Analog and Digital Communication EC223

DSB/SC, SSB, VSB, Methods of Generation

Subject Coordinator

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DSB/SC

- The transmission of a signal, which contains a carrier along with two sidebands can be termed as **Double Sideband Full Carrier system or simply DSBFC**. The below Figure 1 shows :

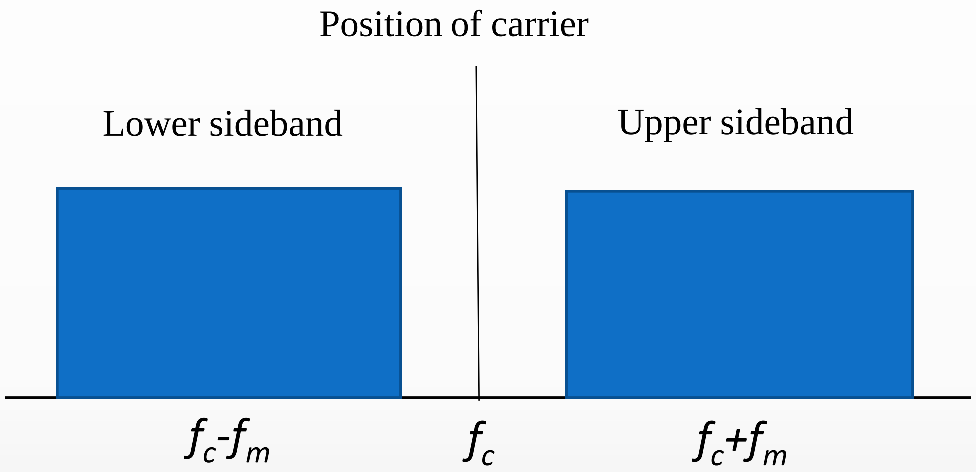

Fig 1

- However, such a transmission is inefficient. Because, two-thirds of the power is being wasted in the carrier, which carries no information

- If this carrier is suppressed and the saved power is distributed to the two sidebands, then such a process is called as **Double Sideband Suppressed Carrier** system or simply **DSBSC**. The below Fig 2 shows:

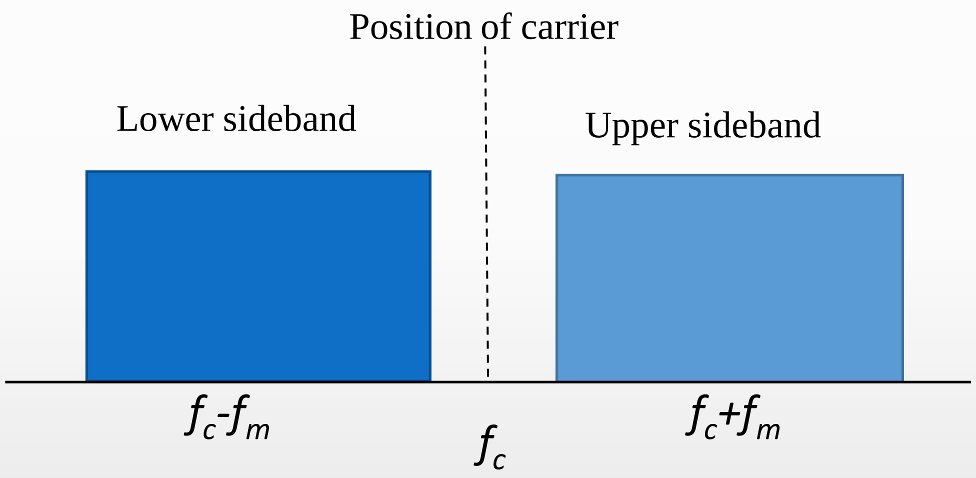

Fig 2

Carrier is suppressed and sidebands are allowed for transmission

Generation of DSB-SC

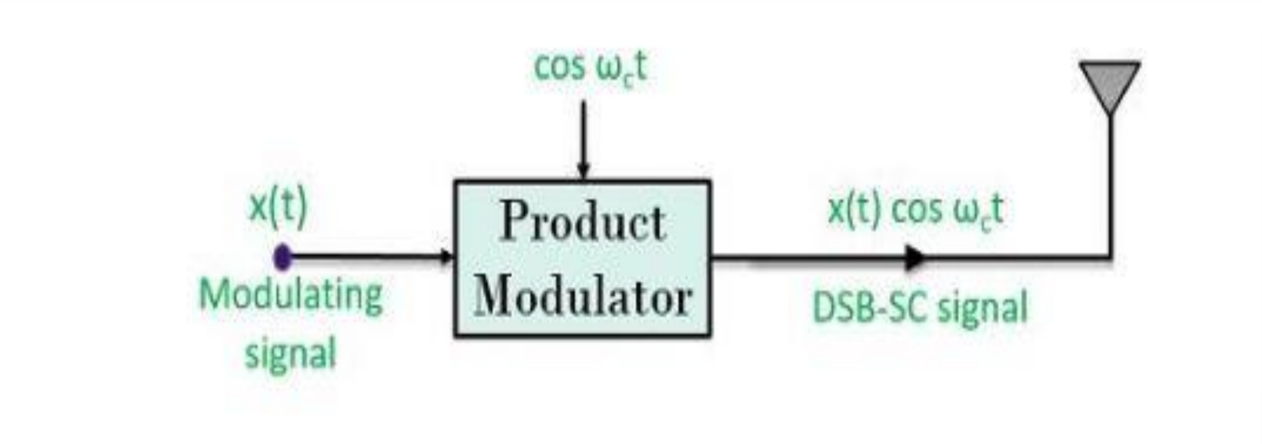

Fig: DSB-SC Signal Generation

- Here, by observing the above figure, we can say that a product modulator generates a DSB-SC signal
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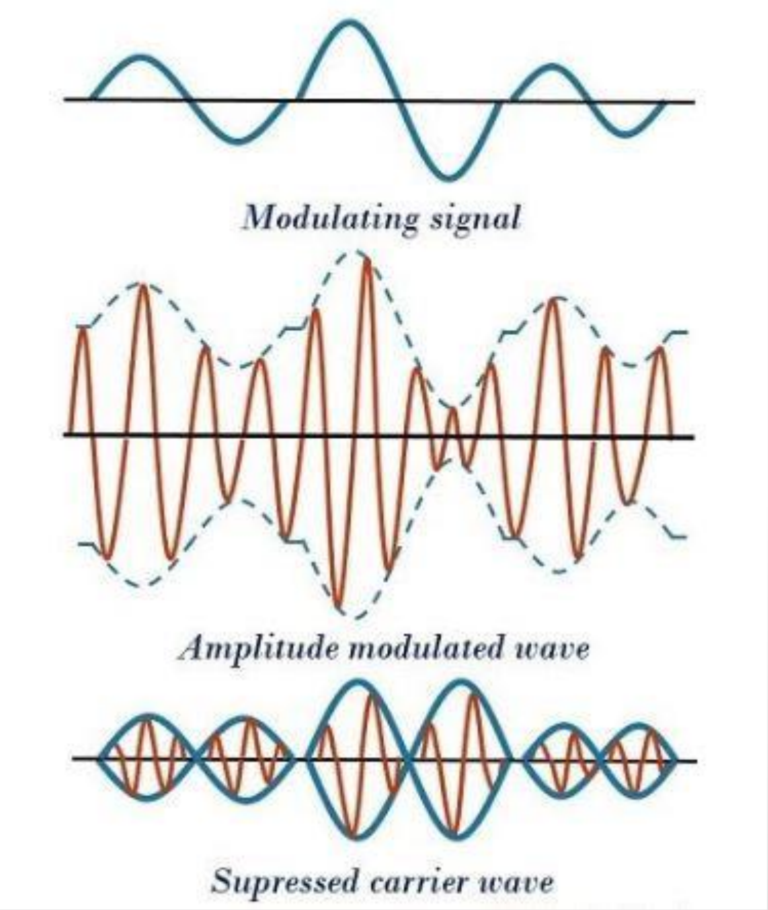


Fig: Pictorial representation of waveform

- Let us consider the same mathematical expressions for modulating and carrier signals as we have considered in the earlier chapters i.e.,

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

Carrier signal $c(t) = A_c \cos(2\pi f_c t)$

$$s(t) = m(t)c(t)$$

we can represent the **equation of DSBSC wave** as the product of modulating and carrier signals.

$$\Rightarrow s(t) = A_m A_c \cos(2\pi f_m t)\cos(2\pi f_c t)$$

Bandwidth of DSBSC Wave :

$$\text{Bandwidth (BW)} = f_{max} - f_{min}$$

Consider the equation of DSBSC modulated wave

$$\Rightarrow s(t) = A_m A_c \cos(2\pi f_m t)\cos(2\pi f_c t)$$

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

- The DSBSC modulated wave has only two frequencies. So, the maximum and minimum frequencies are f_c+f_m and f_c-f_m respectively.

i.e.,

$$f_{max} = f_c+f_m \text{ and } f_c\text{-}f_m$$

Substitute f_{max} and f_{min} values in the bandwidth formula

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

$$\Rightarrow BW=2f_m$$

Thus, the bandwidth of **DSBSC** wave is same as that of **AM** wave and it is equal to twice the frequency of the modulating signal.

Power Calculations of DSBSC Wave

- Consider the following equation of DSBSC modulated wave.

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

- Power of DSBSC wave is equal to the sum of powers of upper sideband and lower sideband frequency components

$$P_t = P_{USB} + P_{LSB}$$

- We know the standard formula for power of cos signal is

$$P = \frac{{V_{rms}}^2}{R} = \frac{\left(V_{rms}\sqrt{2}\right)^2}{R}$$

- First, let us find the powers of upper sideband and lower sideband one by one. Upper sideband power

$$P_{USB} = \frac{(A_m A_c/2\sqrt{2})^2}{R} = \frac{A_m 2 A_c 2}{8R}$$

- Similarly, we will get the lower sideband power same as that of upper sideband power.

$$P_{LSB} = \frac{A_m 2 A_c 2}{8R}$$

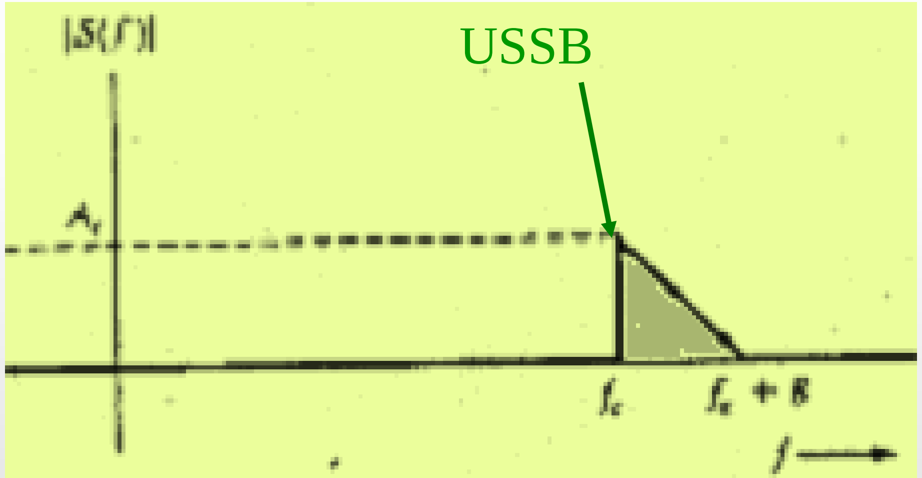
- let us add these two sideband powers in order to get the power of DSBSC wave.

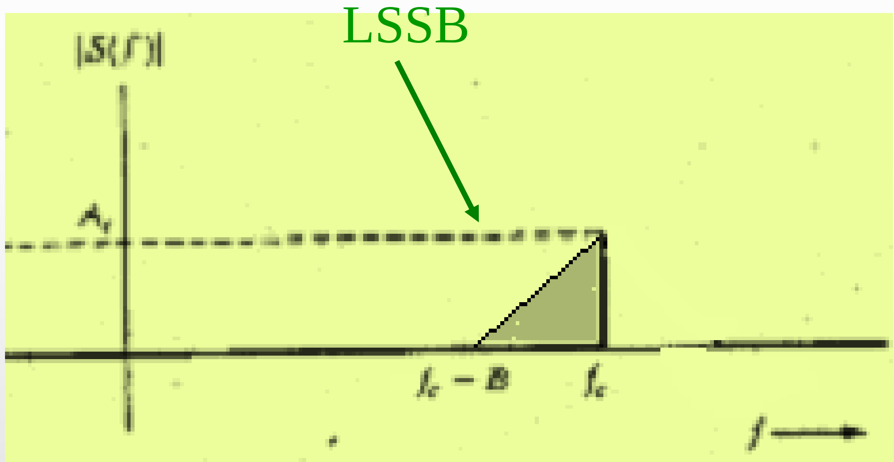
$$P_t = \frac{A_m 2 A_c 2}{8R} + \frac{A_m 2 A_c 2}{8R} = \frac{A_m 2 A_c 2}{4R}$$

- Therefore, the power required for transmitting DSBSC wave is equal to the power of both the sidebands

Single Sideband (SSB) Modulation

- An **upper single sideband** (USSB) signal has a zero-valued spectrum for $|f| < f_c$
- A **lower single sideband** (LSSB) signal has a zero-valued spectrum for $|f| > f_c$
- **SSB-AM** – popular method ~ **BW** is *same* as that of the modulating signal. Normally SSB refers to SSB-AM type of signal

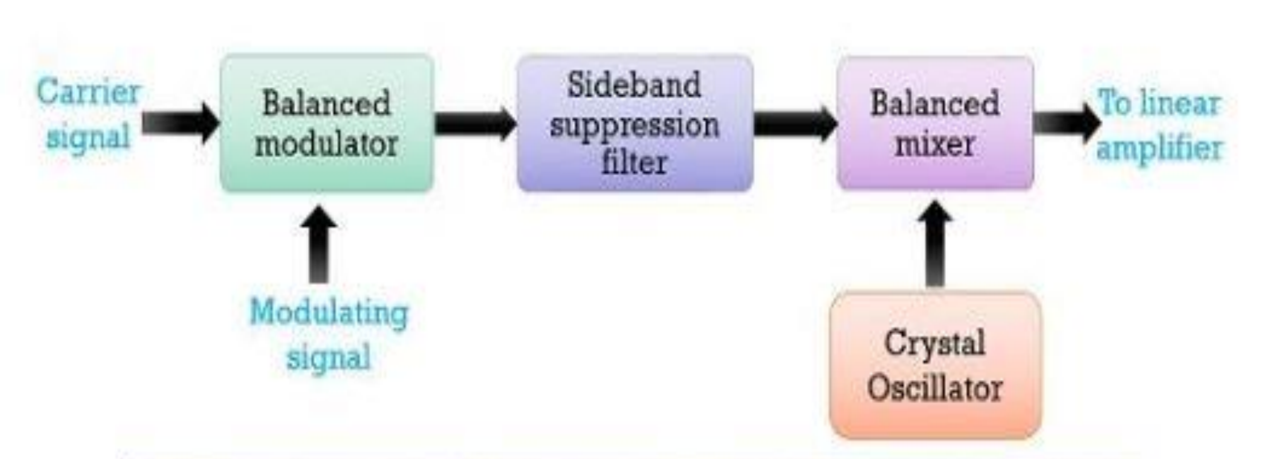




Generation of SSB

- **Methods of generation of Single Sideband modulated wave**
  1. Frequency discrimination method (Filter method)
  2. Phase shift method

1.Frequency discrimination method (Filter method)

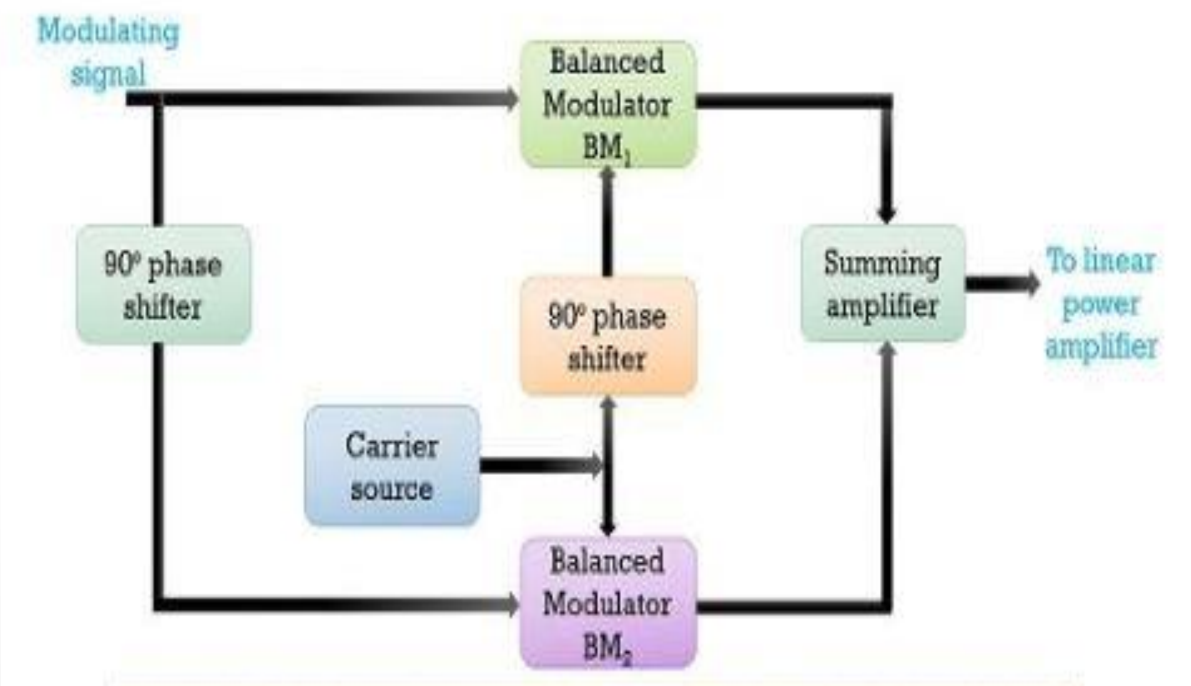


Block diagram of Filter method for Sideband suppression

- A **balanced mixer** and **crystal oscillator** are employed in the circuit to boost the frequency of SSB signal up to the level of transmitter frequency.

- The **balanced modulator** employed here generates DSB-SC amplitude modulated wave as its output.
- As the DSB output contains the two sidebands, and only carrier component is suppressed, so **sideband suppression** filter is needed further in order to eliminate one of the 2 sidebands.
- The **filter characteristics** should be such that, it must have **flat passband** and should possess **high attenuation** beyond the passband. So, to have such a response, the tuned circuit must have a very **high Q factor**

2.Phase shift method : The figure below shows the block diagram of the phase shift method used for the generation of the SSB signal.

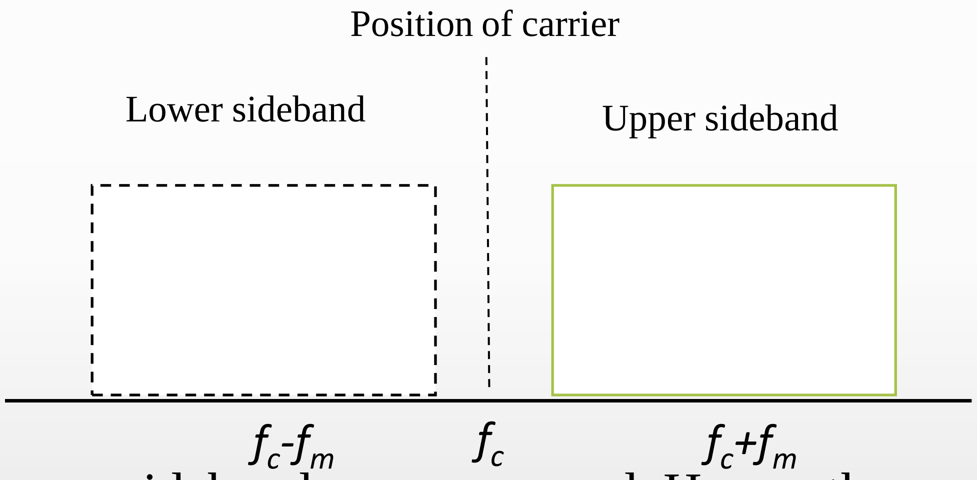


Block diagram of phase shift method for SSB signal generation

- The **summing amplifier** adds the output of the two balanced modulators.
- Hence at the **output** of summing amplifier, we only have **USB** of **SSB signal**.

- The carrier signal generated by the carrier source is fed to the **balanced modulator 1 or BM_1** after it is phase shifted by **90^0**. Also, the modulating or baseband signal is applied to the BM_1.
- Moreover, the carrier is directly fed to the **Balanced modulator 2 or BM_2**, along with this a **90^0** phase shifted modulating signal is also applied to the same.
- Thus, at the output of the two balanced modulators, signals consisting of 2 sidebands are achieved. **BM_1** generates **USB** and **LSB** but both with a **phase shift** of **$+90^0$.**
- Similarly, **BM_2** also generates a signal with both sidebands, but **USB** is shifted by **$+90^0$** while **LSB** is shifted by **-90^0**

- The process of suppressing one of the sidebands along with the carrier and transmitting a single sideband is called as **Single Sideband Suppressed Carrier** system or simply **SSBSC**.



- The carrier and the lower sideband are suppressed. Hence, the upper sideband is used for transmission. Similarly, we can suppress the carrier and the upper sideband while transmitting the lower sideband.
- Let us consider the same mathematical expressions for the modulating and the carrier signals as we have considered in the earlier chapters.

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

Carrier signal $c(t) = A_c \cos(2\pi f_c t)$

we can represent the **equation of SSBSC wave** as

$\Rightarrow s(t) = \frac{A_m A_c}{2} \cos[2\pi(fc + fm)t]$ For USB

$s(t) = \frac{A_m A_c}{2} \cos[2\pi(fc - fm)t]$ For LSB

Bandwidht of DSBSC Wave : We know the bandwidth of DSBSC is BW=$2f_m$

Since SSB contains only one sideband its bandwidth is half of bandwidth of DSBSC modulated wave

$$\text{Bandwidth (BW)} = \frac{2f_m}{2} = f_m$$

Therefore, the bandwidth of SSBSC modulated wave is f_m and it is equal to the frequency of modulating signal.

- By solving the equations of USB and LSB we get the power of SSBSC wave is :

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

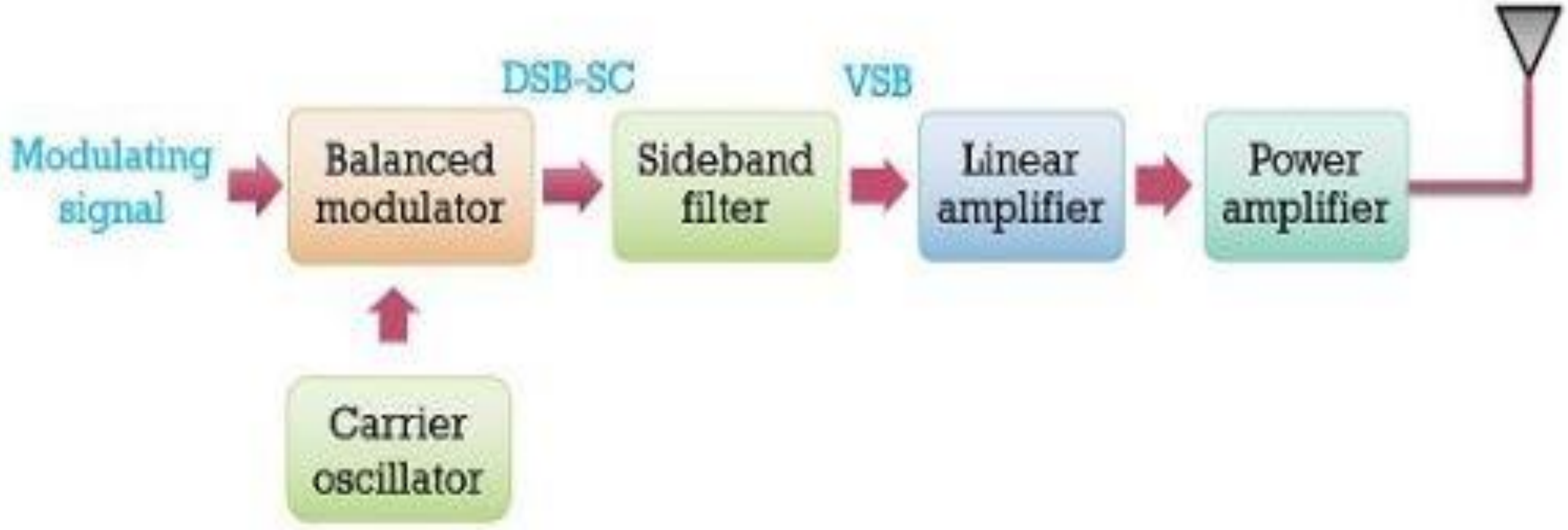
- **Advantages:**
- Bandwidth or spectrum space occupied is lesser than AM and DSBSC waves
- Transmission of more number of signals is allowed
- **Disadvantages:**
- The generation and detection of SSBSC wave is a complex process.
- The quality of the signal gets affected unless the SSB transmitter and receiver have an excellent frequency stability.

Vestigial Side Band Suppressed Carrier(VSBSC)

- VSBSC Modulation is the process, where a part of the signal called as **vestige** is modulated along with one sideband.
- When SSB is difficult to implement, we use vestigial sideband (VSB) modulation.
- VSB is implemented by frequency discrimination but the filtering process does not completely eliminate the unwanted band.
- A VSB modulator and its filter's frequency response are shown below. The response of the VSB filter is denoted as HVSB(f).
- We notice a transition band around the frequency fc.
- Reduction in bandwidth when compared to AM and DSBSC waves is the advantage

Generation of VSB

- The figure shown below for the generation and transmission of Vestigial sideband signal:



VSB signal generation and transmission

Spectrum of the message signal and VSB signal

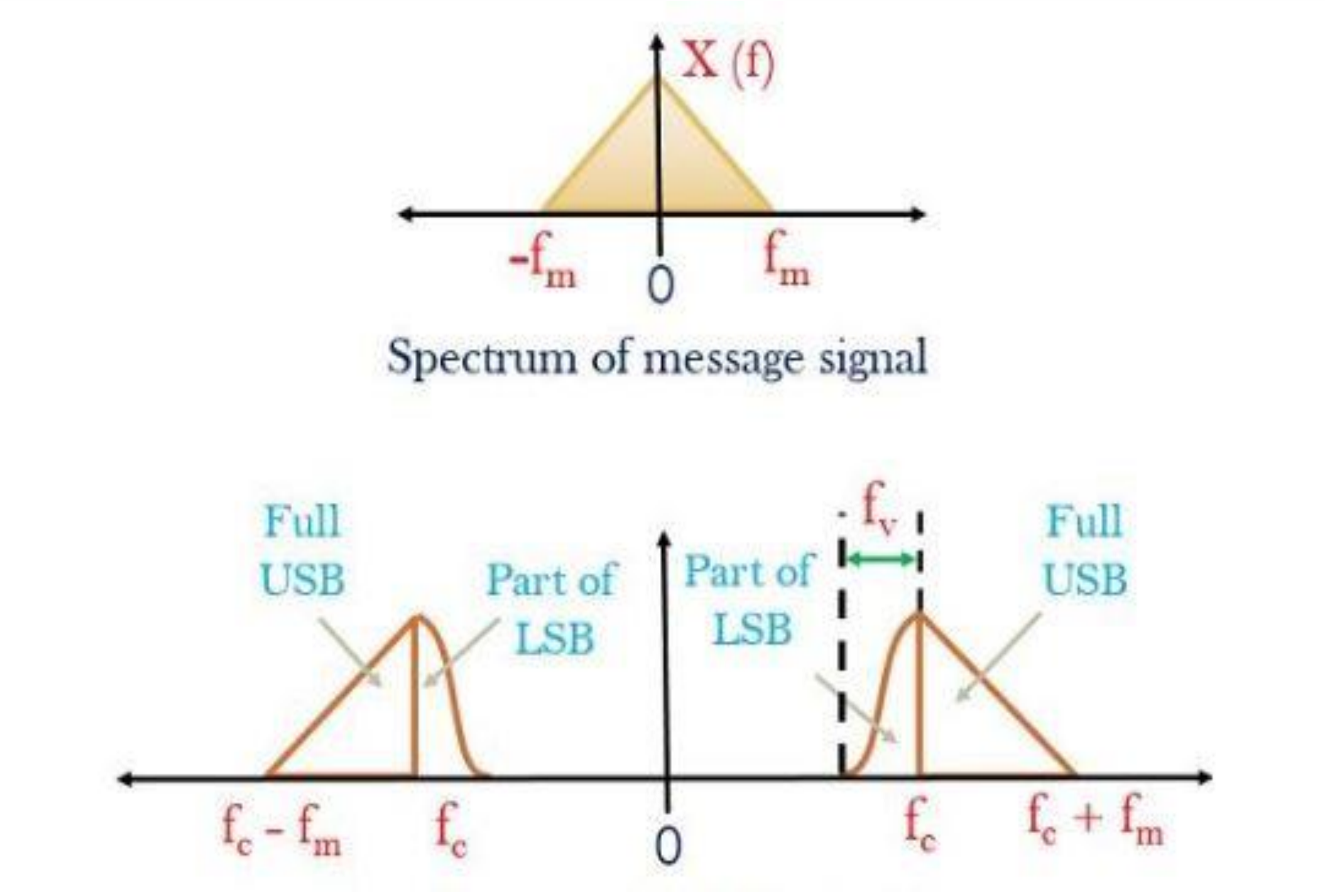


Fig : Spectrum of VSB Signal

Bandwidth of VSBSC
Modulation

- We know that bandwidth of SSBSC modulated wave is f_m.
- Since the VSBSC modulated wave contains the frequency components of one side band along with the vestige of other sideband, the bandwidth of it will be the sum of the bandwidth of SSBSC modulatd wave and vestige frequency f_v

i.e., BW of VSBSC Modulated wave = $f_m + f_v$

Thank You