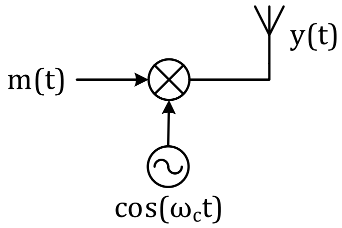
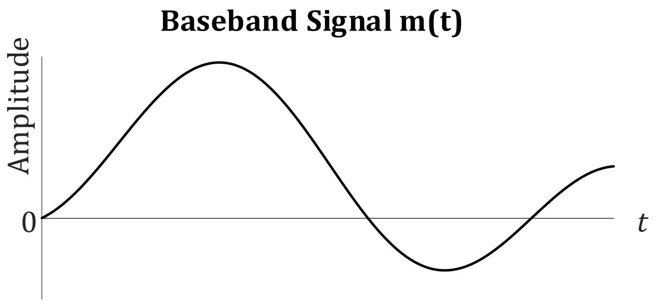
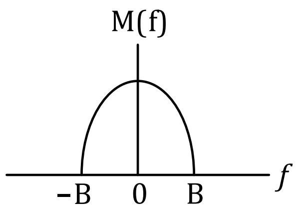
3.2.2 DSB-SC (Double Side Band – Suppressed Carrier)

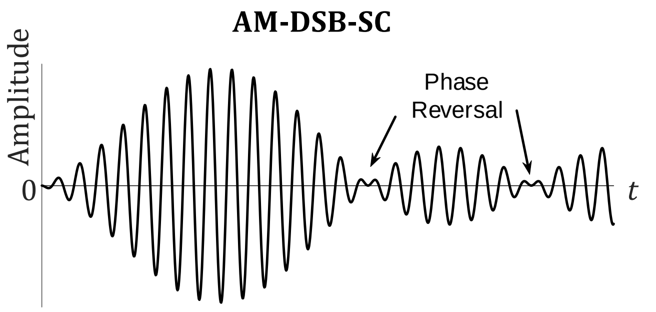
MODULATION

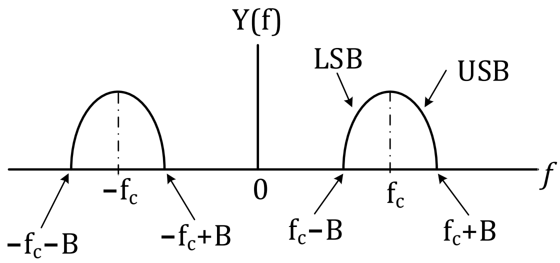
The amplitude modulation can be achieved without the large carrier component in its spectrum. This saves the transmission energy and hence improves ρ. The information signal can be transmitted through a channel by modulating the carrier signal $\cos(\omega_c t)$ via simple multiplication, or *coupling*. The AM-DSB-SC wave becomes $y(t) = m(t)\cos(\omega_c t)$.





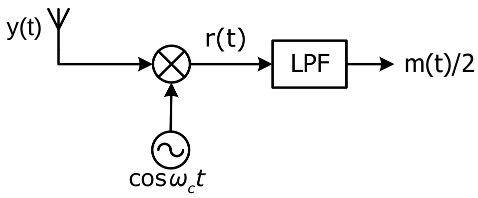


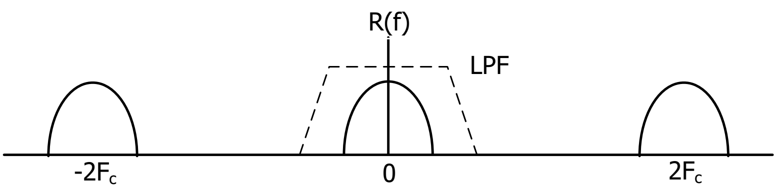




DEMODULATION

Demodulation is restoring the shifted spectrum of $m(t)$ in $y(t)$ back to its original position:





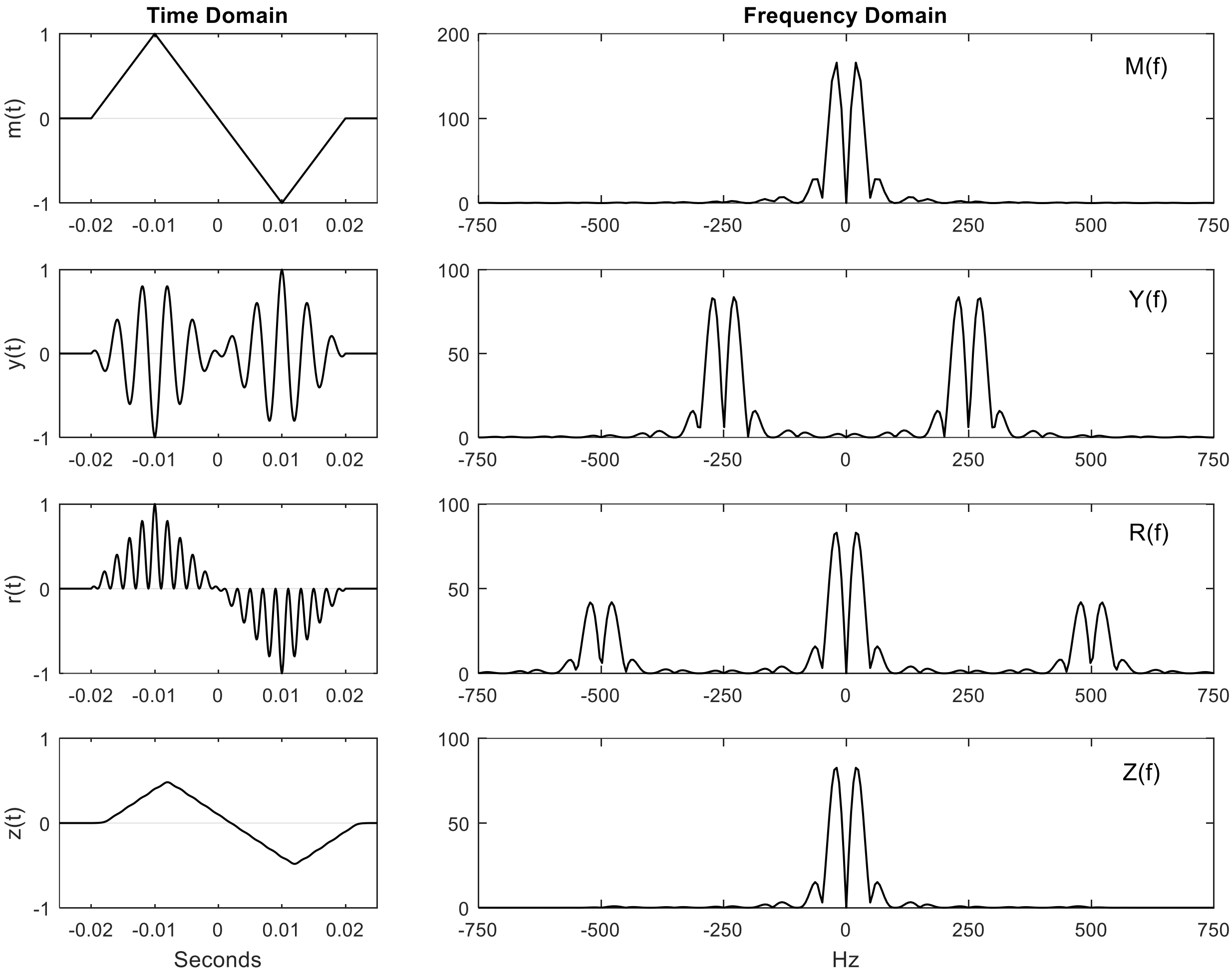
$$r(t) = y(t) \times \cos(\omega_c t) = m(t)\cos^2(\omega_c t)$$

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

The last term is eliminated by LPF. So, the output becomes:

$$z(t) = \frac{1}{2}m(t)$$

Illustration:



Importance of Synchronization in DSB-SC

Due to several reasons, the locally generated carrier signal at the reception end has some differences in frequency and/or phase. If the signal $y(t) = m(t)\cos\omega_c t$ is received, and the receiver carrier is $\cos[(\omega_c + \Delta)t + \theta]$, then

$$r(t) = y(t)\cos[(\omega_c + \Delta)t + \theta]$$

$$= m(t)\cos(\omega_c t)\cos[(\omega_c + \Delta)t + \theta]$$

$$= \frac{1}{2} m(t) \cos(\Delta t + \theta) + \frac{1}{2} m(t) \cos[(2\omega_c + \Delta)t + \theta]$$

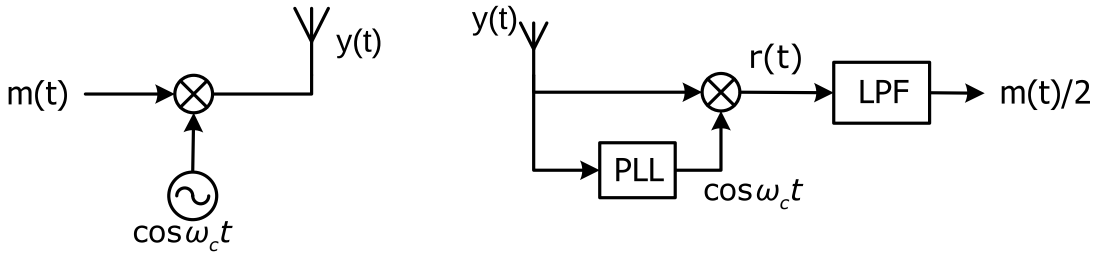
The second term will be removed by LPF, yields $m(t)/2$ multiplied by a factor ≤ 1, as:

$$z(t) = \frac{1}{2} m(t) \cos(\Delta t + \theta)$$

The value of this undesirable scale is governed by Δ and θ. Or:

- $\cos(\Delta t + \theta) = 1$ when Δ & $\theta = 0$ (Synchronous or Coherent Reception)
- $\cos(\Delta t + \theta) < 1$ when Δ & $\theta \neq 0$

So, it is important to perform the synchronous detection of DSB to maximize the output. This can be done using the PLL: when the modulator and the demodulator are remotely located, all synchronous receivers must involve a PLL to re-generate a fresh and in-phase carrier.



Power Calculations of DSB-SC

Let modulating signal or the baseband signal is

$$m(t) = A_m \cos(\omega_m t)$$

And the carrier is

$$c(t) = A_c \cos(\omega_c t)$$

The modulated signal is

$$y(t) = m(t) \times c(t)$$

$$= A_m A_c \cos(2\pi f_m t) \cos(2\pi f_c t)$$

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

Here the USB frequency is $(f_c + f_m)$ and the LSB frequency is $(f_c - f_m)$. And the bandwidth of $y(t)$ is $f_{\max} - f_{\min} = 2f_m$.

The power of DSBSC is the sum of powers of the USB and the LSB components.

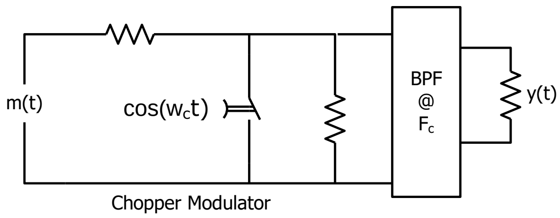
$$P_T = P_{\text{USB}} + P_{\text{LSB}}$$

The formula for power of cosine signal is $P = \frac{V_{\text{rms}}^2}{R} = \frac{\left(V_{\text{peak}}/\sqrt{2}\right)^2}{R}$, so:

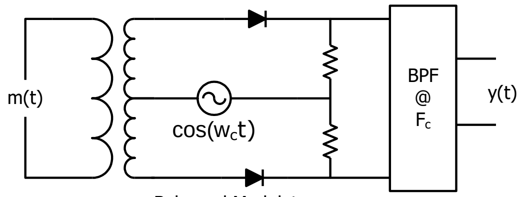
$$P_{\text{USB}} = \frac{\left(A_m A_c/2\sqrt{2}\right)^2}{R} = \frac{A_m^2 A_c^2}{8R} = P_{\text{LSB}}$$

$$\therefore\ P_T = \frac{A_m^2 A_c^2}{4R}$$

GENERATION OF DSB-SC



Chopper Modulator



Balanced Modulator