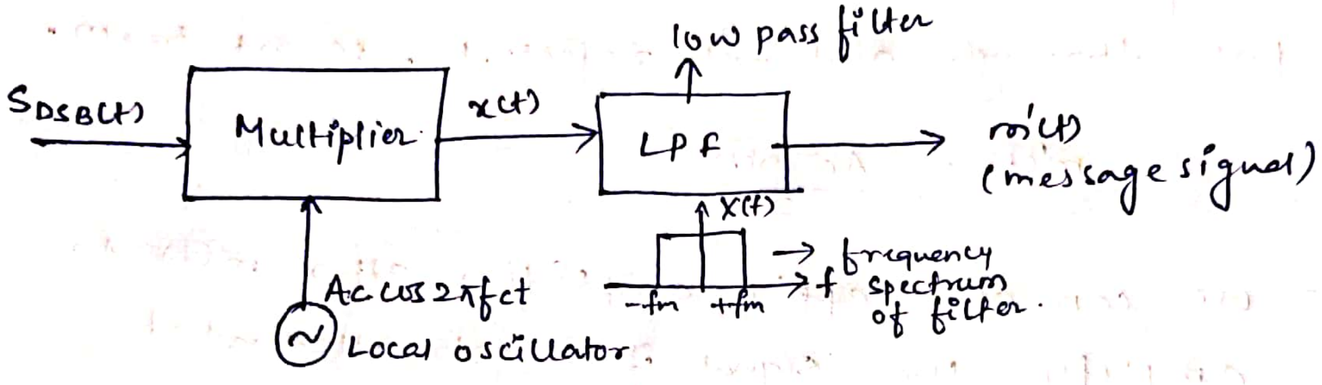
Demodulation of DSB-SC modulated signal:-

⇒ (1) Synchronous (Coherent) Detector:-



Here, DSB-SC signal is applied to multiplier or product modulator in which it is multiplied with the locally ~~oscillator~~ generated carrier $A_c \cos 2\pi f_c t$ (where we assume that there is perfect phase & frequency synchronization of local oscillator output and the carrier c(t) in DSB-SC signal).

Now, $(MUL)o/p = x(t) = S_{DSB}(t) \times A_c \cos 2\pi f_c t$

And, we know that:-

$$S_{DSB}(t) = A_c m(t) \cos 2\pi f_c t$$

$$\therefore \; x(t) = A_c^2 \cos^2 2\pi f_c t \, m(t)$$

$$= \frac{A_c^2 m(t)}{2} (1 + \cos 4\pi f_c t) \quad \left[\because \cos^2\theta = \frac{1+\cos 2\theta}{2}\right]$$

This signal x(t) is then passed through low pass filter.

Thus we have, ✓ ×

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

The filter will allow only the first term to pass through and will reject the second term.

$$\therefore \quad m'(t) = \frac{A_c^2 m(t)}{2}$$

→ we can also apply amplifier after $m'(t)$ to amplify the signal if its gets attenuated during the demodulation process.

⇒ lets take another case where the locally generated carrier is not perfectly phase synchronized with carrier wave $c(t)$ in DSB-SC signal then,

Local oscillator o/p := $A_c \cos(2\pi f_c t + \phi)$

↓ No phase synchronization.

Now,

$$(\text{MUL})\ o/p = x(t) = (A_c\, m(t) \cos 2\pi f_c t) \cdot A_c \cos(2\pi f_c t + \phi)$$

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

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

[∵ ~~cos A · cos B = $\frac{\cos A+B}{2} + \frac{\cos(A-B)}{2}$~~]

$$\left[\because \cos A \cdot \cos B = \frac{1}{2}\cos(A+B) + \frac{1}{2}\cos(A-B)\right]$$

Now, x(t) is fed to LPF; where second term will term will be rejected and we will get 1st term as output.

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

Due to this extra $\cos\phi$ in the output, we have following problems:

1. In practice, we usually find that the phase error ϕ varies randomly with time, owing to random variations in the communication channel. The result is that at the detector output, the multiplying factor $\cos\phi$ also varies randomly with time, which is obviously undesirable.
   ∴ To maintain ϕ constant, additional circuitry has to be provided, which increases the complexity of the receiver.

2. When phase $\phi = \pm\pi/2$ or $\pm(90°)$
   $\cos\phi = 0$
   ∴ we get zero demodulated output in the receiver.

This effect is called Quadrature Null Effect (QNE) where we get zero output in the receiver instead of the DSB-SC signal applied at the input.

Advantages of DSB-SC modulation

1. Transmitter power will be saved i.e 100% modulation efficiency.
2. Used for long distance communication.
3. It is used in Quadrature Carrier Multiplexing.

Disadvantages of DSB-SC modulation:-

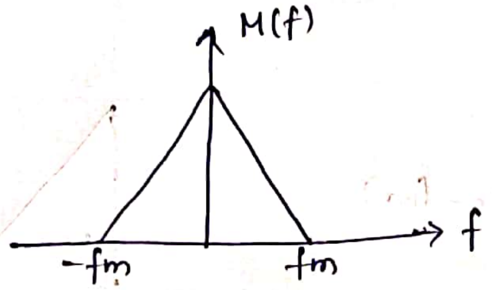
1. Demodulation technique is complex and expensive.
2. A Demodulation is affected by QNE.
3. Needs high transmission bandwidth.

SSB-SC modulation
(Single side-band - suppressed carrier)

→ The advantage of SSB over AM and DSB is that both the transmitter power and bandwidth will be saved.

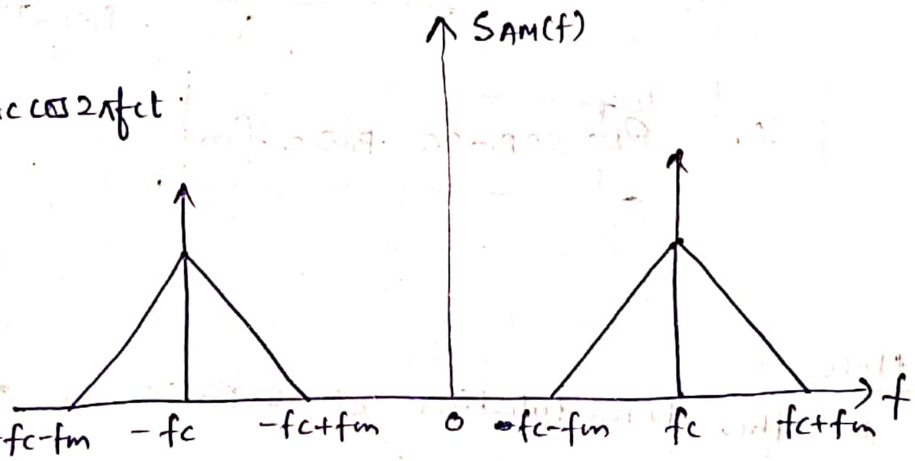
let

$m(t) \longleftrightarrow$



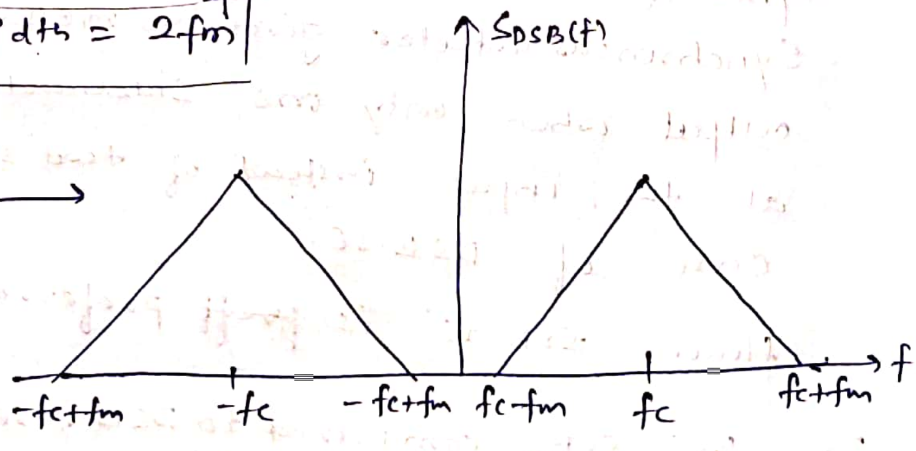
And, let $c(t) = A_c \cos 2\pi f_c t$

$S_{AM}(t) \longleftrightarrow$



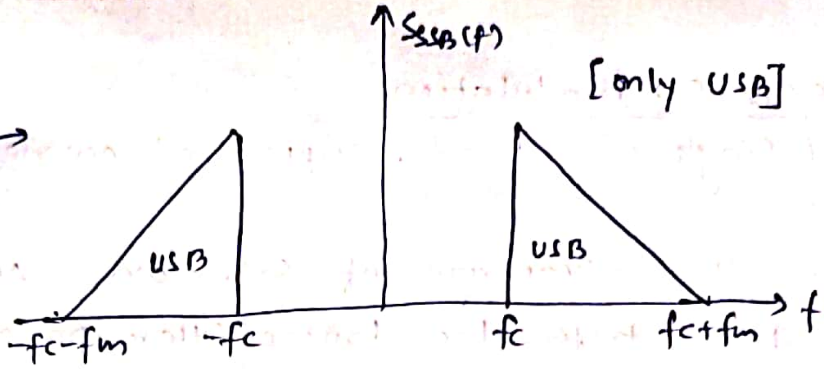
Standard AM Bandwidth = 2fm

$S_{DSB}(t) \longleftrightarrow$

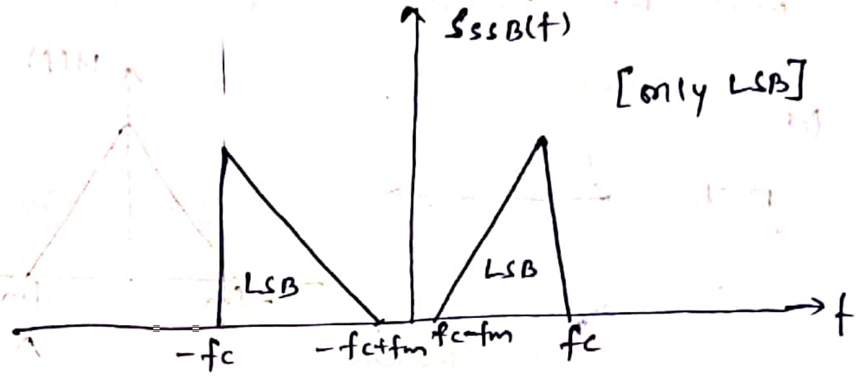


DSB-SC BW = 2fm

$S_{SSB}(t) \longleftrightarrow$



- $BW = f_c + f_m - f_c$
  $= f_m$



$BW = f_c - (f_c - f_m)$
$= f_m$

$\therefore$ **SSB-SC $BW = f_m$**

Note:

1. The demodulation of SSB-SC is also done by the Synchronous detector.
   Synchronous detector gives the message signal as the output when only one sideband is provided at the input instead of two sidebands in case of DSB-SC.
   Hence, SSB-SC is ~~preff~~ preferred over DSB-SC.

2. In SSB, compared to DSB, 50% transmitter power is saved. and 50% Bandwidth will be saved.

3. The percentage power saved in SSB and DSB compared to AM depends on modulation index 'μ'.

Single-tone SSB-SC :-

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

$$S_{AM}(t) = A_c\{1 + k_a m(t)\}\cos 2\pi f_c t$$

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

Now,

$$S_{SSB}(t) = \frac{A_c A_m}{2}\cos 2\pi(f_c \pm f_m)t$$

+ → USB

− → LSB

Spectrum: