EE 567

Homework 3

Due Tuesday, September 18, 2018

Work all 7 problems.

Problem 1. Suppose

$$m(t) = sinc(100t), \quad sinc(x) = \frac{\sin \pi x}{\pi x}.$$

We form the DSB-SC signal as

$$s(t) = m(t) \cos(10000\pi t).$$

Find $S(f)$.

Problem 2. Suppose

$$m(t) = \frac{1}{1 + t^2}.$$

We form the DSB-SC signal as

$$s(t) = m(t) \cos(10000\pi t).$$

Find $S(f)$.

Problem 3. Suppose

$$m(t) = \cos(100\pi t) + 2\cos(300\pi t).$$

We form the DSB-SC signal as

$$s(t) = 2m(t) \cos(1000\pi t).$$

Find $S(f)$.

Problem 4. Suppose

$$m(t) = \sin(100\pi t)\sin(500\pi t).$$

We form the DSB-SC signal as

$$s(t) = 2m(t)\cos(10000\pi t).$$

Find $S(f)$.

Problem 5. Let

$$m(t) = \sum_{k=-\infty}^{\infty} (40(t-0.1k)-2)\,(u(t-0.1k)-u(t-0.1k-0.1))$$

Plot $s(t) = [A + m(t)]cos(2\pi f_c t)$ for modulation indexes $\mu = 0.5,\ 1,\ 2,\ \infty$. Observe that $\mu = \infty$ is equivalent to DSB-SC modulation. Here t is in units of seconds and $f_c = 10$ Hz.

Problem 6. In this problem you can use Matlab but work as much analytically as you can. Suppose you transmit to someone the message signal

$$m(t) = \begin{cases} 1, & 0 \le t \le 1 \text{ msec}, \\ 0, & elsewhere. \end{cases}$$

The actual transmission is accomplished by using DSB-SC via

$$s(t) = m(t)\cos(2\pi f_c t)$$

where, $f_c = 1$ MHz. This is a finite duration signal so it has an infinite nonzero frequency content. At the receiver a bandpass filter is applied to $s(t)$ so necessarily $m(t)$ cannot be recovered perfectly in an actual system. Suppose an ideal bandpass filter $H_B(f)$ is used with height unity centered at $\pm f_c$ that extends from $f_c - B$ to $f_c + B$ and $-f_c - B$ to $-f_c + B$.

Let us define a distortion measure as

$$D_B = 10 \cdot \log_{10} \frac{\int_{-\infty}^{\infty} |S(f)H_B(f)|^2 df}{\int_{-\infty}^{\infty} |S(f)|^2 df} \quad \text{(dB)}$$

so that no distortion ($B = \infty$) corresponds to $D_B = 0$ dB.

a. Plot D_B for $B = 200$ Hz up to $B = 20$ KHz.

b. Determine the smallest value of B such that $D_B > -1$ dB.

Problem 7. What does the concept of negative frequency mean?