EE 567

Homework 3

Due Tuesday, September 17, 2019

Work all 4 problems.

Problem 1. You are given the baseband signal $m(t) = \cos(1000\pi t)$.

a. Sketch the spectrum of $m(t)$.

b. Sketch the spectrum of the DSB-SC signal $m(t)\cos(10,000\pi t)$.

Problem 2. You are asked to design a DSB-SC to generate a modulated signal $s(t) = km(t)\cos(2\pi f_c t)$ where $m(t)$ is a signal band-limited to B Hz. One could simply multiply $km(t)$ by $\cos(2\pi f_c t)$ to accomplish this. However, suppose that we do not have available an oscillator to generate the signal $\cos(2\pi f_c t)$ but we do have available an oscillator that can generate the signal $\cos^3(2\pi f_c t)$. We also have a bandpass filter that we can tune to any frequency and bandwidth. Can we still generate $s(t)$ with this equipment? If so, explain how. Hint: Make use of a trig identity involving $\cos^3(\theta)$.

Problem 3. In a DSB-SC amplitude modulation system the message signal is $m(t) = e^{-t}u(t-2)$ and the carrier signal is $\cos(2000\pi t)$.

a. Find the Fourier transform of the message signal and plot its magnitude.

b. Find the Fourier transform of the modulated signal and plot its magnitude.

Problem 4. In this problem you are to use a software tool (such as Matlab). Suppose you transmit to someone the message signal

$$m(t) = \begin{cases} 1000t, & 0 \le t \le 1/2 \text{ msec}, \\ 1 - 1000t, & 1/2 < t \le 1 \text{ msec}. \end{cases}$$

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 $B = 10$ KHz down to $B = 100$ Hz.

b. Determine the smallest value of B such that $D_B > -2$ dB.