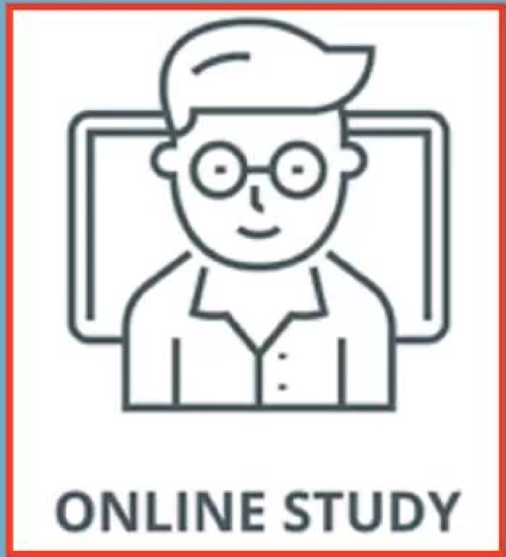

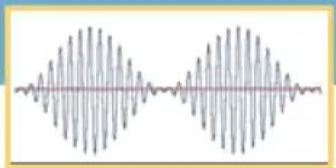

LET US START ONLINE STUDY…….

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DIGITAL COMMUNICATION

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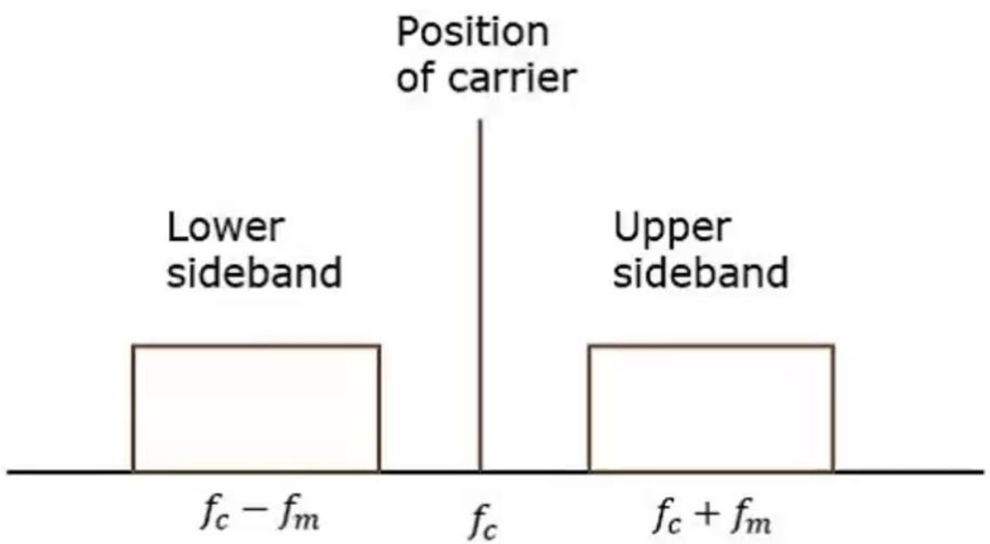
- DSBFC, DSBSC, SSB
- SSB SC – Single Side Band Suppressed Carrier

Good Morning

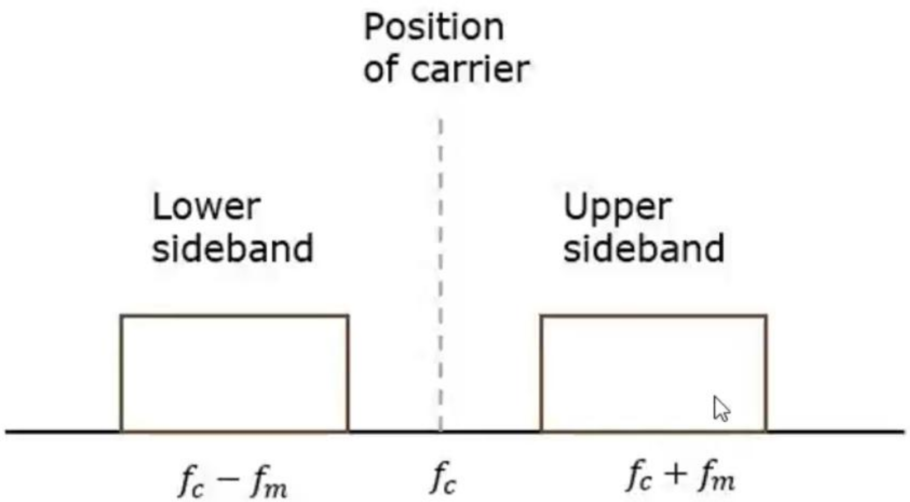
In the process of Amplitude Modulation, the modulated wave consists of the carrier wave and two sidebands. The modulated wave has the information only in the sidebands. **Sideband** is nothing but a band of frequencies, containing power, which are the lower and higher frequencies of the carrier frequency.

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**. It is plotted as shown in the following figure.

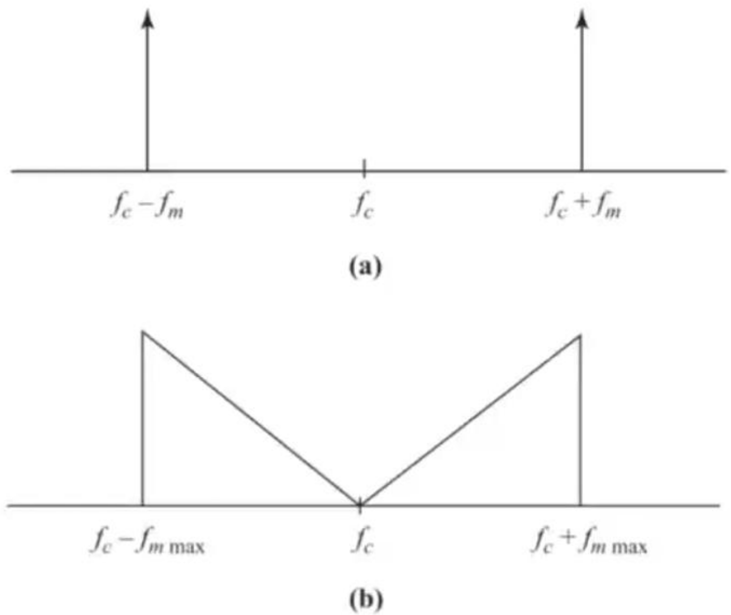


However, such a transmission is inefficient. Because, two-thirds of the power is being wasted in the carrier, which carries no information.

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**. It is plotted as shown in the following figure.



Carrier is suppressed and sidebands are allowed for transmission



DSBSC spectrum for
(a) sinusoidal modulation and (b) the general case.

i.e., Modulating signal

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

Carrier signal

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

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

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

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

Power Calculations of DSBSC Wave

Consider the following equation of DSBSC modulated wave.

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

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

$$P = \frac{{v_{rms}}^2}{R} = \frac{(v_m \sqrt{2})^2}{R}$$

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

Upper sideband power

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

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

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

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

Upper sideband power

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

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

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

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

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

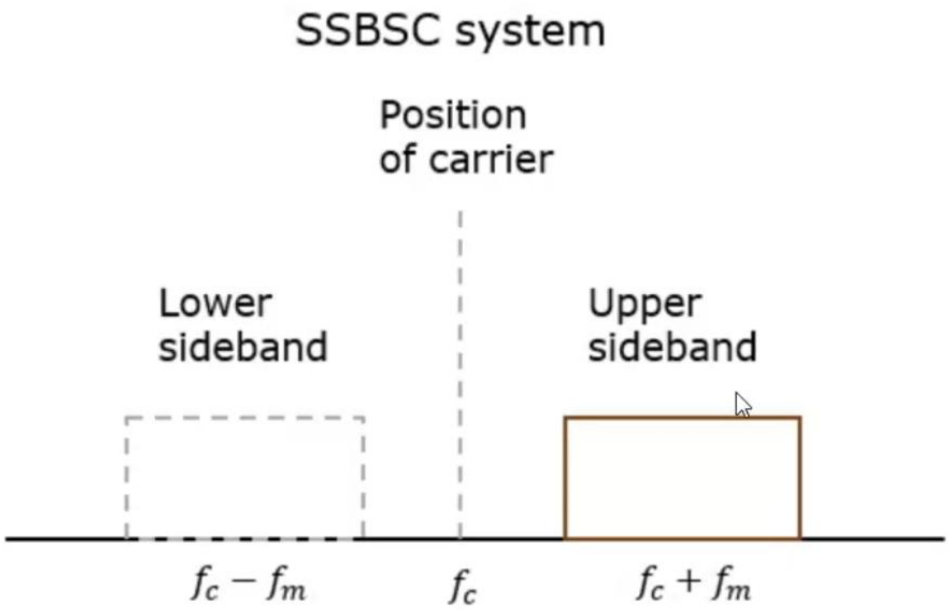
$$\Rightarrow P_t = \frac{{A_m}^2 {A_c}^2}{4R}$$

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

Communications in the HF bands have become increasingly crowded in recent years, requiring closer spacing of signals in the spectrum. Single-sideband systems requiring only half the bandwidth of normal AM and considerably less power are used extensively in this portion of the spectrum as a result.

It was noted in earlier discussion that each sideband of a normal AM signal contains all the information necessary for signal transmission and recovery. It was also pointed out that for 100% sinusoidal modulation each sideband contains one-sixth of the total signal power, while the carrier contains two-thirds of the total power. Furthermore, the carrier itself carries no information contributed by the modulating signal.

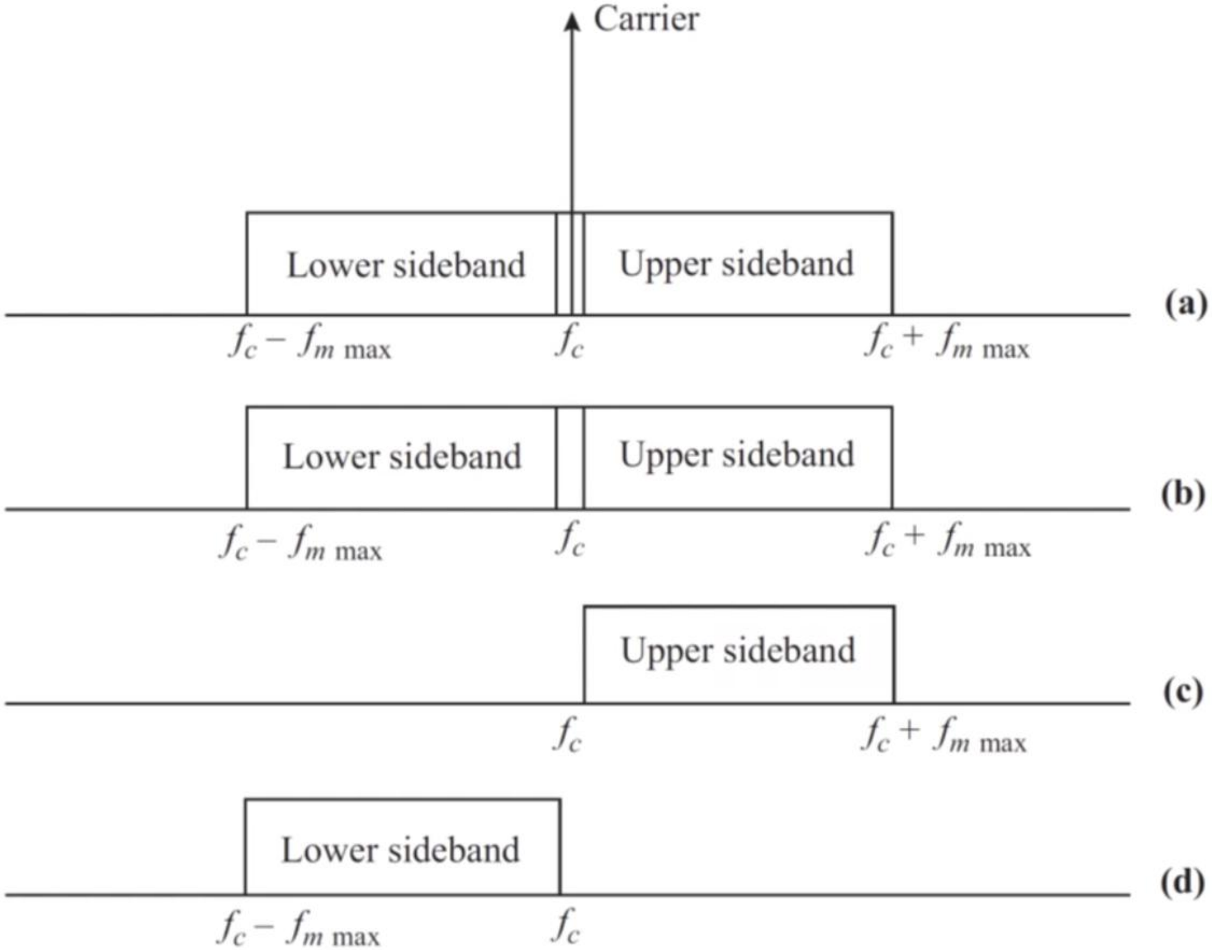
The process of suppressing one of the sidebands, along with the carrier and transmitting a single sideband is called as **Single Sideband Suppressed Carrier** system, or simply **SSB-SC** or **SSB**. It is plotted as shown in the following figure.



Carrier and a sideband are suppressed and a single sideband is allowed for transmission

This SSB-SC or SSB system, which transmits a single sideband has high power, as the power allotted for both the carrier and the other sideband is utilized in transmitting this **Single Sideband (SSB)**.

Hence, the modulation done using this SSB technique is called as **SSB Modulation**.


Carrier
Lower sideband
Upper sideband
(a)
$f_c - f_{m\ max}$
f_c
$f_c + f_{m\ max}$
Lower sideband
Upper sideband
(b)
$f_c - f_{m\ max}$
f_c
$f_c + f_{m\ max}$
Upper sideband
(c)
f_c
$f_c + f_{m\ max}$
Lower sideband
(d)
$f_c - f_{m\ max}$
f_c

Mathematical Expressions

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

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

Mathematically, we can represent the equation of SSBSC wave as

$$s(t) = \frac{A_m A_c}{2} \cos[2\pi (f_c + f_m) t]$$ for the upper sideband

$$s(t) = \frac{A_m A_c}{2} \cos[2\pi (f_c - f_m) t]$$ for the lower sideband

Bandwidth of SSBSC Wave

We know that the DSBSC modulated wave contains two sidebands and its bandwidth is $2f_m$.

Since the SSBSC modulated wave contains only one sideband, its bandwidth is half of the bandwidth of DSBSC modulated wave.

i.e., ***Bandwidth of SSBSC modulated wave*** = $\frac{2f_m}{2} = f_m$

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

Power Calculations of SSBSC Wave

Power of SSBSC wave is equal to the power of any one sideband frequency components.

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

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

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

In this case, the power of the upper sideband is

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

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

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

Therefore, the power of SSBSC wave is

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

Advantages

- Bandwidth or spectrum space occupied is lesser than AM and DSBSC waves.
- Transmission of more number of signals is allowed.
- Power is saved.
- High power signal can be transmitted.
- Less amount of noise is present.
- Signal fading is less likely to occur.

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.

Applications

- For power saving requirements and low bandwidth requirements.
- In land, air, and maritime mobile communications.
- In point-to-point communications.
- In radio communications.
- In television, telemetry, and radar communications.
- In military communications, such as amateur radio, etc.

For an AM DSBFC transmitter with an unmodulated carrier power $P_c = 100$ W that is modulated simultaneously by three modulating signals with coefficients of modulation $m_1 = 0.2$, $m_2 = 0.4$ and $m_3 = 0.5$, determine :
1) Total coefficient of modulation 2) Upper and lower sideband power 3) Total transmitted power.

Sol. :

$$P_c = 100 \text{ W},\ m_1 = 0.2,\ m_2 = 0.4,\ m_3 = 0.5$$

$$m_t = \sqrt{m_1^2 + m_2^2 + m_3^2} = \sqrt{0.2^2 + 0.4^2 + 0.5^2} = 0.671$$

$$P_{total} = P_c\left(1 + \frac{m_t^2}{2}\right) = 100\left(1 + \frac{0.671^2}{2}\right) = 122.5\ W$$

$$P_{total} = P_c + P_{SB}$$

$$\therefore \quad P_{SB} = P_{total} - P_c = 122.5 - 100 = 22.5\ W$$

$$\therefore \quad P_{LSB} = P_{USB} = \frac{P_{SB}}{2} = \frac{22.5\,W}{2} = 11.25\ W$$