Department of Communications Engineering

Communication Systems

Third Year Class

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Lecture 2

Amplitude Modulation

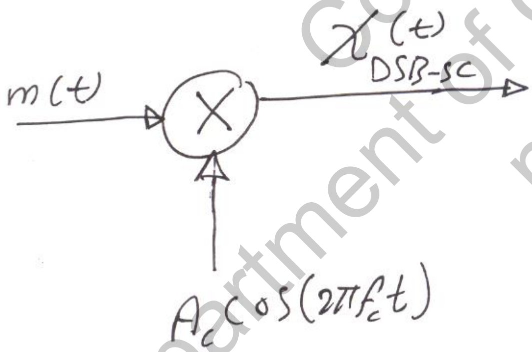
Amplitude Modulation :-

* In linear modulation, there are DSB-SC, AM-modulation, & SSB modulation.

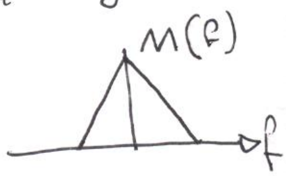
For the double side band DSB modulation:-

if the message is $m(t)$ and the carrier is $A_c \cos(2\pi f_c t)$, then the modulated DSB-SC signal is

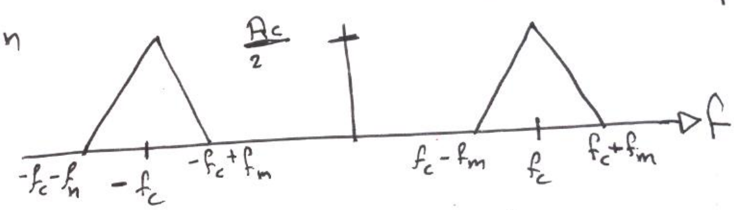
$$x_{DSB-SC}(t) = A_c m(t) \cos(2\pi f_c t) \quad (1)$$



assume the message in frequency domain is a triangular function

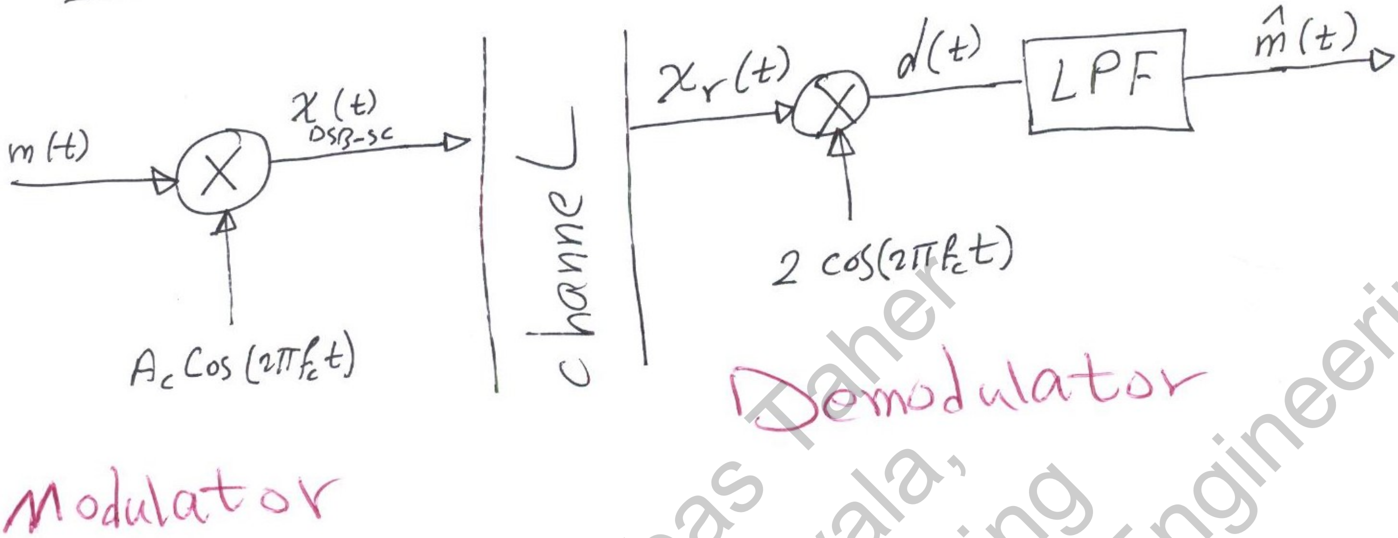


then



Thus, $X_{DSB-SC}(f) = \frac{A_c}{2} M(f - f_c) + \frac{1}{2} A_c M(f + f_c)$

DSB-SC Demodulation

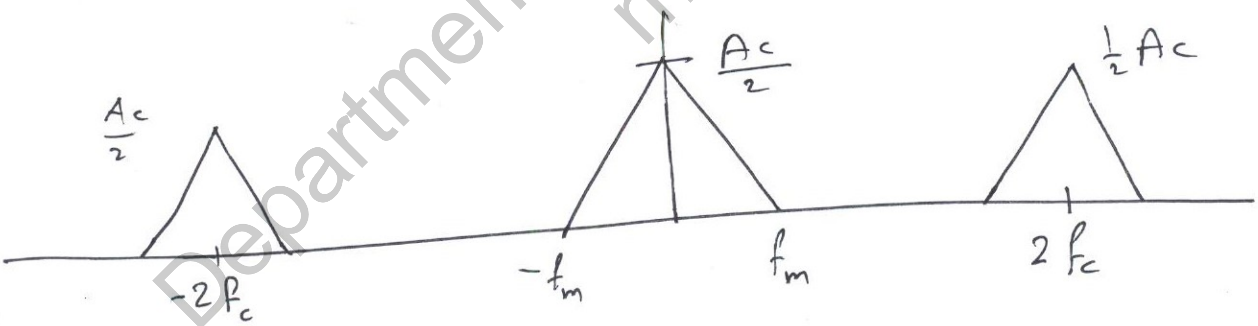


Assuming an ideal channel

$$d(t) = \left[A_c\, m(t) \cos(2\pi f_c t)\right] 2\cos(2\pi f_c t)$$

$$d(t) = A_c\, m(t) + A_c\, m(t) \cos(2\pi (2f_c) t)$$

$$D(f) = A_c M(f) + \frac{A_c}{2} M(f - 2f_c) + \frac{A_c}{2} M(f + 2f_c)$$



* A_c can be adjusted since it is simply a gain only. AGC amplifier can adjust it as an example.

In Double Side Band modulation, the required bandwidth (see the plot of the spectrum on page 2) is double the message's frequency f_m.

$$\therefore BW_{DSB\text{-}SC} = 2f_m$$

At the Demodulator side, the carrier should be identical to that in the transmitter (Modulation). Moreover, the phase also should be exactly synchronous.

if neither the frequency nor the phase are correct, there will be a major problem in the process of message recovery.

* Let the carrier is imperfect as $c(t) = 2\cos[2\pi f_c t + \theta(t)]$, then, where $\theta(t)$ is time-varying phase error

$$d(t) = A_c m(t)\cos\theta + A_c m(t)\cos[2\pi f_c t + \theta(t)]$$

$\hat{m}(t) = m(t)\cos(\theta(t))$ ——— if $\theta(t)$ slowly varying or constant then, $\cos(\theta(t))$ appears as fixed or time varying attenuation factor

- If $\theta(t) = \Delta f t$

and $m(t) = \cos(2\pi f_m t)$ then

$$\hat{m}(t) = \frac{1}{2}\left[\cos[2\pi(f_m - \Delta f)t] + \cos[2\pi(f_m + \Delta f)t]\right]$$

thus, the received message $\hat{m}(t)$ is a sum of two tones.

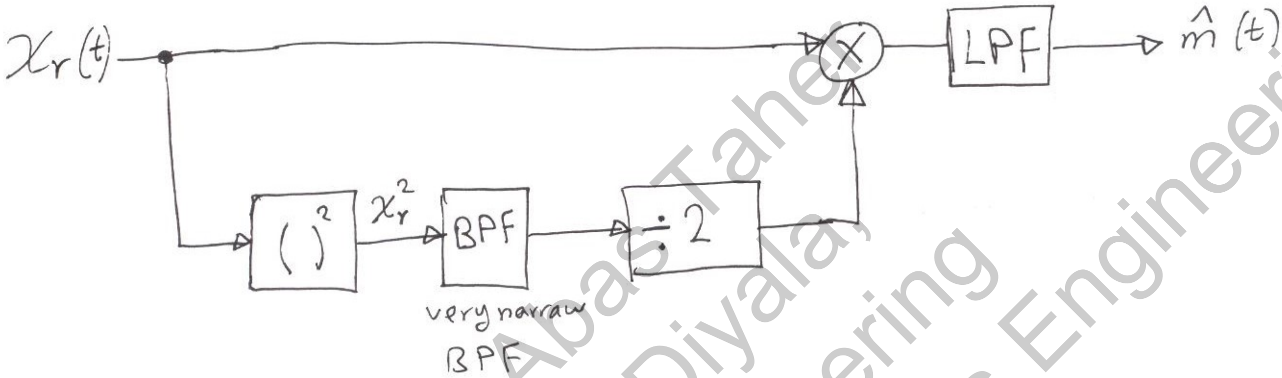
Hence, it is very important to provide a perfect synchronized carrier in the receiver. Then we perform the Coherent demodulation

Many methods are available to recover the carrier from the transmitted (modulated) signals such as the;

1. square Law.
2. phase Locked Loop (PLL).

we will see here the first method, square Law, while the PLL will be discussed Later in details.

By squaring the received signal $\hat{m}(t)$, we can extract the carrier completely as follows:-



$$x_r^2(t) = A_c^2\, m^2(t) \cos^2(2\pi f_c t)$$

$$= \frac{1}{2} A_c^2 m^2(t) + \frac{1}{2} A_c^2 m^2(t) \cos\left[2\pi (2f_c)\, t\right]$$

Amplitude Modulation :- [used in Radio broadcasting & TV picture]

amplitude modulation is simply **DSB + carrier**

Thus,

$$x_{AM}(t) = A_c\, m(t) \cos(2\pi f_c t) + A_c \cos(2\pi f_c t)$$

$$X_{AM}(f) = \frac{A_c}{2}\left[M(f+f_c) + M(f-f_c)\right] + \underbrace{\frac{A_c}{2}\left[\delta(f+f_c) + \delta(f-f_c)\right]}_{\text{pure carrier}}$$

* In this case the Bandwidth $BW = 2f_m$