Single Side Band (SSB) Modulation

An SSB signal can be generated directly from the DSBSC signal using an ideal band-pass filter with cut-off frequencies of:

- f_c and $(f_c + W)$ for the upper sideband
- $(f_c - W)$ and f_c for the lower sideband

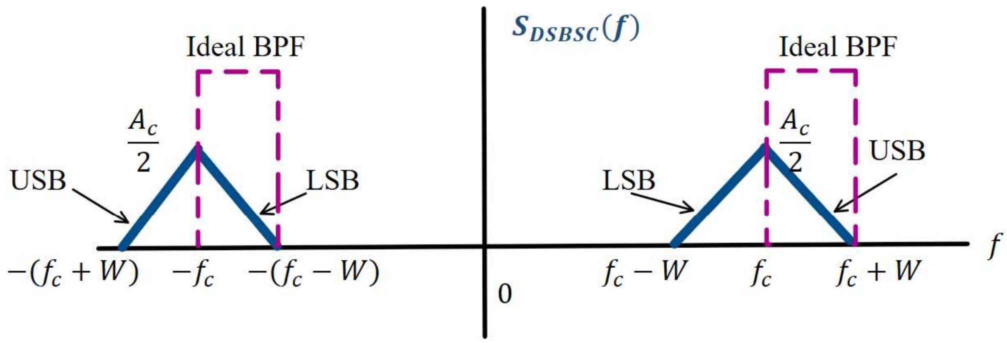

Figure Spectrum of DSBSC signal

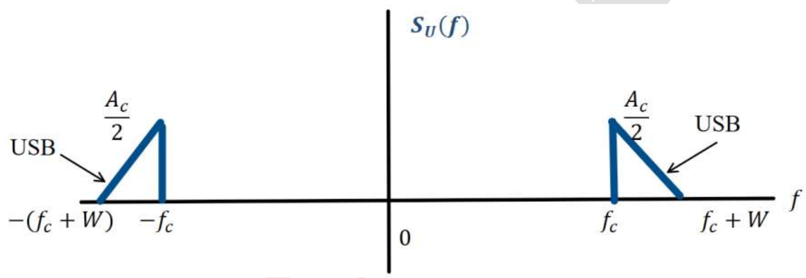

Figure Spectrum of SSB signal containing USB

Similarly, SSB signal containing LSB can be obtained using an ideal BPF with passband extending from $(f_c - W)$ to f_c.

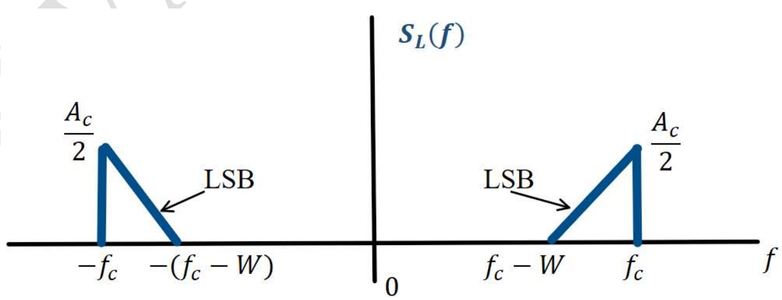

Figure Spectrum of SSB signal containing LSB

SSB finds its greatest application is in the transmission of an analog voice signal. Analog voice has an energy gap in the spectrum near the origin (<300 Hz).

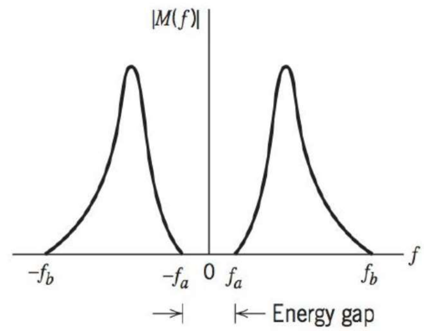

Figure Voice Spectrum with $f_a = 300\ Hz$

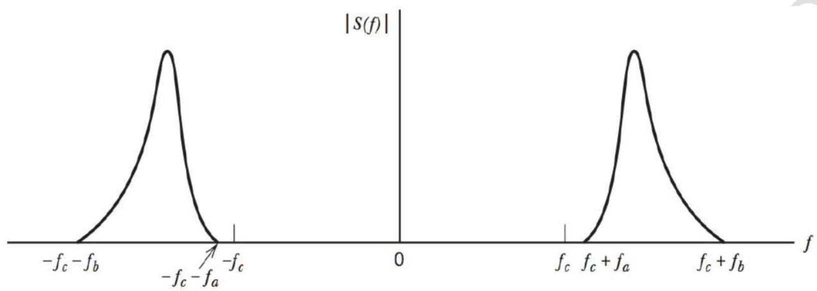

Figure Spectrum of SSB modulated signal from Voice

For message signals like voice, the SSB filter can have a transition band extending from f_c to $(f_c + f_a)$. This nonzero transition bandwidth greatly simplifies the design of the SSB filter.

In particular, the filter must only satisfy the following requirements:

- The desired sideband lies inside the passband of the filter
- The unwanted sideband lies inside the stopband of the filter

SSB Generation:

The SSB signal generation is depicted in the following block diagram:

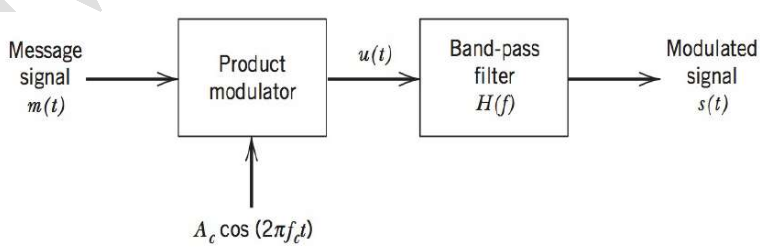

Figure SSB modulator

$H(f)$ = Transfer unction of ideal bandpass filter required to choose desired sideband.

The output of the product modulator is

$$u(t) = A_c \mathrm{m(t)} \cos(2\pi f_c t) \longleftrightarrow U(f) = \frac{A_c}{2}[\mathrm{M}(f - f_c) + \mathrm{M}(f + f_c)]$$

The SSB signal can be expressed in time domain using the concept, called 'Hilbert transform' ie

$$\boxed{s(t) = \frac{A_c}{2}\mathrm{m(t)}\cos(2\pi f_c t) \mp \frac{A_c}{2}\hat{\mathrm{m}}(\mathrm{t})\sin(2\pi f_c t)}$$

Where $\hat{\mathrm{m}}(\mathrm{t})$ is the Hilbert Transform of $m(\mathrm{t})$.

Coherent detection of SSB signal:

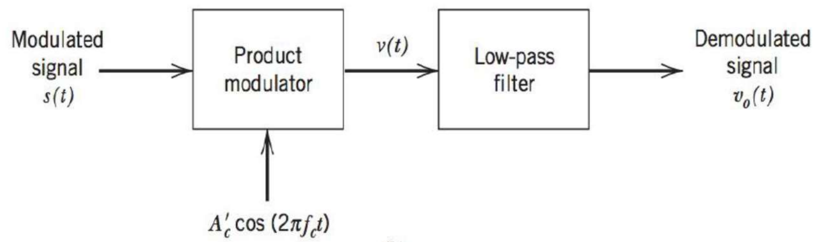

Figure Coherent detection of SSB signal

The synchronization information required to perform coherent demodulation is often obtained by one of two methods:

- Transmitting a low power pilot carrier in addition to the selected sideband,
- Using highly stable local oscillators in receiver for generating carrier frequency.

Advantages:

1. It is a bandwidth-efficient modulation; it demands 50% less bandwidth when compared to that of DSBSC signal.

$$BW\ of\ SSB\ signal = W$$

$$BW\ of\ DSBSC\ signal = 2W$$

2. SSB is also power-efficient technique. It consumes only 50% power when compared to that of DSBSC signal.

Power saving by DSBSC signal $= \frac{P_c}{P_t} = \frac{P_c}{P_c+P_U+P_L} = \frac{P_c}{P_c+P_c\frac{\mu^2}{4}+P_c\frac{\mu^2}{4}} = \frac{1}{1+\frac{\mu^2}{2}}$

Minimum Power saving by DSBSC signal ($\mu = 1$) $= \frac{1}{1+\frac{1}{2}} = \frac{2}{3}$

Minimum Power saving by DSBSC signal = 66.66%

Power saving by SSB signal $= \frac{P_c}{P_t} = \frac{P_c+P_L}{P_c+P_U+P_L} = \frac{P_c+P_c\frac{\mu^2}{4}}{P_c+P_c\frac{\mu^2}{4}+P_c\frac{\mu^2}{4}} = \frac{1+\frac{\mu^2}{4}}{1+\frac{\mu^2}{2}}$

Minimum Power saving by SSB signal $(\mu = 1)$ = $\frac{1+\frac{1}{4}}{1+\frac{1}{2}} = \frac{5}{6}$

Minimum Power saving by SSB signal = 83.33%

Disadvantages:

1. SSB modulation is complex in terms of implementation
2. SSB is expensive because of its demand for highly efficient and complex hardware