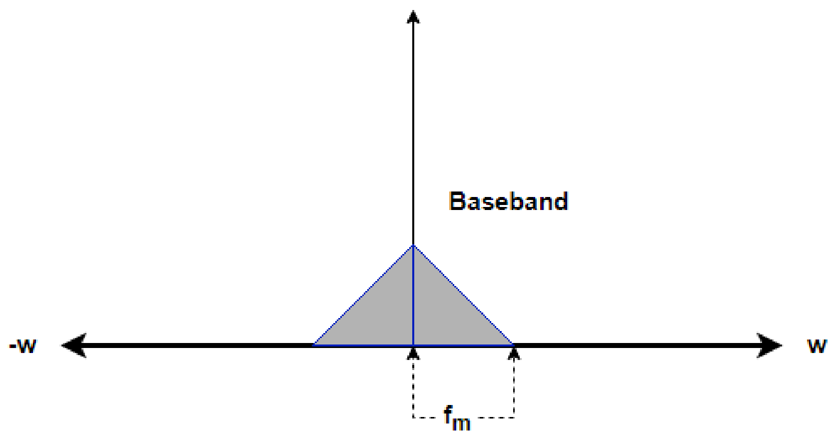
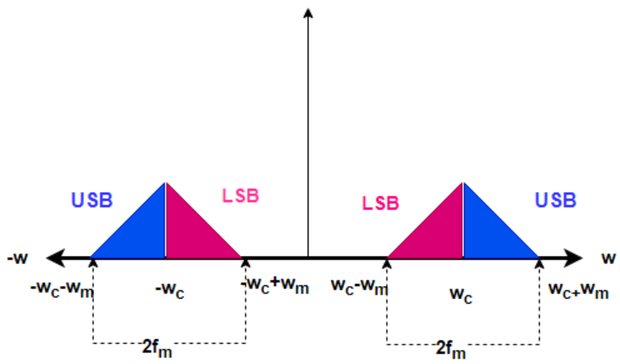
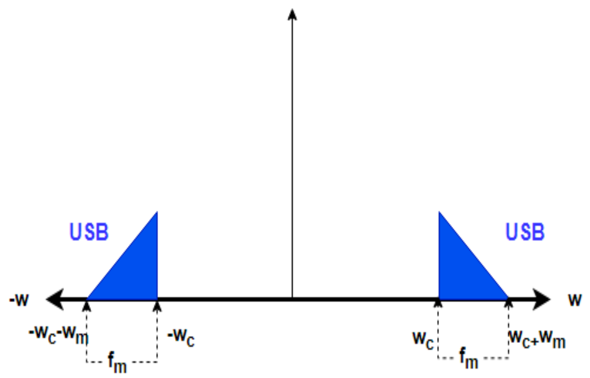
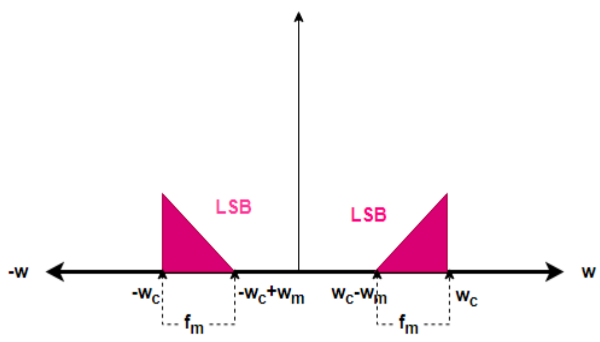
Amplitude Modulation: Single Sideband (SSB)

In suppressing the carrier, DSB-SC modulation takes care of a major limitation of AM that pertains to the wastage of transmitted power. To take care of the other major limitation of AM that pertains to channel bandwidth, we need to suppress one of the two sidebands in the DSB-SC modulated wave. This modification of DSB-SC modulation is precisely what is done in *single sideband (SSB) modulation*. In effect, SSB modulation relies solely on the lower sideband or upper sideband to transmit the message signal across a communication channel. Depending on which particular sideband is actually transmitted, we speak of *lower SSB* or *upper SSB* modulation.





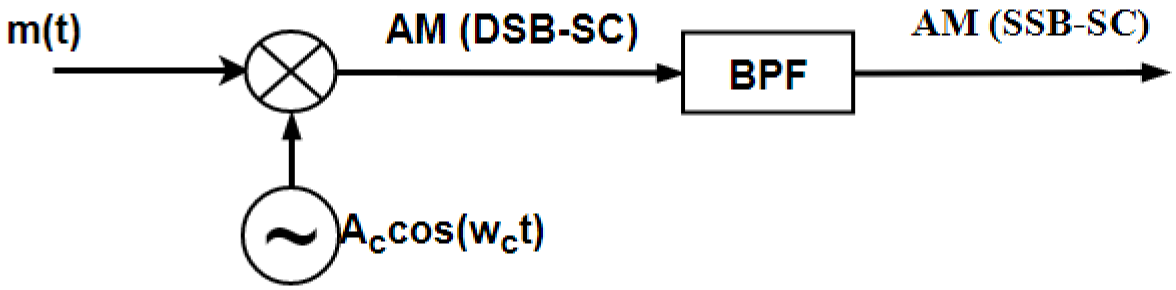




SSB Modulation Systems

1- Selective Filtering Method

The most commonly used method of generating SSB signals, a DSB-SC signal is passed through a sharp cutoff filter to eliminate the undesired sideband. To obtain the USB, the filter should pass all components above frequency f_c unattenuated and completely suppress all components below f_c.



$$x(t) = m(t)A_c \cos(w_c\, t)$$

$$m(t) = A_m \cos(w_m\, t)$$

$$x(t) = A_m \cos(w_m\, t)\, A_c \cos(w_c\, t)$$

$$AM(DSB - SC) = \frac{A_m A_c}{2} \cos(w_c - w_m)t + \frac{A_m A_c}{2} \cos(w_c + w_m)t$$

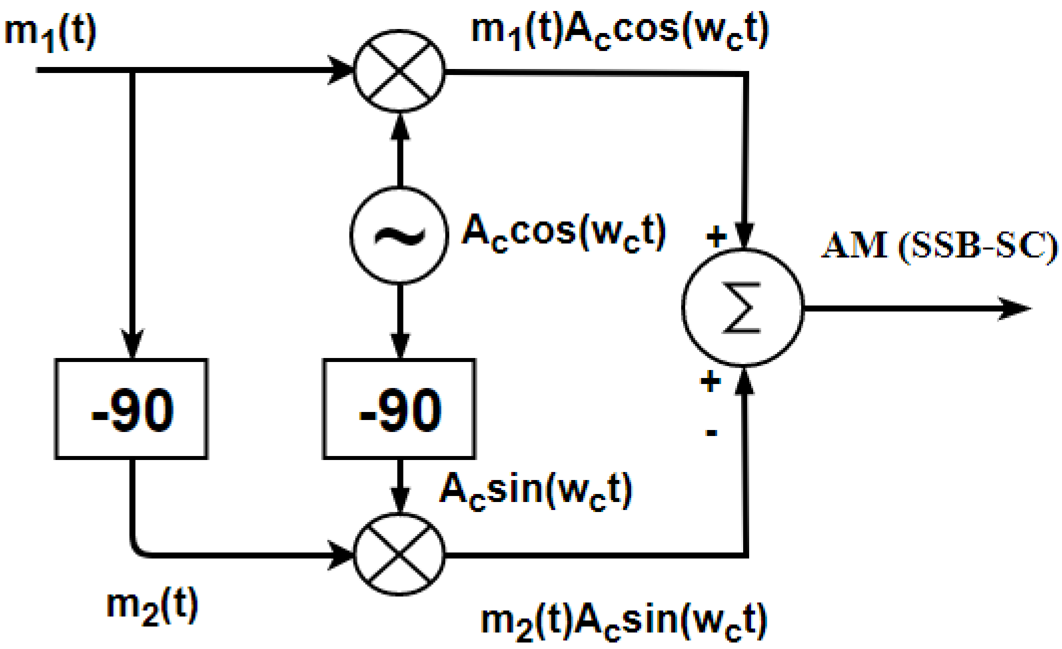
After BPF passing USB

$$\boldsymbol{AM(USSB - SC) = \frac{A_m A_c}{2} \cos(w_c + w_m)\, t}$$

After BPF passing LSB

$$\boldsymbol{AM(LSSB - SC) = \frac{A_m A_c}{2} \cos(w_c - w_m) t}$$

2- Phase Shift Method



$c(t) = A_c \cos(w_c\, t)$

$m(t) = A_m \cos(w_m\, t)$

$x_1(t) = A_m \cos(w_m\, t)\, A_c \cos(w_c\, t)$

$x_1(t) = \frac{A_m A_c}{2}\cos(w_c - w_m)t + \frac{A_m A_c}{2}\cos(w_c + w_m)$

$x_2(t) = A_m \sin(w_m\, t)\, A_c \sin(w_c\, t)$

$x_2(t) = \frac{A_m A_c}{2}\cos(w_c - w_m)t - \frac{A_m A_c}{2}\cos(w_c + w_m)$

$AM(LSB - SC) = x_1(t) + x_2(t)$

$\boldsymbol{AM(LSB - SC) = A_m A_c \cos(w_c - w_m)t}$

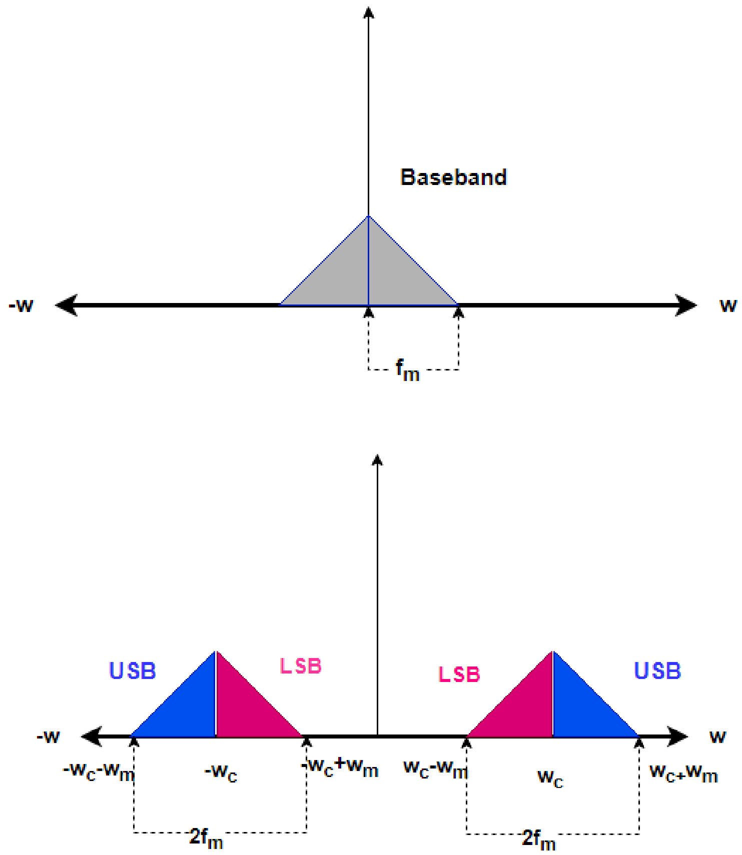
$AM(USB - SC) = x_1(t) - x_2(t)$

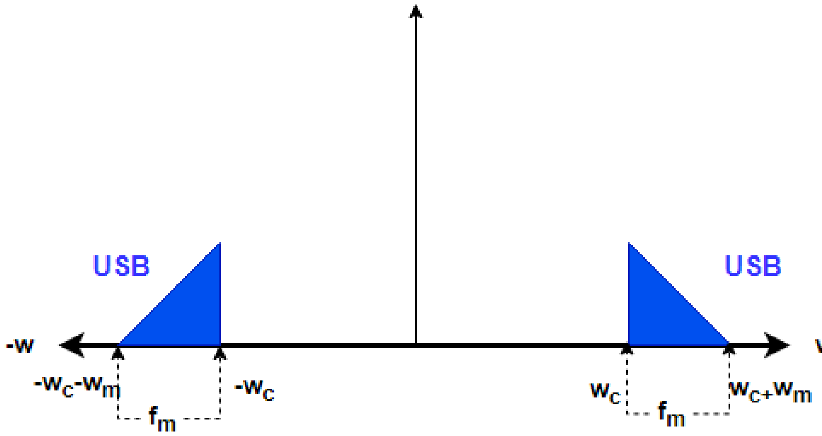
$\boldsymbol{AM(USB - SC) = A_m A_c \cos(w_c + w_m)t}$

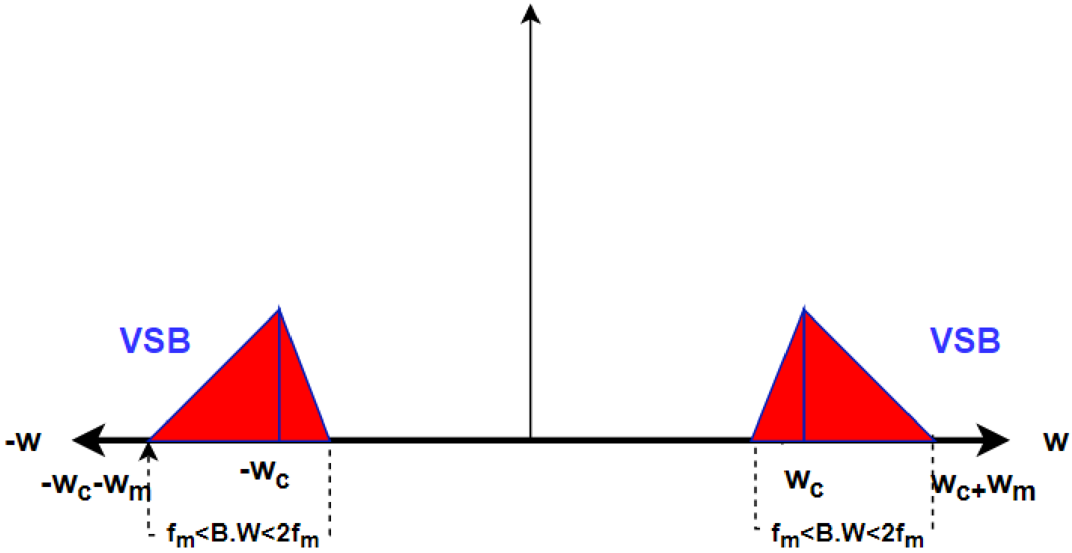
Vestigial Sideband Modulation

As discussed earlier, it is rather difficult to generate exact SSB signals. They generally require that the message signal *m(t)* have a null around de. A phase shifter, required in the phase shift method, is unrealizable, or only approximately realizable. The generation of DSB signals is much simpler, but it requires twice the signal bandwidth. ***Vestigial sideband (VSB)*** modulation, also called the asymmetric sideband system, is a compromise between DSB and SSB. It inherits the advantages of DSB and SSB but avoids their disadvantages at a small cost. VSB signals are relatively easy to generate, and, at the same time, their bandwidth is only a little (typically 25%) greater than that of SSB signals.

In VSB, instead of rejecting one sideband completely (as in SSB), a gradual cutoff of one sideband as shown in Figure below, is accepted. The baseband signal can be recovered exactly by a synchronous detector in conjunction with an appropriate equalizer filter $H_o(w)$ at the receiver output. If a large carrier is transmitted along with the VSB signal, the baseband signal can be recovered by an envelope (or a rectifier) detector.







Modulation VSB

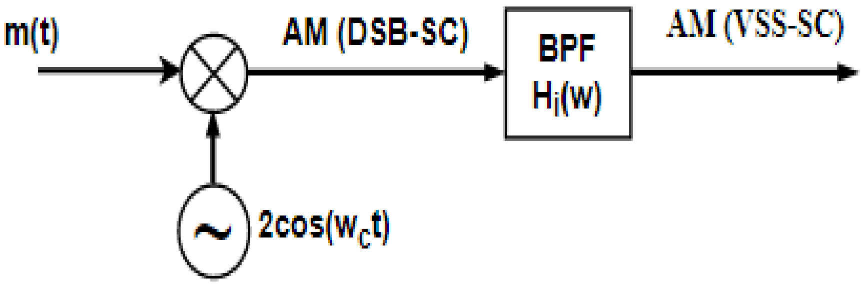
$$x(t) = m(t)2\cos(w_c\,t)h_i(t)$$

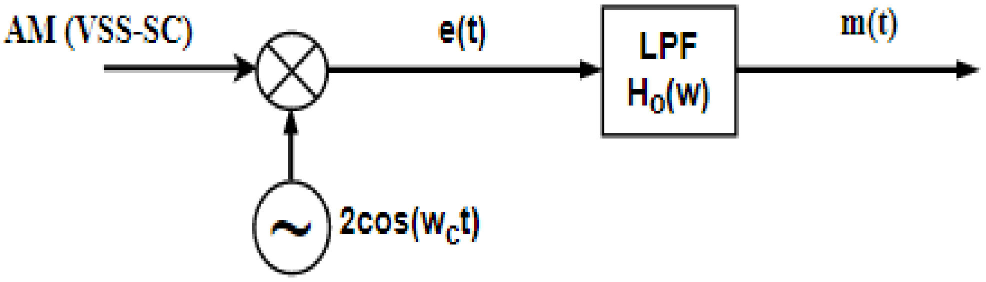
$$\boldsymbol{X}(\boldsymbol{w}) = [\boldsymbol{M}(\boldsymbol{w}+\boldsymbol{w_c}) + \boldsymbol{M}(\boldsymbol{w}+\boldsymbol{w_c})]\boldsymbol{H_i}(\boldsymbol{w})$$

Demodulation VSB

$$m(t) = x(t)2\cos(w_c\,t)h_o(t)$$

$$m(t) = m(t)2\cos(w_c\,t)h_i(t)2\cos(w_c\,t)h_o(t)$$





Amplitude Modulation Advantages & Disadvantages

As with any technology there are advantages and disadvantages to be considered.

Advantages

- It is simple to implement
- It can be demodulated using a circuit consisting of very few components
- AM receivers are inexpensive because no specialized components are required

Disadvantages

- It is not efficient with respect to power usage
- It is not efficient in bandwidth; requires a bandwidth equal to twice the highest audio frequency
- It is prone to high levels of noise because most noise is amplitude based and AM detectors are sensitive to it.