Single -sideband suppressed-carrier transmission (SSB-SC)

The DSBSC modulated signal has two sidebands. Since, the two sidebands carry the same information, there is no need to transmit both sidebands. We can eliminate one sideband.

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. It is plotted as shown in the following figure 1.3.1.

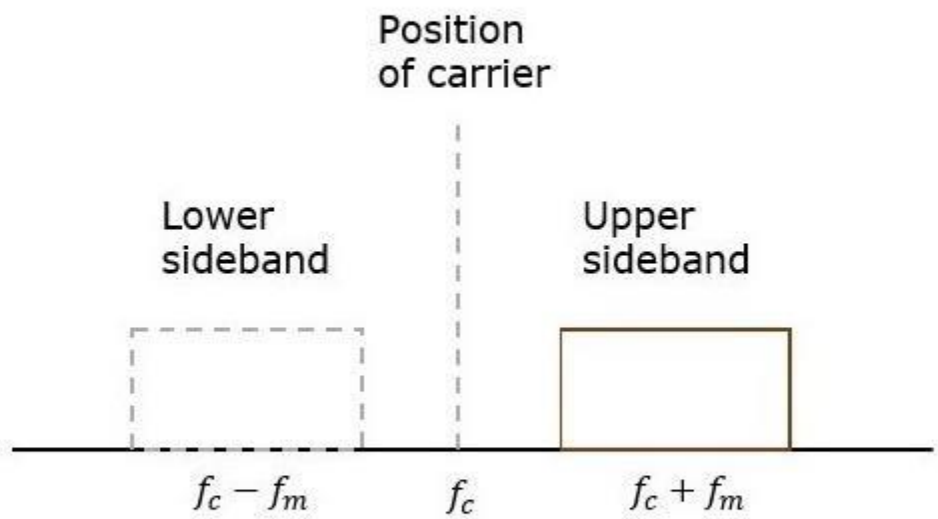

Fig 1.3.1 Carrier and Side band are Suppressed and a single side band is allowed for transmission,

Diagram Source Brain Kart

In the above figure, 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.

This SSBSC 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.

Mathematical Expressions

Let us consider the same mathematical expressions for the modulating and the carrier signals as we have considered in the modulating signal

$$m(t)=A_m\cos(2\pi f_m t) \quad (1)$$

Carrier signal

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

Mathematically, we can represent the equation of SSBSC wave as

$$s(t)=AmAc2\cos[2\pi(fc+fm)t] \text{ for the upper sideband} \quad (3)$$

$$s(t)=AmAc2\cos[2\pi(fc-fm)t] \text{ for the lower sideband}$$

Bandwidth of SSBSC Wave

We know that the DSBSC modulated wave contains two sidebands and its bandwidth is 2fm2fm. 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 =2fm/2

$$=f_m$$

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

Power Calculations of SSBSC Wave

Consider the following equation of SSBSC modulated wave.

$$s(t)=AmAc2\cos[2\pi(fc+fm)t] \text{for the upper sideband Or}$$

$$s(t)=AmAc2\cos[2\pi(fc-fm)t] \text{]for the lower sideband}$$

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

$$Pt=PUSB=PLSB$$

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

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

In this case, the power of the upper sideband is

$$PUSB=(AmAc/2/\sqrt{2})^2/R$$
$$=Am^2Ac^2/8R$$

Therefore, the power of SSBSC wave is

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

SSB TRANSMISSION:

There are two methods used for SSB Transmission.

1. Filter Method
2. Phase Shift Method
3. Block diagram of SSB

Filter Method:

This is the filter method of SSB suppression for the transmission. Figure 1.3.2

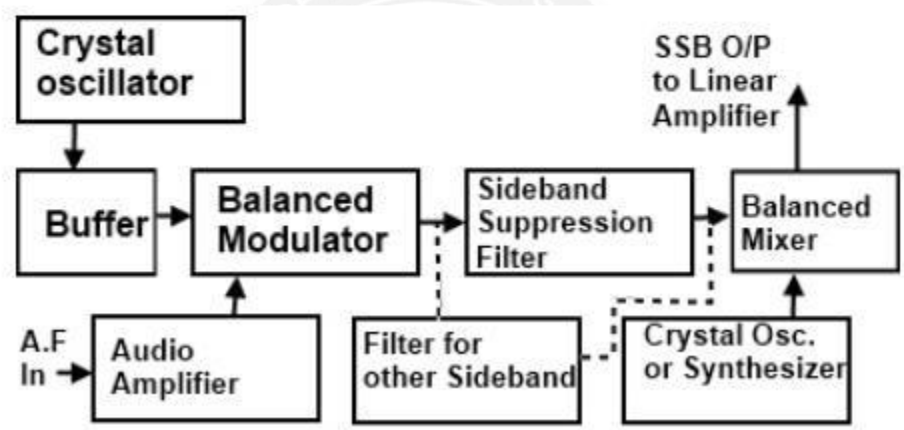

Fig 1.3.2 Filter Method

Diagram Source Electronic tutorials

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.

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 synthersizer 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.

Phase Shift Method:

The phasing method of SSB generation uses a phase shift technique that causes one of the side bands to be canceled out. A block diagram of a phasing type SSB generator is shown in fig 1.3.3.

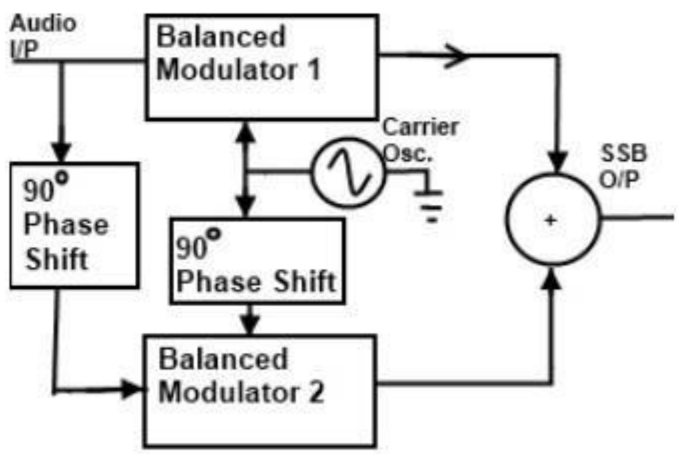

Fig 1.3.3 Phase Shift Method

Diagram Source Electronic tutorials

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 90o 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 canceled out when the two balanced modulator outputs are combined.

Block diagram of SSB:

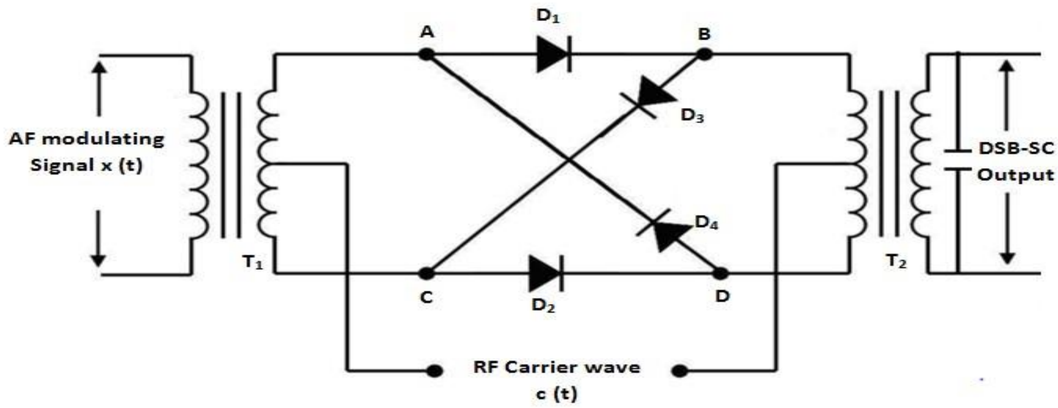

Fig 1.3.4 Balanced Ring Modulator

Diagram Source Electronic Post

Operation of Balance Ring Modulator:

Ring modulation is a signal-processing function in electronics, an implementation of amplitude modulation or frequency mixing, performed by multiplying two signals, where one is typically a sine-wave or another simple waveform is shown in figure 1.3.4. It is referred to as "ring" modulation because the analog circuit of diodes originally used to implement this technique took the shape of a ring. This circuit is similar to a bridge rectifier, except that instead of the diodes facing "left" or "right", they go "clockwise" or "anti-clockwise". A ring modulator is an effects unit working on this principle.

The carrier, which is AC, at a given time, makes one pair of diodes conduct, and reverse-biases the other pair. The conducting pair carries the signal from the left transformer secondary to the primary of the transformer at the right. If the left carrier terminal is positive, the top and bottom diodes conduct. If that terminal is negative, then the "side" diodes conduct, but create a polarity inversion between the transformers. This action is much like that of a DPDT switch wired for reversing connections. Ring modulators frequency mix or heterodyne two waveforms, and output the sum and difference of the frequencies present in each waveform. This process of ring modulation produces some signal rich in partials. As well, neither the carrier nor the incoming signal is prominent in the outputs, and ideally, not at all.

Two oscillators, whose frequencies were harmonically related and ring modulated against each other, produce sounds that still adhere to the harmonic partials of the notes, but contain a very different spectral make up. When the oscillators' frequencies are not harmonically related, ring modulation creates inharmonic, often producing bell-like or otherwise metallic sounds.

If the same signal is sent to both inputs of a ring modulator, the resultant harmonic spectrum is the original frequency domain doubled (if $f1 = f2 = f$, then $f2 - f1 = 0$ and $f2 + f1 = 2f$). Regarded as multiplication, this operation amounts to squaring. However, some distortion occurs due to the forward voltage drop of the diodes.

Some modern ring modulators are implemented using digital signal processing techniques by simply multiplying the time domain signals, producing a nearly-perfect signal output. Before digital music synthesizers became common, at least some analog synthesizers (such as the ARP 2600) used analog multipliers for this purpose; they were closely related to those used in electronic analog computers. (The "ring modulator" in the ARP 2600 could multiply control voltages; it could work at DC.)

Multiplication in the time domain is the same as convolution in the frequency domain, so the output waveform contains the sum and difference of the input frequencies. Thus, in the basic case where two sine waves of frequencies f1 and f2 ($f1 < f2$) are multiplied, two new sine waves are created, with one at $f1 + f2$ and the other at $f2 - f1$. The two new waves are unlikely to be harmonically related and (in a well designed ring modulator) the original signals are not present. It is this that gives the ring modulator its unique tones.

Inter modulation products can be generated by carefully selecting and changing the frequency of the two input waveforms. If the signals are processed digitally, the frequency-domain convolution becomes circular convolution. If the signals are wideband, this will cause aliasing distortion, so it is common to oversample the operation or low-pass filter the signals prior to ring modulation.

One application is spectral inversion, typically of speech; a carrier frequency is chosen to be above the highest speech frequencies (which are low-pass filtered at, say, 3 kHz, for a carrier of perhaps 3.3 kHz), and the sum frequencies from the modulator are removed by more low-pass filtering. The remaining difference frequencies have an inverted spectrum - High frequencies become low, and vice versa.

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.