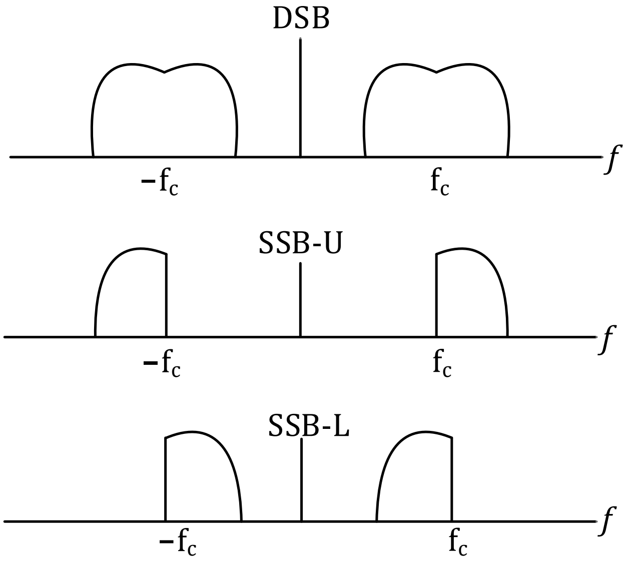
3.2.3 SSB (Single Side Band)

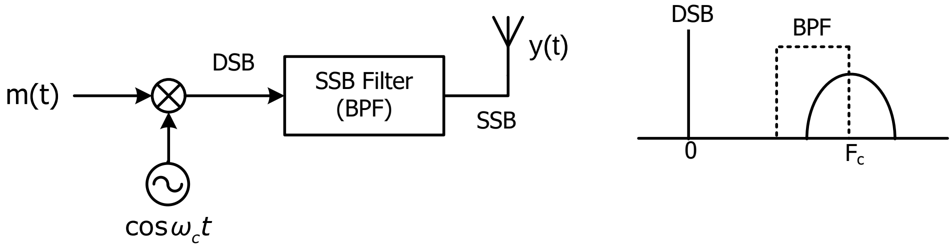
DSB method results in doubling of $m(t)$ bandwidth, which is disadvantage when channel is crowded or expensive. So, we can use only one sideband to be transmitted as it contains all the information about $m(t)$.



<u>MODULATION</u>

(1) Filtering method:

SSB can be generated by filtering the DSB signal. In practice, this operation is not easy because it is difficult to meet such filter requirements.



(2) Phase shift method:

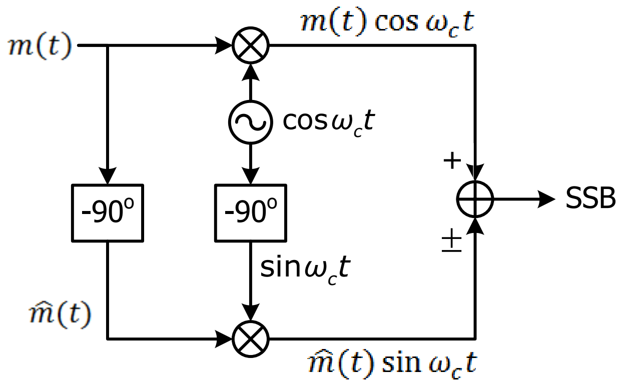
Since the ordinary AM signal is $y(t) = m(t)\cos(\omega_c t)$, letting $m(t) = \cos(\omega_m t)$, so:

$y(t) = \cos(\omega_m t) \times \cos(\omega_c t) = \frac{1}{2}\cos(\omega_c + \omega_m)t + \frac{1}{2}\cos(\omega_c - \omega_m)t$ =DSB

Yields:

$\cos(\omega_c + \omega_m)t = \cos(\omega_c t)\cos(\omega_m t) - \sin(\omega_c t)\sin(\omega_m t)$ ≡ Upper SSB

$\cos(\omega_c - \omega_m)t = \cos(\omega_c t)\cos(\omega_m t) + \sin(\omega_c t)\sin(\omega_m t)$ ≡ Lower SSB



But $\cos\theta = \sin(\theta \pm 90°)$, hence:

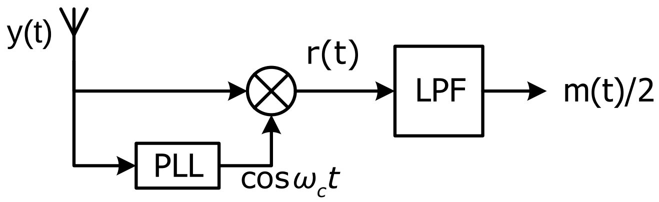
Upper SSB is $y(t) = m(t)\cos(\omega_c t) - \hat{m}(t)\sin(\omega_c t)$

Lower SSB is $y(t) = m(t)\cos(\omega_c t) + \hat{m}(t)\sin(\omega_c t)$

Where $\hat{m}(t)$ is shifting the phase of $m(t)$ by 90°

The main problem of SSB systems is the practical realization of the 90° phase shifter.

DEMODULATION



$y(t) = m(t)\cos(\omega_c t) \pm \hat{m}(t)\sin(\omega_c t)$

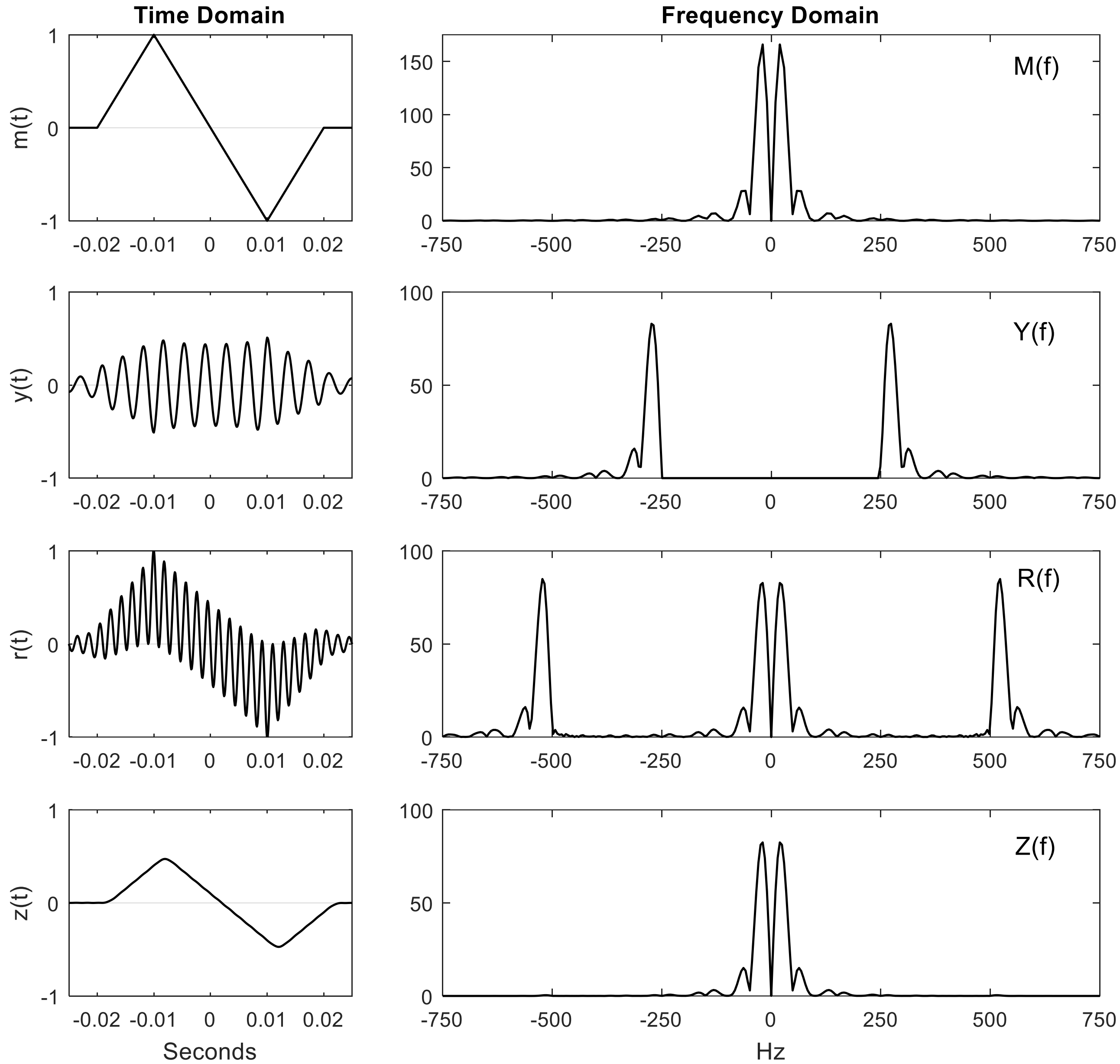
$$R(t) = y(t)\cos(\omega_c t)$$

$$= m(t)\cos^2(\omega_c t) \pm \hat{m}(t)\sin(\omega_c t)\cos(\omega_c t)$$

$$= \frac{1}{2}m(t) + \frac{1}{2}m(t)\cos(2\omega_c t) \pm \frac{1}{2}\hat{m}(t)\sin(2\omega_c t)$$

The high frequency parts are removed by LPF, yields: $m(t)/2$.

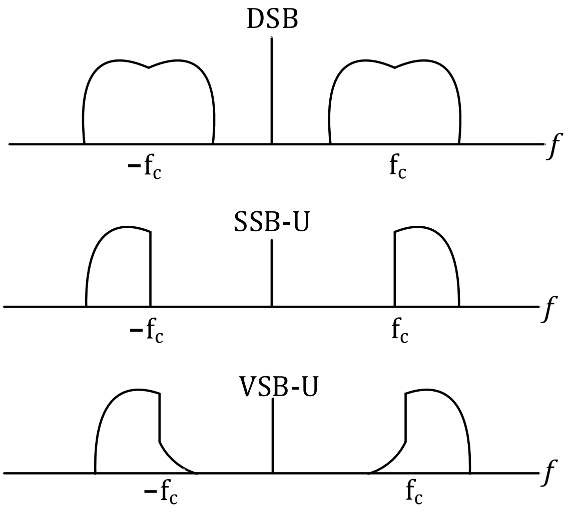
Illustration:



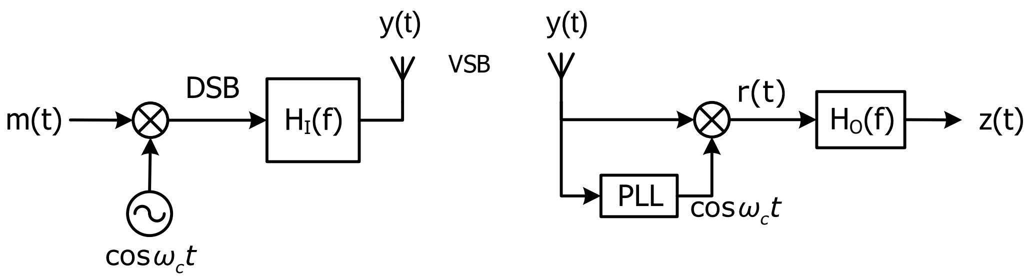
3.2.4 VSB (Vestigial Side Band)

Because of double BW usage in DSB method, and the selective-filtering and phase shifter limitations in SSB method, VSB is a compromise between DSB and SSB.

Instead of rejecting one sideband completely as in SSB, a gradual cutoff of one sideband is accepted: (VSB BW=one sideband +25% of the other sideband)



MODULATION AND DEMODULATION

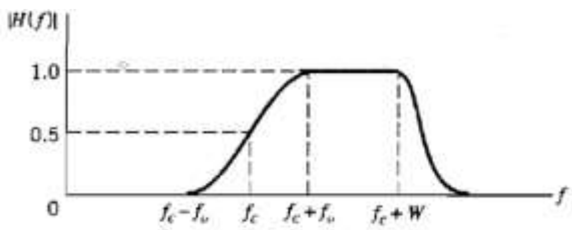


$Y_{VSB}(f) = \{M(f + f_c) + M(f - f_c)\} \times H_I(f)$

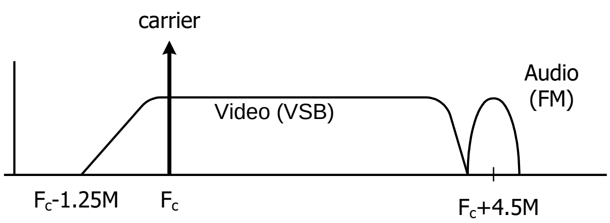
$r(t) = y_{VSB}(t)\cos\omega_c t \Leftrightarrow R(f) = Y_{VSB}(f + f_c) + Y_{VSB}(f - f_c)$

$$Z(f) = M(f)\{H_I(f + f_c) + H_I(f - f_c)\} \times H_O(f)$$

And to obtain $z(t) = m(t), H_O(f) = \frac{1}{H_I(f+f_c)+H_I(f-f_c)}$



The VSB technique is used in the analog TV broadcasting system for video signals. The following figure is a typical analog TV signal (Audio Video), *why?*



3.2.5 AM Summary

(1) Full amplitude modulation (DSB-LC), in which the upper and lower sidebands are transmitted in full, accompanied by the carrier wave. Accordingly, demodulation of an AM signal is done rather simply in the receiver by using an envelope detector, for example. It is for this reason we find that full AM is commonly used in commercial AM radio broadcasting, which involves a single powerful transmitter and numerous receivers that are relatively inexpensive to build.

(2) DSB-SC, in which only the upper and lower sidebands are transmitted. The suppression of the carrier wave means that DSB-SC modulation requires much less power than full AM to transmit the same message signal; this advantage of, however, attained at the expense of increased receiver complexity. Suppressed carrier signals require complicated circuits at receivers for synchronization. DSB-SC is therefore well suited for point-to-point communication involving one transmitter and one receiver.

(3) SSB, in which only the upper sideband or lower sideband is transmitted. This is the optimum form of CW modulation if is required the minimum transmitted power and the minimum channel bandwidth for conveying a message signal from one point to another. However, its use is limited to message signals with an energy gap centered on zero frequency beside its complex systems.

(4) VSB, in which almost all of one sideband and a vestige of the other sideband are transmitted. It requires a channel bandwidth that is between that required for SSB and DSB-SC systems, and the saving in bandwidth can be significant if modulating signals with large bandwidths are being handled, as in the case of television signals and high-speed data.