Notes 14 largely plagiarized by %khc

1 AM-DSB Synchronous Demodulation without Phase Lock

When we use a synchronous demodulator, we implicitly assume that the carrier $\cos \omega_c t$ is perfectly synchronized with the oscillator in the synchronous demodulator. This condition of being perfectly synchronized is referred to as being "in phase lock". What happens if AM-DSB is demodulated in a synchronous demodulator without phase lock?

Let's consider the synchronous demodulator in Figure 1. Assume that the oscillator in the synchronous demodulator

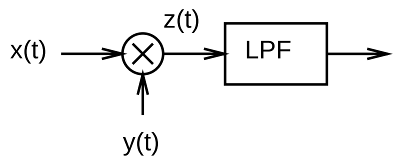

Figure 1: Synchronous demodulator.

is out of phase from the carrier by θ. So

$$\begin{aligned} y(t) &= \cos(\omega_c t + \theta) \\ &= \cos \omega_c t \cos \theta - \sin \omega_c t \sin \theta \end{aligned}$$

If $x(t)$ has the spectrum $X(\omega)$ as in Figure 2 [so that the original message is a triangle], multiplying $x(t)$ in time by $y(t)$ is the same as convolving $X(\omega)$ by $Y(\omega)$. Note that even though $Y(\omega)$ is complex, there really isn't anything

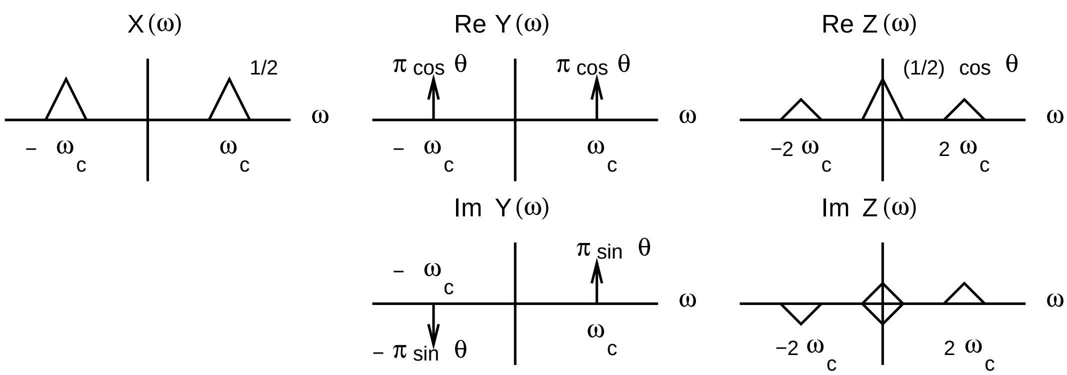

Figure 2: Synchronous demodulator.

new here. Instead of doing one convolution, we do two of them instead. [In general, convolving a complex signal with another complex signal will involve four convolutions, one for each possible combination of real and imaginary parts.] What we come out with in Figure 2 is that $Z(\omega)$ will have only one thing at baseband— the original message, but scaled by $\frac{1}{2} \cos \theta$.

It is this $\cos \theta$ factor which causes AM-DSB to be improperly demodulated. If the oscillator in the demodulator leads or lags the carrier by $\frac{\pi}{2}$, then $\cos \theta$ will be zero, and we will get no message.

2 Power

To examine the power used in sending an AM-DSB-LC signal, let's consider sending a periodic $m(t)$ with power P_m. Following our development in notes 13, we end up sending out the modulated signal:

$$\begin{aligned} x(t) &= (1 + \mu m(t)) \cos \omega_c t \\ &= \cos \omega_c t + \mu m(t) \cos \omega_c t \end{aligned}$$

The spectrum of this signal is also sketched in that same set of notes. Since the cosine is periodic, we can use Parseval's theorem for periodic signals, which relates the power of a periodic signal to its Fourier series coefficients:

$$\frac{1}{T}\int_T x^2(t)dt = \sum_{k=-\infty}^{+\infty} |a_k|^2$$

So the Fourier series coefficients of the $\cos\omega_c t$ term are $\pm\frac{1}{2}$ and the power in the carrier is then $\frac{1}{2}$.

Let's assume that $m(t)$ has power P_m. The $\mu m(t)\cos\omega_c t$ term leads to two copies of $M(\omega)$, each scaled by $\frac{\mu}{2}$. The power of the copy centered at ω_c is $\frac{\mu^2}{4}P_m$ [if the signal is scaled by A, the power increases by A^2]; since there are two copies, the total power in the $\mu m(t)\cos\omega_c t$ term will be $\frac{\mu^2}{2}P_m$.

Summing the two quantities, we end up with total power $\frac{1}{2}+\frac{\mu^2}{2}P_m$, as discussed in lecture.

3 A Look Ahead

Dual sideband schemes waste bandwidth. Single sideband schemes don't. We'll see them next time, along with the Hilbert transform.