EC8395-Communication Engineering

SSB Generation & Demodulation

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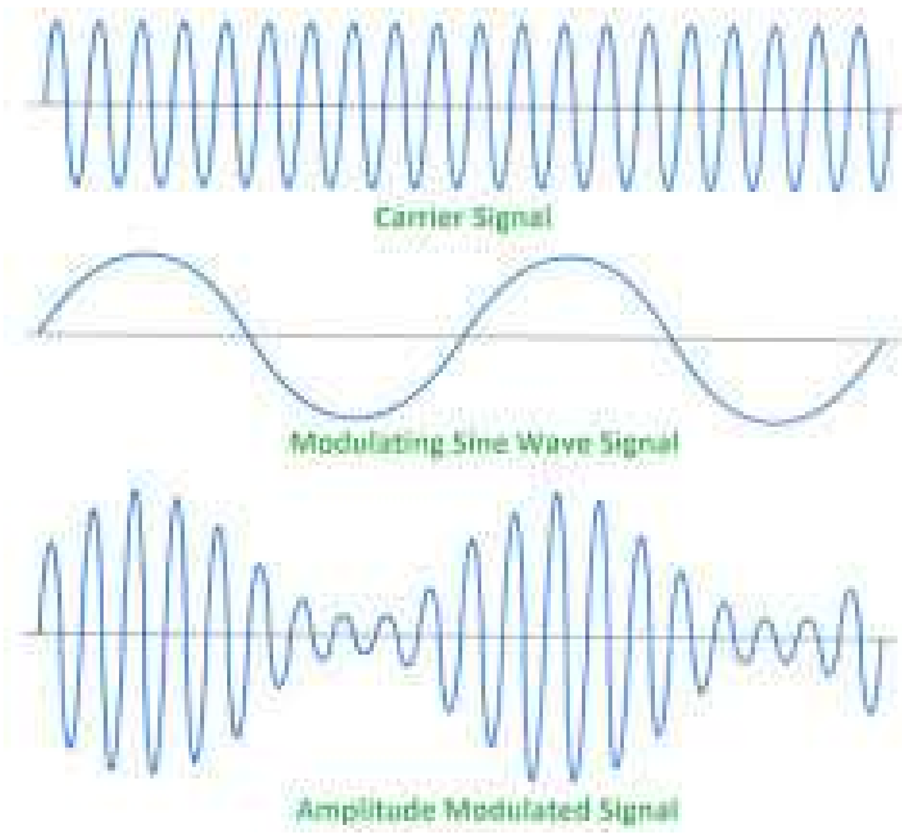
Objective

1. To discuss about SSB-SC generation using filter and phase shift method.
2. To discuss about SSB demodulation using coherent detection and Envelope detector.

Pictorial Representation (Time domain) of AM



Pictorial Representation (Frequency domain) of AM

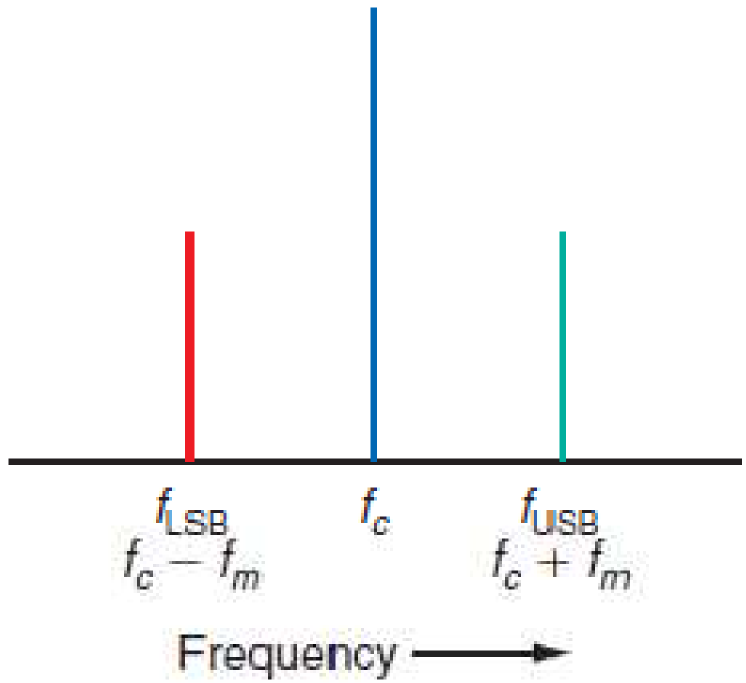


Fig: Frequency domain representation of AM

Types of AM

1. DSB-SC-Double sideband suppressed carrier modulation

2. SSB-Single sideband modulation

3. VSB-Vestigial sideband modulation

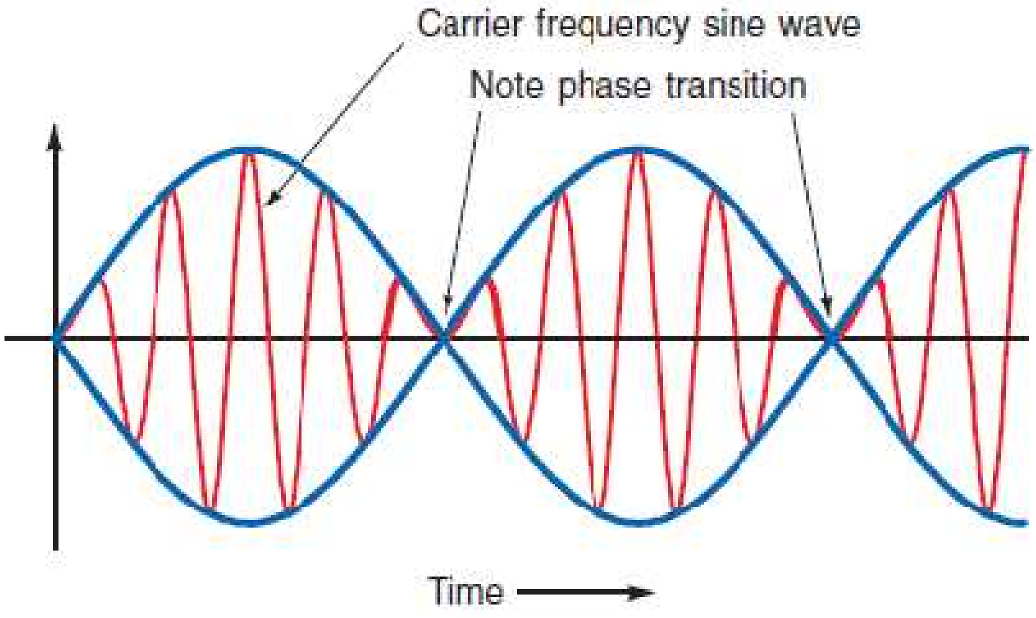
DSB-SC-Double sideband suppressed carrier modulation

- Carrier is known occupy most of the transmission power also not conveying any useful information. Hence the idea is to suppress the carrier and transmit only the side bands. Since sidebands alone convey the information signal f_m.
- **Total power in DSB-SC:**

$$P_{T(DSB-SC)} = P_C \, m^2/2$$

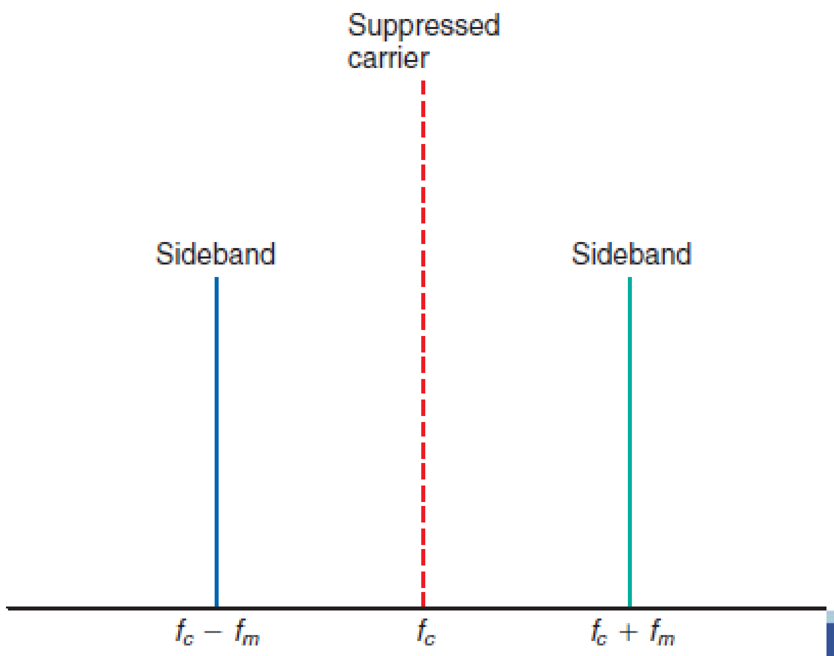
Time domain representation of DSB-SC signals

- The envelope of the signal is not the same as that of the modulation signal. The unique characteristic of DSB-SC signal is phase transition that occurs at the lower amplitude portion of the wave.



Frequency domain view of DSB-SC

- The DSB-SC does not find extensive use despite the suppression of the carrier in the technique. This is because demodulation requires a very complex circuit. One important application of DSB-SC technique is in the conveying of color information TV broadcasting.

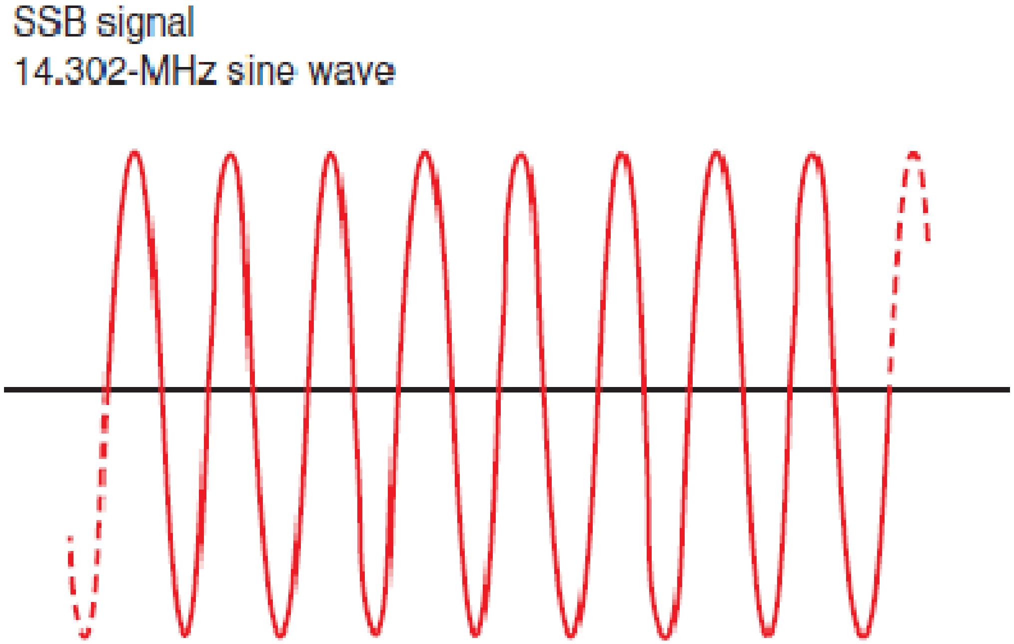


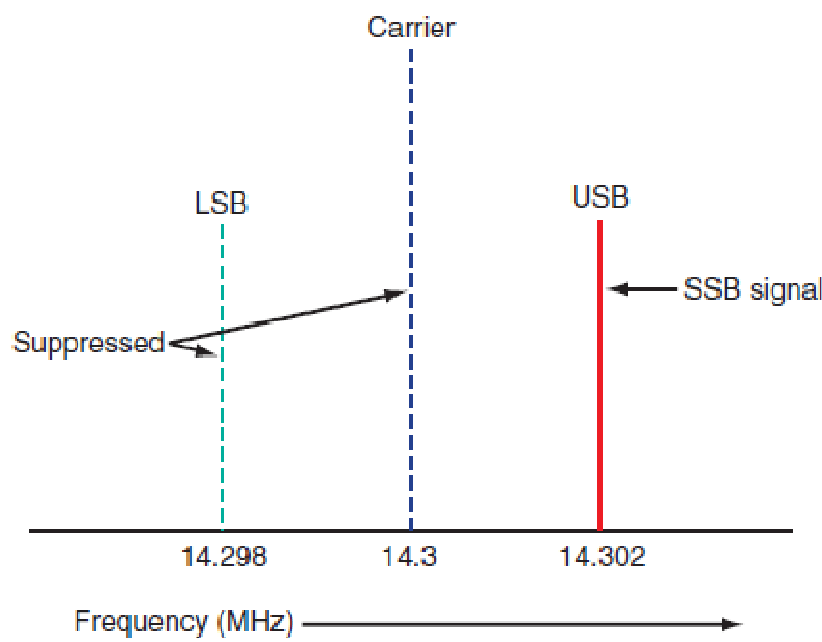
SSB-Single sideband modulation

- In DSB-SC, both the side bands covey the same information. Hence the next possible idea is to eliminate one of the sidebands, with the resulting technique being a single sideband modulation (SSB).
- The carrier and one of the sidebands are suppressed in SSB, only one sideband is transmitted from radio station.
- Total power in SSB technique:

$$P_{T(SSB)} = P_C \, m^2/4$$

Time domain and frequency domain of SSB





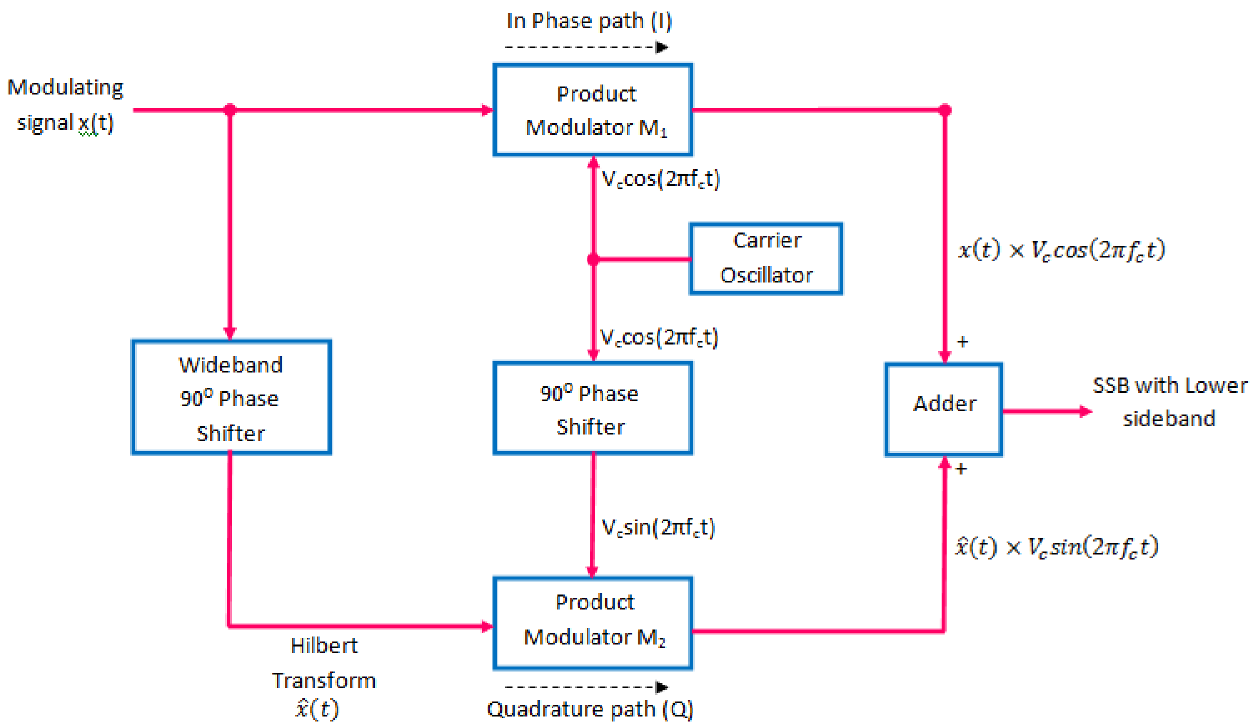
SSB Generation

- There are two methods are used for SSB transmission

  1. Phase Shift Method and
  2. Filter Method

Phase Shift Method

- This system uses two balanced modulators M_1 and M_2 and two 90^o phase shifting networks as shown in fig. 1 .



- It uses two balanced modulators instead of one.
- The balanced modulators effectively eliminate the carrier.
- The carrier oscillator is applied directly to the upper balanced modulator along with the audio modulating signal.
- Then both the carrier and modulating signal are shifted in phase by 90 and applied to the second, lower, balanced modulator.
- The two balanced modulator output are then added together algebraically. The phase shifting action causes one side band to be cancelled out when the two balanced modulator outputs are combined

Analysis

- The carrier signal is $V_c \sin 2\pi f_c t$ the modulating signal is $V_m \sin 2\pi f_m t$ Balanced modulator produces the product of these two signals.

$$\left(V_m \sin 2\pi f_m t\right)\left(V_c \sin 2\pi f_c t\right)$$

- Applying a trigonometric identity.

$$\left(V_m \sin 2\pi f_m t\right)\left(V_c \sin 2\pi f_c t\right) = \frac{1}{2}\left[\cos 2\pi\left(f_c - f_m\right)t - \cos 2\pi\left(f_c + f_m\right)t\right]$$

- Note that these are the sum and difference frequencies or the upper and lower side bands.
- It is important to remember that a cosine wave is simply a sine wave shifted by 90
- The 90 phase shifters create cosine waves of the carrier and modulating signal which are multiplied in balanced modulator to produce

$$V_m \cos 2\pi f_m t \, V_c \cos 2\pi f_c t = \frac{1}{2}\left[\cos 2\pi\left(f_c + f_m\right)t + \cos 2\pi\left(f_c - f_m\right)t\right]$$

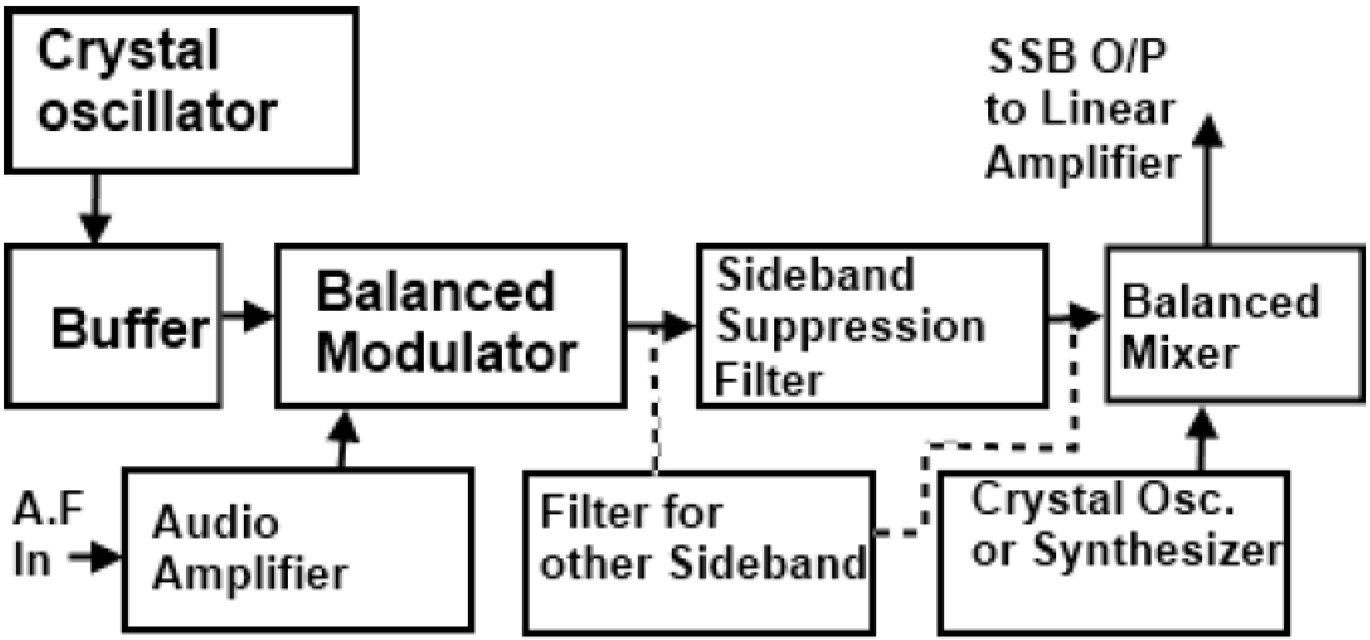
- Another common trigonometric identity translates this to

$$\left[\cos 2\pi\left(f_c - f_m\right)t\right]$$

- Now if you add these two expressions together the sum frequencies cancel while the difference frequencies add producing only the lower side band: $\left[\cos 2\pi\left(f_c - f_m\right)t\right]$

Filter Method

- This is the filter method of SSB suppression for the transmission.



- 1. A crystal controlled master oscillator produces a stable carrier frequency fc (say 100 KHz)
- 2. This carrier frequency is then fed to the balanced modulator through a buffer amplifier which isolates these two stages.
- 3. The audio signal from the modulating amplifier modulates the carrier in the balanced modulator. Audio frequency range is 300 to 2800 Hz. The carrier is also suppressed in this stage but allows only to pass the both side bands. (USB & LSB).
- 4. A band pass filter (BPF) allows only a single band either USB or LSB to pass through it. It depends on our requirements. Let we want to pass the USB then LSB will be suppressed. In this case.

fc = 100 KHz

Audio range = 300 2800Hz

USB frequency range = fc + 300 to fc + 2800

= 100000 + 300 to 100000 + 2800

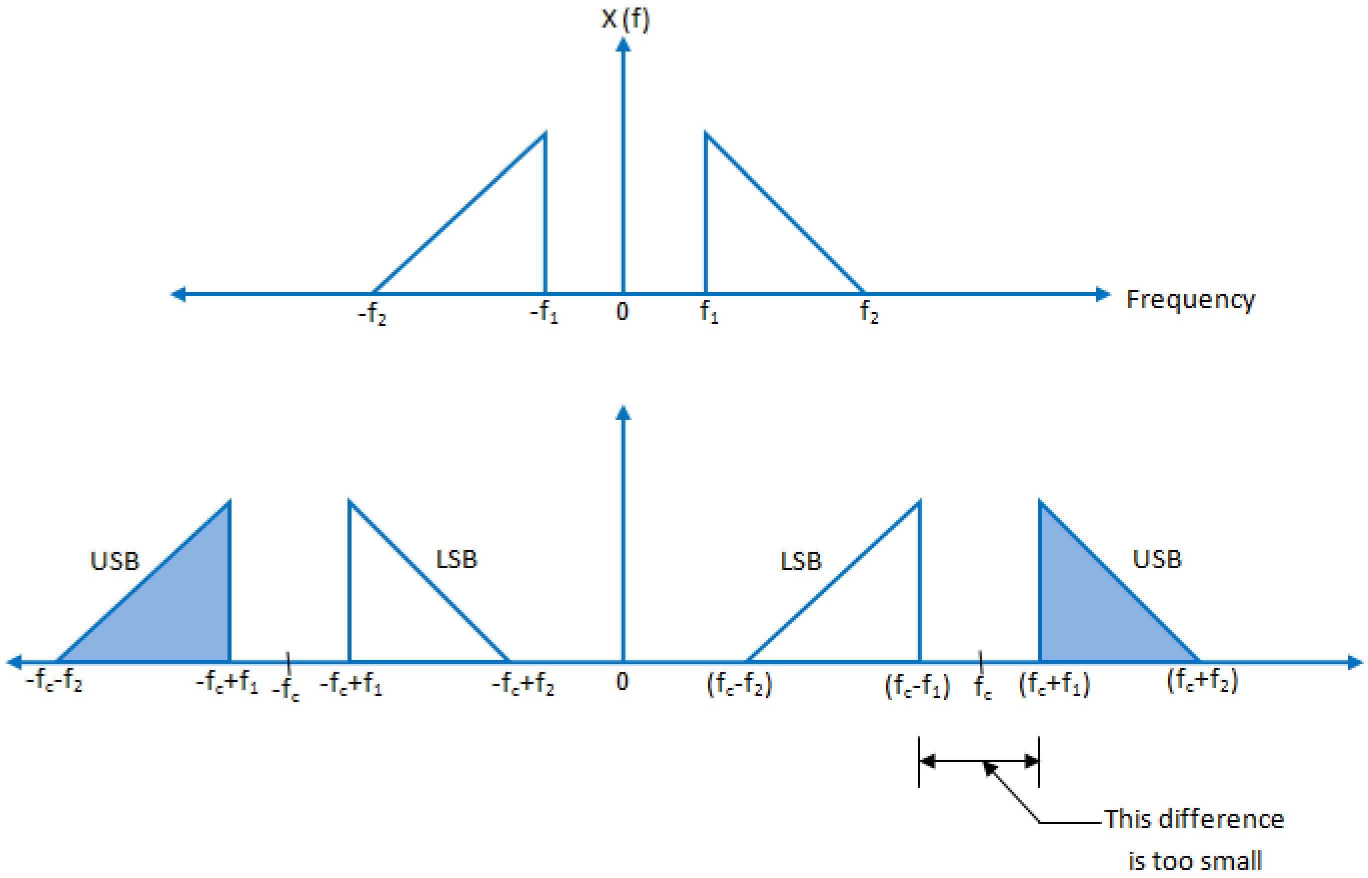
= 100300 to 102800 Hz

So this band of frequency will be passed on through the USB filter section

- 5. This side band is then heterodyned in the balanced mixer stage with 12 MHz frequency produced by crystal oscillator or synthesizer depends upon the requirements of our transmission. So in mixer stage, the frequency of the crystal oscillator or synthesizer is added to SSB signal. The output frequency thus being raised to the value desired for transmission.
- 6. Then this band is amplified in driver and power amplifier stages and then fed to the aerial for the transmission.

- The filter method can be used for generating the SSB modulated wave if the message signal satisfies the following conditions :
  1. The message signal should not have any low frequency content . The audio signal posses this property, e.g. the telephone signal will have a frequency range extending from 300 Hz to 3.4 kHz . The frequencies in the range 0-300 Hz are absent .
  2. The highest frequency in the spectrum of the message signal i.e. W Hz should be much smaller than carrier frequency fc .

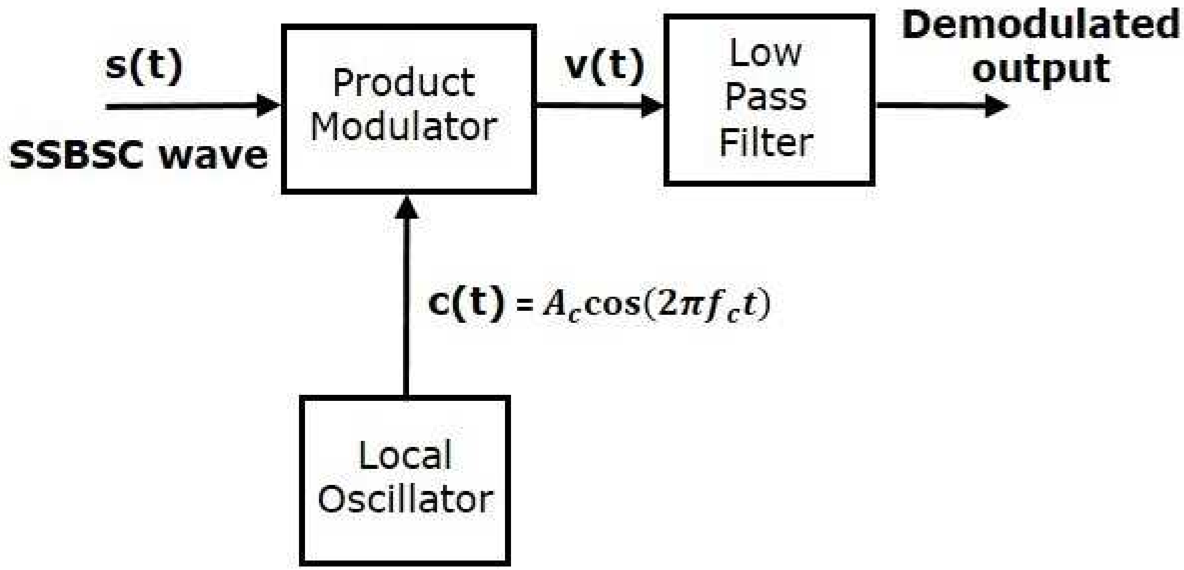
Demerit



X (f)
Frequency
-f2
-f1
0
f1
f2
USB
LSB
LSB
USB
-fc-f2
-fc+f1
-fc
-fc+f1
-fc+f2
0
(fc-f2)
(fc-f1)
fc
(fc+f1)
(fc+f2)
This difference
is too small

- Let us consider fig. 1 which shows the DSB-SC signal at the output of the product modulator which contains both the sidebands .
- The frequency difference between the highest frequency in LSB and the lowest frequency in USB is too small as shown in fig.2 .
- This makes the design of the bandpass filter extremely difficult because its frequency response need to have very sharp change over from attenuation to pass band and vice versa.
- The design of bandpass filter must be based on satisfying the following condition
  - The width of the guard band which separates the passband from stopband be twice the lowest frequency component of the message signal . i.e. Guard band = $2f_1$ Hz

SSB Demodulation



Coherent Detector

- The process of extracting an original message signal from SSBSC wave is known as detection or demodulation of SSBSC. Coherent detector is used for demodulating SSBSC wave.
- Here, the same carrier signal (which is used for generating SSBSC wave) is used to detect the message signal. Hence, this process of detection is called as coherent or synchronous detection.

- In this process, the message signal can be extracted from SSBSC wave by multiplying it with a carrier, having the same frequency and the phase of the carrier used in SSBSC modulation.
- The resulting signal is then passed through a Low Pass Filter. The output of this filter is the desired message signal.

- Consider the following **SSBSC** wave having a **lower sideband**.

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

- The output of the local oscillator is

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

- From the figure, we can write the output of product modulator as

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

- Substitute s(t)and c(t) values in the above equation.
-

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

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

$$= \frac{A_m {A_c}^2}{4} \{\cos[2\pi (2f_c - fm)] + \cos(2\pi f_m) t\}$$

$$v(t) = \frac{A_m {A_c}^2}{4} \cos(2\pi f_m t) + \frac{A_m {A_c}^2}{4} \cos[2\pi (2f_c - f_m) t]$$

- In the above equation, the first term is the scaled version of the message signal. It can be extracted by passing the above signal through a low pass filter.
- Therefore, the output of low pass filter is
- $$v_0(t) = \frac{A_m {A_c}^2}{4} \cos(2\pi f_m t)$$