 33.3% of the total Power. When the Carrier is Suppressed the total power & sideband power are equal. So, modulation efficiency is 100%.

→ To cover the same distance in a wireless Communication system DSB Modulation require less power with compared with AM. If the same power is used in DSB the distance B/w Tx & Rx is increased.

⇒







$\Rightarrow \quad s(t) = A_c \cancel{\cos 2\pi f_c t} + A_c \underbrace{k_a}_{\boxed{k_a = 1}} m(t) \cos 2\pi f_c t.$

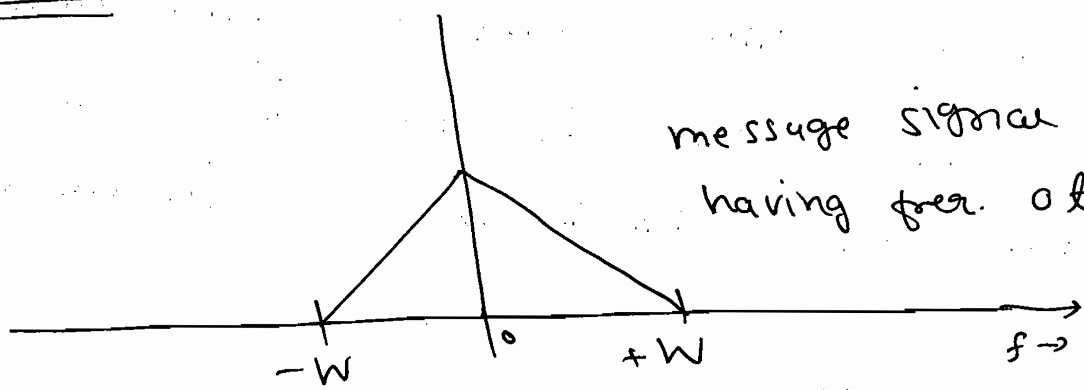
$\Rightarrow$ Time domain eqn of DSB.

$$\boxed{\begin{aligned} s(t) &= A_c m(t) \cos 2\pi f_c t. \\ s(t) &= m(t) \cdot c(t). \end{aligned}}$$ H.B.

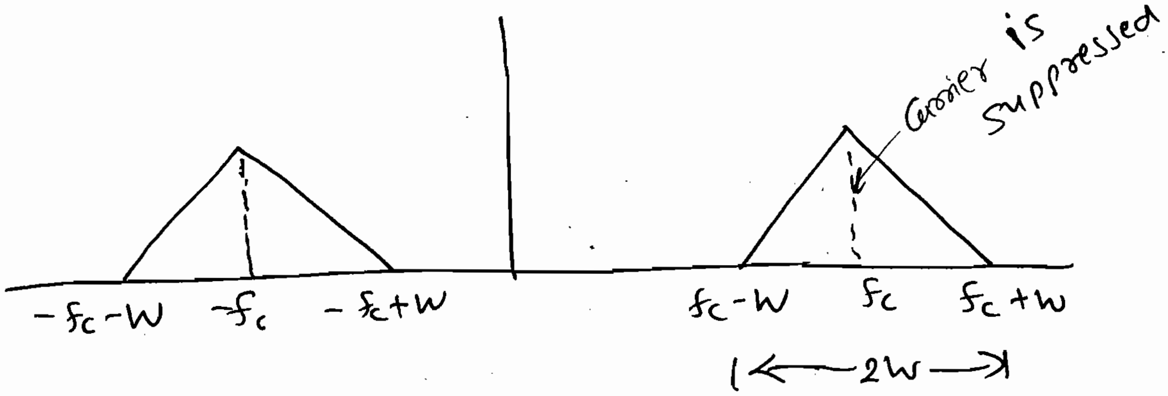
$\Rightarrow$ Freq. domain eqn of DSB,

$$\boxed{S(f) = \frac{A_c}{2}\left[M(f - f_c) + M(f + f_c) \right]}$$ H.B.

$\Rightarrow$ Spectrum:



message signal having freq. 0 to W



* Single tone Modulation of DSB.

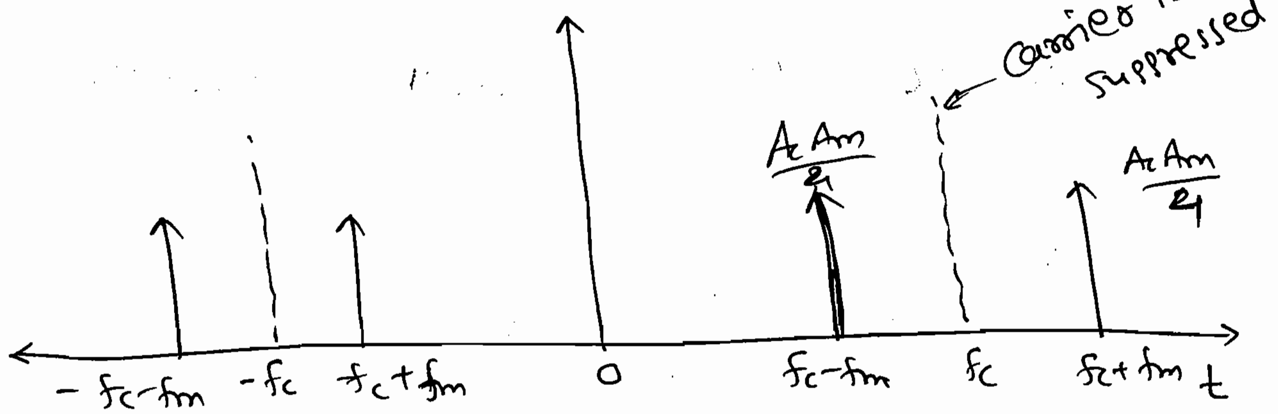
$\Rightarrow$ $$s(t) = A_c\, m(t).\ \cos 2\pi f_c t$$

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

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

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

H.B



* Power Calculation:

$\Rightarrow$ $$P_t = P_{USB} + P_{LSB}.$$

$$\therefore\ = \frac{\left(\frac{A_c A_m}{2\sqrt{2}}\right)^2}{R} + \frac{\left(\frac{A_c A_m}{2\sqrt{2}}\right)^2}{R}.$$

$$P_t = \frac{A_c^2 A_m^2}{8R} + \frac{A_c^2 A_m^2}{8R}.$$

$$\therefore\ \boxed{P_t = \frac{A_c^2 A_m^2}{4R}}$$ H.B.

$$\boxed{P_t = \frac{A_c^2 A_m^2}{4R} \quad (W).}$$ H.B

$$\therefore \boxed{\eta = 100\%}$$

$$\Rightarrow \quad P_t = \cancel{P_c} + \frac{P_c \mu^2}{2}.$$

$$\therefore \quad P_t = \frac{P_c \mu^2}{2}.$$

$$\therefore \quad P_t = \frac{A_c^2}{2R}, \quad K_a = 1 \Rightarrow A_m = \mu.$$

$$\therefore \boxed{P_t = \frac{A_c^2 A_m^2}{4R}.}$$ H.B

Ex-1 A carrier signal $c(t) = 20\cos 2\pi 10^6 t$ is modulated by a message signal $m(t) = 5\cos 2\pi 10^4 t$ to generate a DSB signal. Sketch the spectrum & calculate the B.W., power & modulation efficiency.

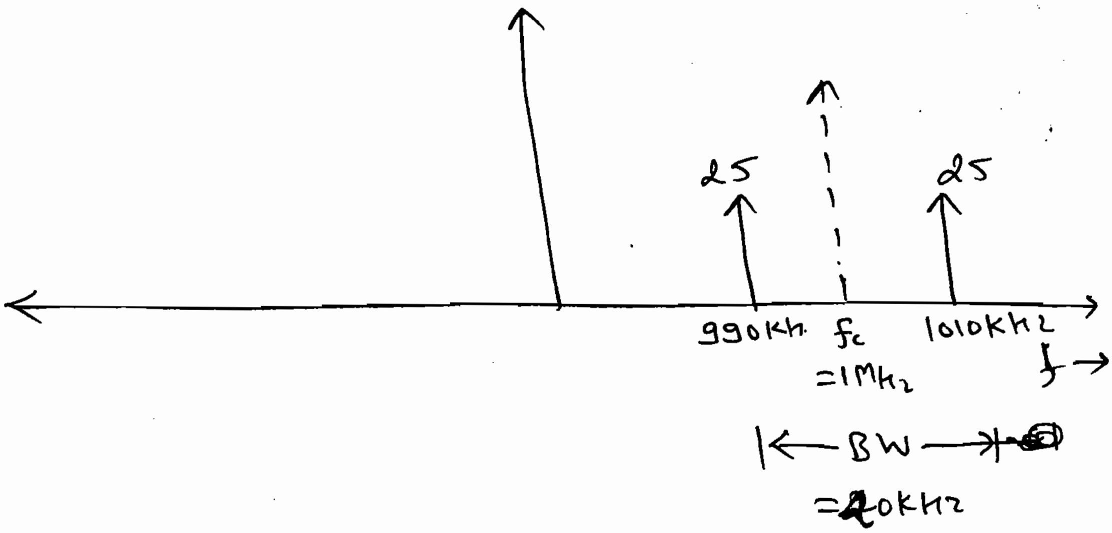
Ans: $c(t) = 20\cos 2\pi 10^6 t.$

$\Rightarrow \quad A_c = 20.$

$f_c = 10^6 \text{ Hz} = 1 \text{ MHz}.$

$\Rightarrow \quad m(t) = 5\cos 2\pi 10^4 t$

$\Rightarrow \quad f_m = 10\,KHz.$ $\qquad A_m = 5$ ..



$\Rightarrow \quad BW = 2f_m = 2\times 10\,KHz$

$$\boxed{BW = 20\,KHz}.$$

$$\boxed{\eta = 100\%.}$$

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

$$\therefore P_t = \frac{\cancel{400}^{\,200} \times 25}{\cancel{2}\times R}$$

$$\therefore \boxed{P_t = 2.5\,KW.}$$

Ex-2 Repeat the above Problem when the msg signal $m(t) = 5\cos 2\pi 10^4 t + 2\cos 8\pi 10^3 t.$

Ans: $f_{m_1} = 10\,KHz, \qquad f_{m_2} = 4\,KHz.$

$A_{m_1} = 5\,V, \qquad A_{m_2} = 2\,V.$

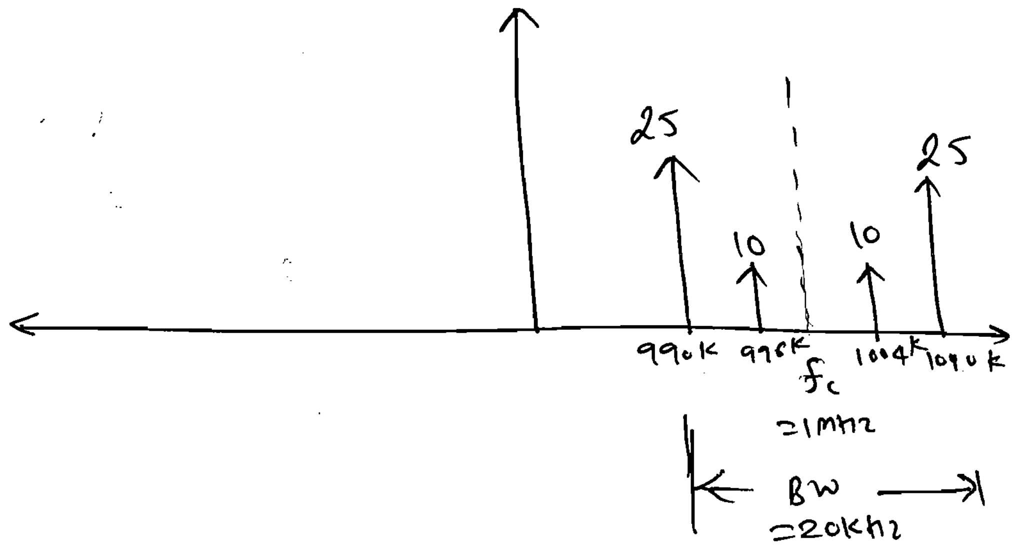
$$\therefore \quad P_t = \frac{A_c^2}{4R}\left[\mu_1^2 + \mu_2^2\right].$$

$$\therefore \quad P_t = \frac{400}{4}\left[A_{m_1}^2 + A_{m_2}^2\right].$$

$\therefore \quad P_t = 100\,[25 + 4].$

$\therefore \quad \boxed{P_t = 2.9\ kW}$

$\boxed{\eta = 100\,\%}$

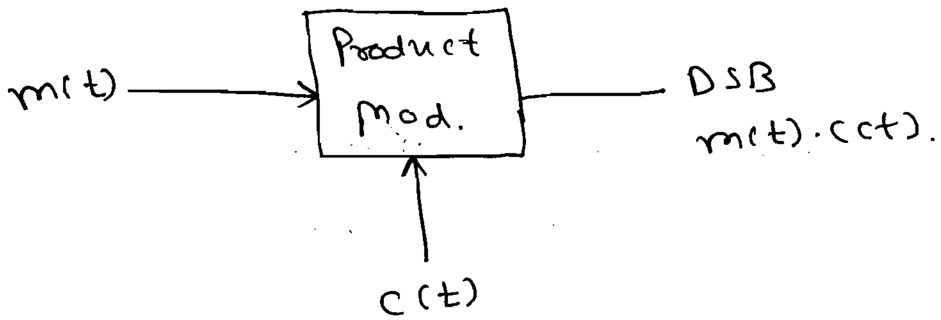


$\Rightarrow \quad BW = 2 f_m.$

$\boxed{BW = 20\ KHz}$

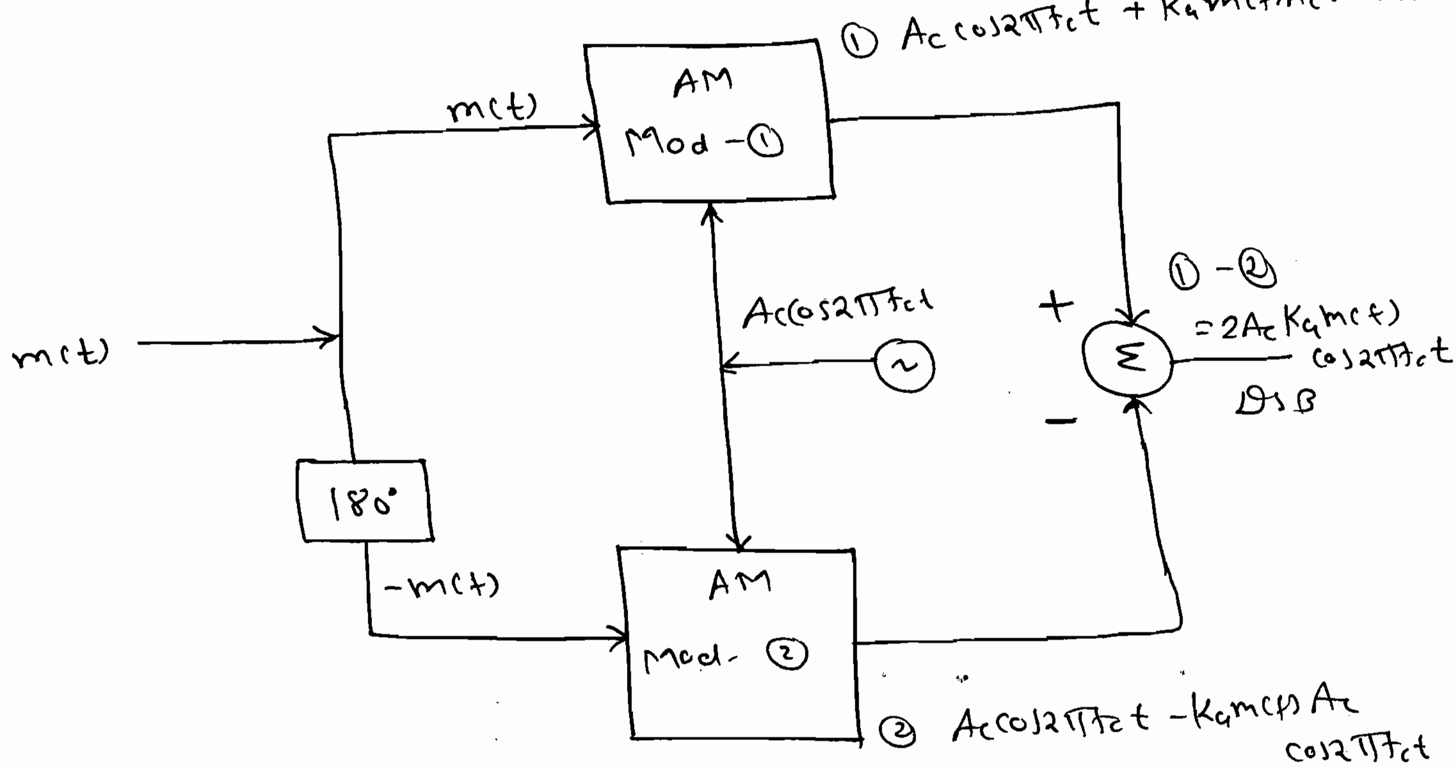
* Generation of DSB signal:

→ Any modulator which generate DSB signal it is also called a product modulator.



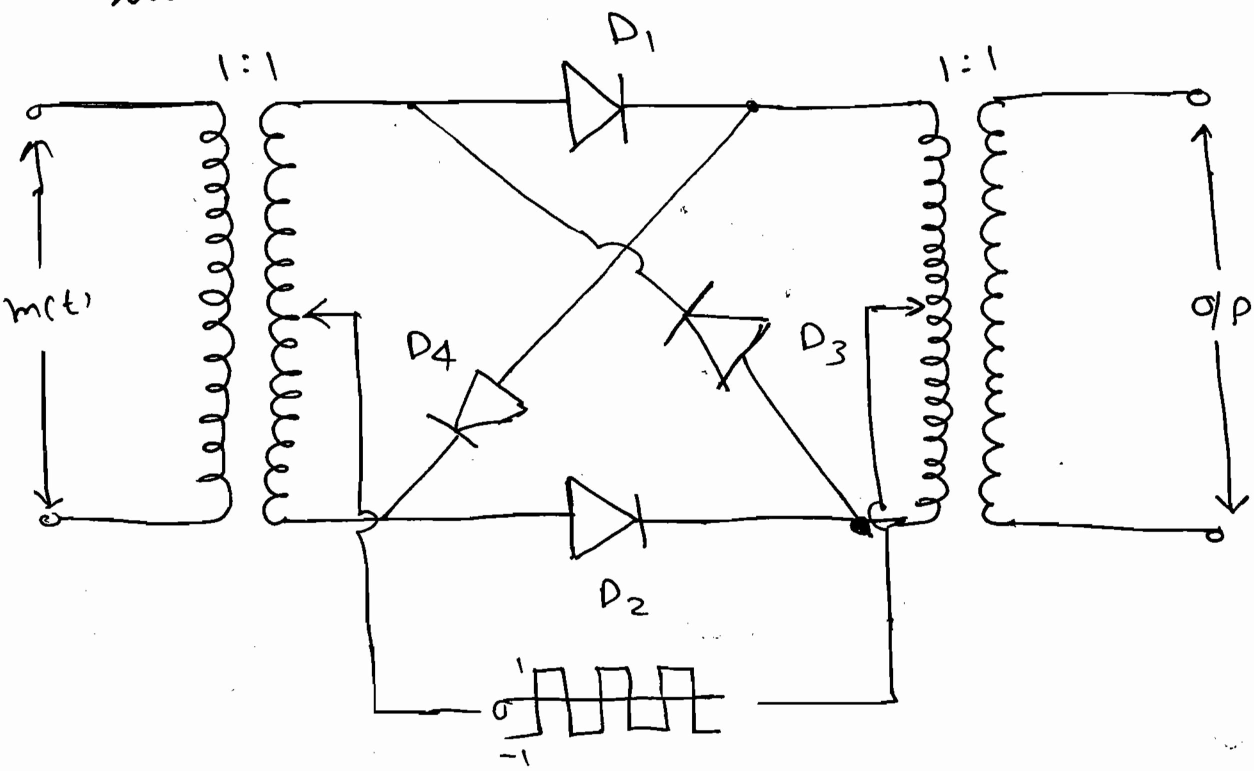
1. Balanced Modulator.
2. Ring modulator.

① Balanced Modulator:



=> "Balanced modulator can be used as "multiplier"."

② Ring Modulator:



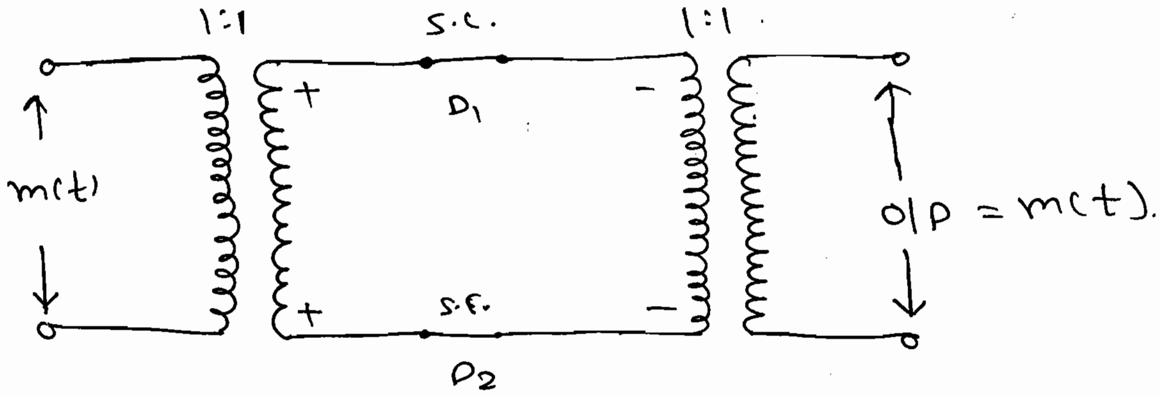
"Carrier"

→ Carrier is taken as square wave for convinience.

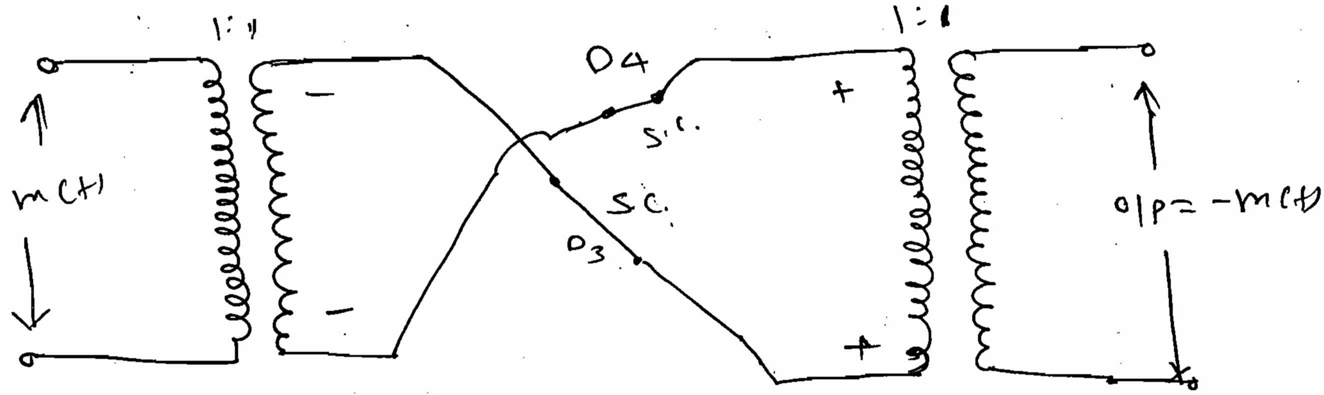
NOTE: ⇒ In all practical application we use sinusoidal signal because it contains only one freq 'f_c'.

⇒ Other signal, according to the fourier series there will be infinite freq.

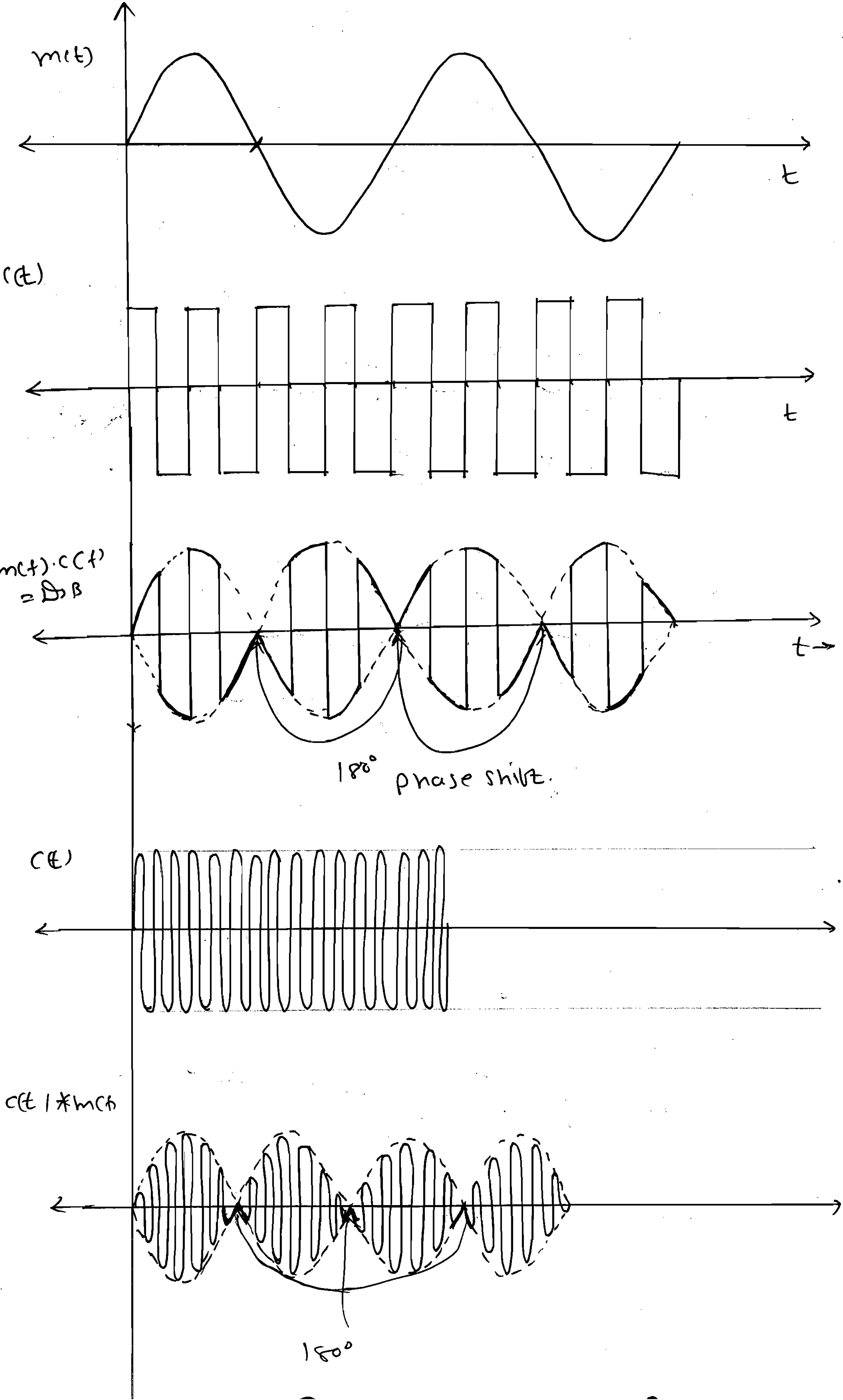
⇒ Carrier Polarity is '+Ve':



⇒ Carrier Polarity is '-Ve':



⇒ In DSB when ~~carrier~~ signal changes its polarity (or) crosses 'zero' line then there will be 180° phase shift in DSB signal.

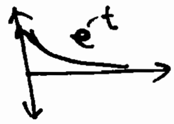

m(t)
t
c(t)
t
m(t)·c(t)
= DSB
t→
180° phase shift.
c(t)
c(t) * m(t)
180°

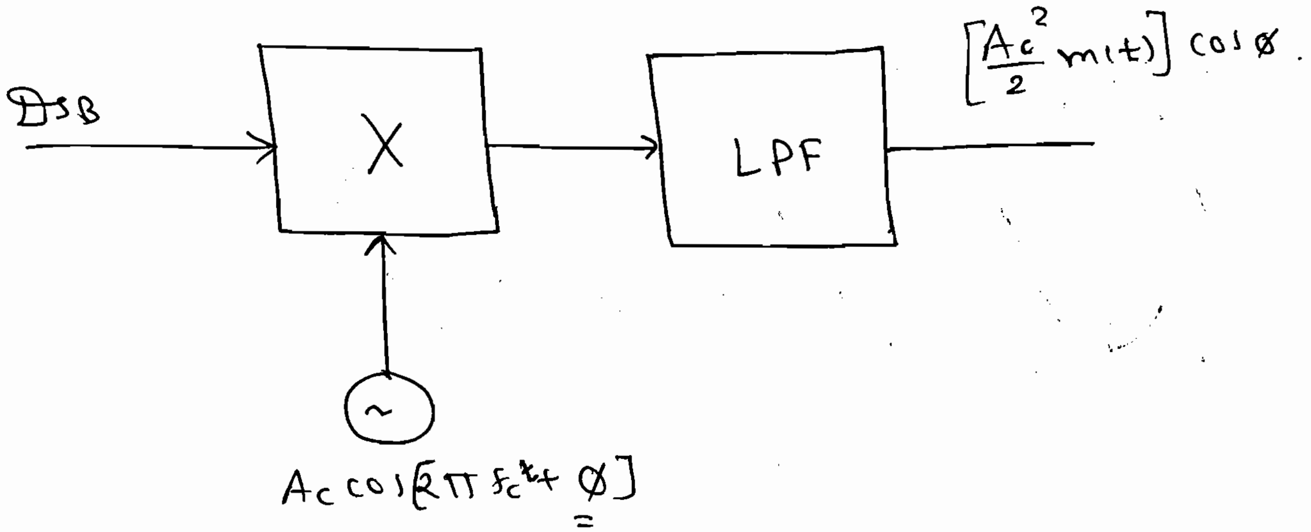
* Demodulation of DSB signal:

→ When a DSB signal is passed through a Envelope detector, the o/p is "$|m(t)|$".

So, Envelope detector is not used as demodulator. Therefore, **Synchronous Detector** is used as demodulator.

But, the signal which has +ve (amp. of) m(t) then it can be also demodulated by E.D for e.g. e^{-t}





⇒ o/p of Multiplier = (DSB)(Lo).

$$= [A_c m(t) \cos 2\pi f_c (t)]\, A_c \cos 2\pi f_c t$$

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

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

⇒ o/p of LPF = $\frac{A_c^2}{2} m(t)$.

⇒ Modulation concept used only in demodulation of AM by Envelope detector. It is not for synchronous demodulator for DSB.

$\Rightarrow$ If there are some phase shift ϕ.

then, (DSB) (LO).

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

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

$\Rightarrow$ o/p of LPF $= \frac{A_c^2}{2} m(t). \cos\phi.$

$\rightarrow$ The Hardware Complexity of DSB receiver is very high when compared with AM.

Ex-1 A DSB signal is generated using non-linear system having characteristic $V_o = aV_i + bV_i^3$, $V_i = [m(t) + \cos 2\pi f_1 t]$. The o/p of the non-linear system is passed through a bandpass filter to select the DSB signal. Determine the value of f_1 so that carrier freq. of DSB signal is 1 MHz.

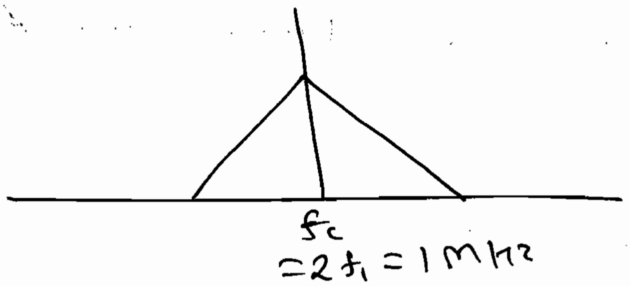
(A) 1 MHz (B) 3 MHz (C) 0.33 MHz (D) 0.5 MHz.

$$V_i \longrightarrow \boxed{\text{NLS}} \xrightarrow{V_o} \boxed{\text{BPF}} \longrightarrow \text{DSB}$$

Ans: $V_o = aV_i + bV_i^3.$

$$\therefore V_o = a\cancel{m}(t) + a\cos \cancel{2\pi f_1 t} + b\cancel{m^3}(t) + b\cos^3 \cancel{2\pi f_1 t}$$
$$+ b3\cancel{m^2}(t). \cos 2\pi f_1 t + 3bm(t). \cos^2 2\pi f_1 t.$$

$$V_o = 3b\cancel{m}(t) + \frac{3bm(t)}{2} \cos 2\pi (2f_1) t$$



$\therefore$ $\boxed{f_1 = 0.5\,MHz.}$

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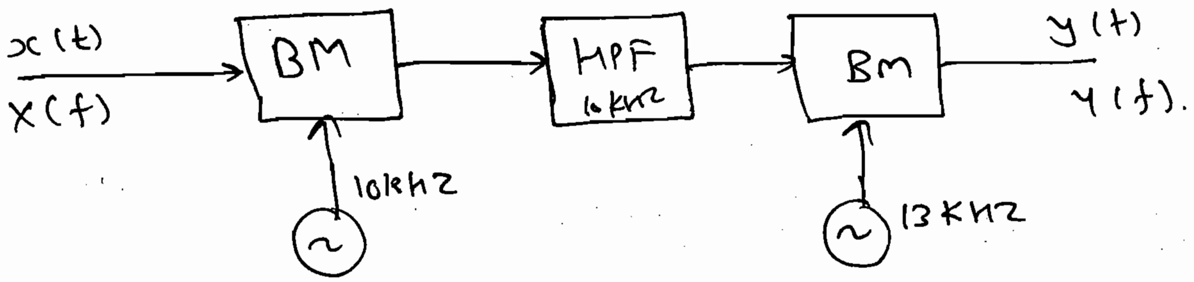
Ex-2 Consider the system shown in fig. Determine the +ve freq. at which $Y(f)$ is having spectral peaks.



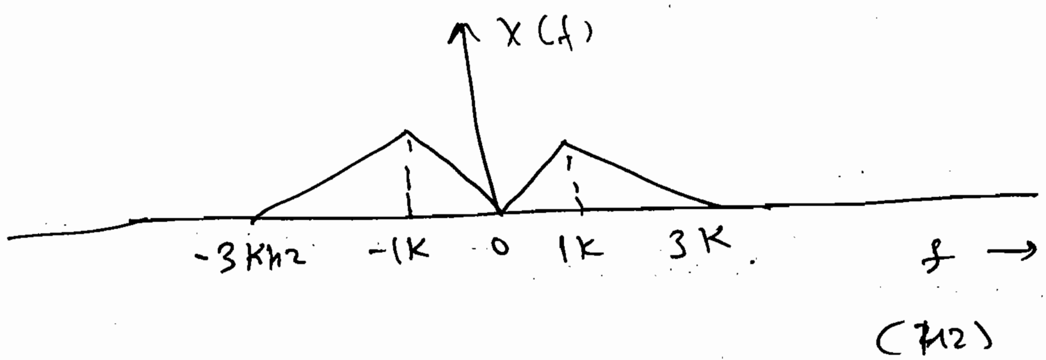
(A) 2 kHz & 14 kHz

(B) 2 kHz & 24 kHz

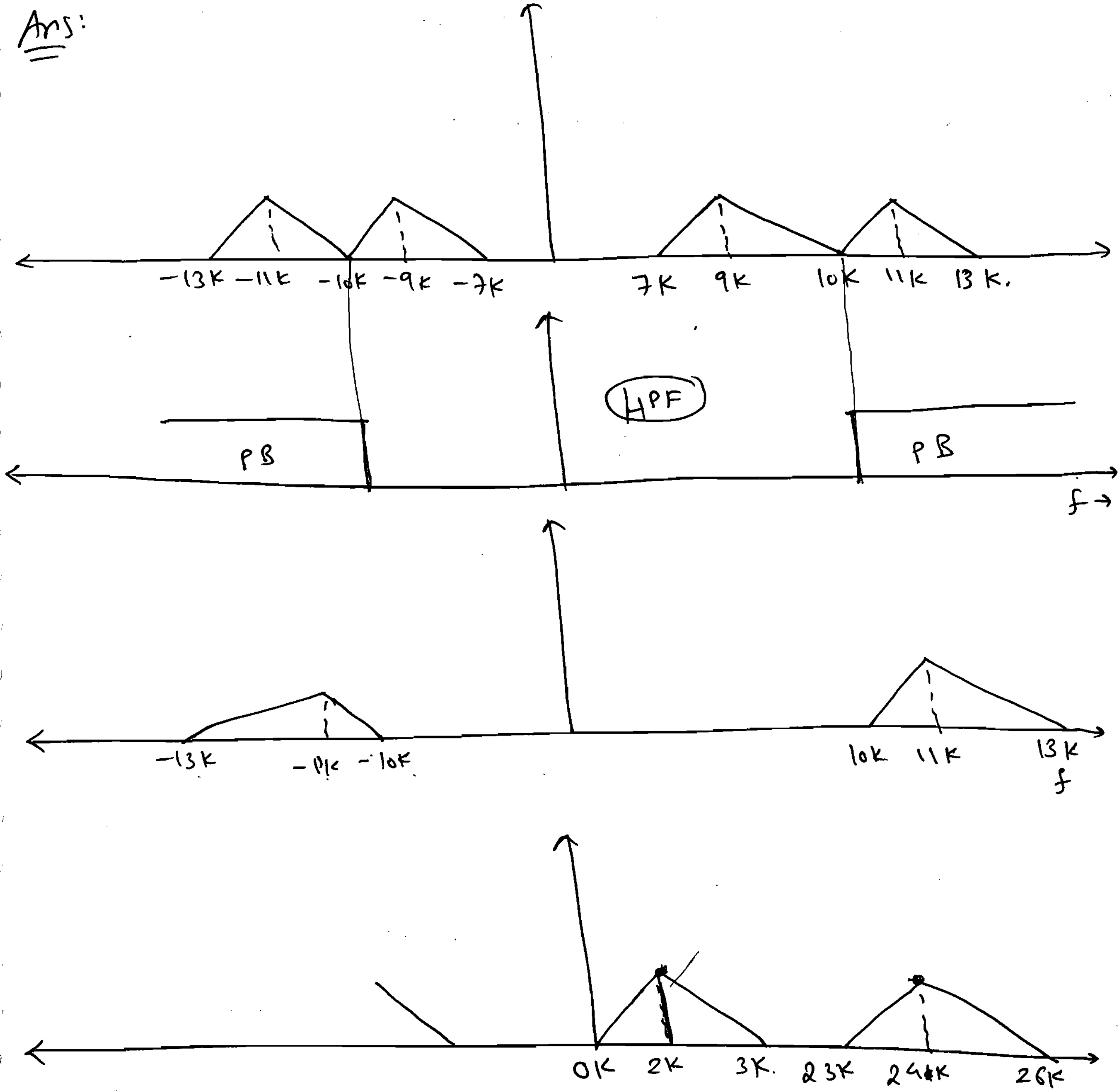
(C) 2 kHz & 14 kHz

(D) 1 kHz & 24 kHz.

→ spectrum of i/p signal,

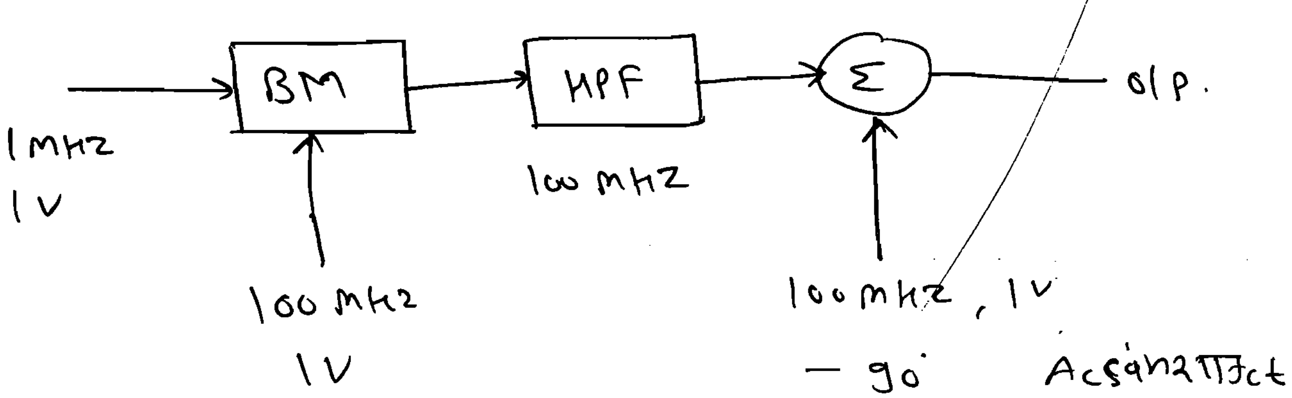


Ans:



So, Ans: (B) 2 kHz & 24 kHz.

Ex-3 Consider a system as shown in fig.



determine the envelope of the o/p signal.

Ans:

$\rightarrow A_c \cos 2\pi f_c t \cdot A_m \cos 2\pi f_m t$

$$= \frac{A_c A_m}{2} \cos 2\pi (f_c + f_m) + \frac{A_c A_m}{2} \cos 2\pi (f_c - f_m).$$

$$= \frac{1}{2} \cos 2\pi\, 101 m t + \frac{1}{2} \cos \cancel{2\pi\, 99 m t}.$$

$\rightarrow$ The o/p of HPF.

$$\Rightarrow \frac{1}{2} \cos 2\pi (f_c + f_m) t.$$

Now.

$$\Rightarrow o/p = \frac{A_c A_m}{2} \cos 2\pi (f_c + f_m) t + A_c \sin 2\pi f_c t.$$

$$= \frac{A_c A_m}{2} \left[\cos 2\pi f_c t \cdot \cos 2\pi f_m t - \sin 2\pi f_c t \cdot \sin 2\pi f_m t\right] + A_c \sin 2\pi f_c t.$$

$$= \underbrace{\left[\frac{A_c A_m}{2} \cdot \cos 2\pi f_m t\right]}_{A} \cos 2\pi f_c t + \underbrace{\left[A_c - \frac{A_c A_m}{2} \sin 2\pi f_m t\right]}_{B} \sin 2\pi f_c t.$$

$$\therefore o/p = \sqrt{A^2 + B^2}$$

$$o/p = \sqrt{\frac{A_c^2 A_m^2}{4} \cos^2 2\pi f_m t + A_c^2 - \frac{\cancel{2} A_c^2 A_m}{\cancel{2}} \sin 2\pi f_m t + \frac{A_c^2 A_m^2}{4} \sin^2 2\pi f_m t}$$

$$= \sqrt{\frac{1}{4} + 1 - \sin 2\pi f_m t}$$

$$\boxed{o/p = \sqrt{5/4 - \sin 2\pi f_m t}}$$