Homework 4 (Due on Oct. 16)

1. (Different Analog Modulation Schemes) (20pts)

Using the message signal $m(t) = 10\cos 10\pi t$ and modulation carrier $C(t) = 2\cos 200\pi t$, determine the modulated signals (time domain expression) for the following methods of modulation, and draw the spectrum of the modulated signals.

a) Double-sideband-suppressed carrier (DSB-SC) modulation.
b) Double-sideband, Large carrier (DSB-LC) modulation with modulation index a=0.1.
c) Single-sideband (SSB) modulation with upper sideband retained.
d) Vestigial-sideband (VSB) modulation with the following VSB filter H(f) in Figure1.

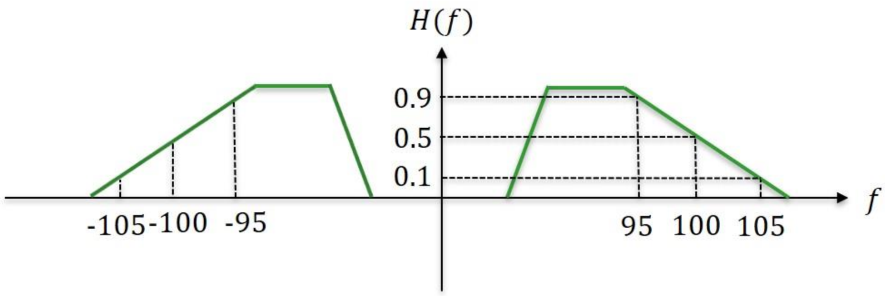

Figure 1

2. (DSB-LC or AM) (20pts)

An AM (i.e., DSB-LC) modulator has output $x_c(t) = 40\cos[400\pi t] + 10\cos[360\pi t] + 10\cos[440\pi t]$. Determine the modulation index, the carrier power, the sideband power and the transmission efficiency.

3. (Demodulation of SSB) (20pts)

a) Consider a message signal m(t) containing frequency components at 100, 200 and 400 Hz. This signal is applied to an SSB modulator together with a carrier at 100 kHz, with only the upper sideband retained. In the coherent detector used to recover m(t), the local oscillator supplies a cosine wave of frequency 100.02 kHz. Determine the frequency components of the detector output.
b) Repeat your analysis, assuming that only the lower sideband is transmitted.

Note that the following two problems are two extension problems based on what you have learned on the class.

4. (Square-Law Modulator) (30pts)

Consider a square-law modulator, as shown in Figure 2. Assume that the average value of m(t) is zero ($\langle m(t)\rangle = 0$), and that the maximum value of $|m(t)|$ is M. Also assume that the square-law device in Figure 2 is defined by $y(t) = a_1 x(t) + a_2 x^2(t)$, where a_1 and a_2 are constants.

a) Write the equation for $y(t)$.
b) Assume the bandwidth of the message signal m(t) is W. Describe the filter in Figure 2, that yields an AM signal for g(t) with f_c as the carrier frequency. Give the necessary

filter type and the carrier frequencies of interest. (Hint: What is the center frequency of the filter, what's the bandwidth of the filter, what's the requirement for the carrier frequency f_c in order to generate an AM signal using square-law modulator. Note that AM signal means DSB-LC modulated signal)

c) What's the modulation index of the output AM signal g(t)? (Hint: express the modulation index using a_1, a_2 and M)

d) What is the advantage of this method of modulation?

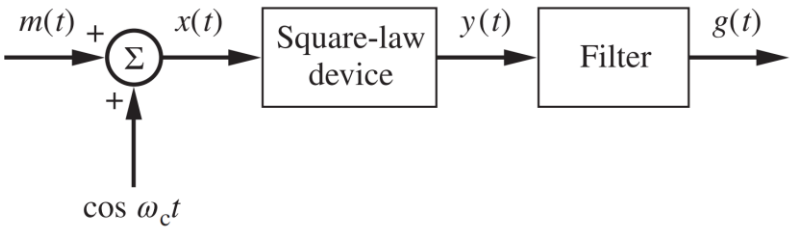

Figure 2

5. (Square-Law Detector) (10pts)

Consider a square-law detector as shown in Figure 3, using a nonlinear device whose transfer characteristic is defined by $y(t) = a_1 x(t) + a_2 x^2(t)$, where a_1 and a_2 are constants, $x(t)$ is the input, and $y(t)$ is the output. The input consists of the AM wave $x(t) = A_c[1 + a m_n(t)] \cos \omega_c t$.

a) Write the equation for $y(t)$.

b) Find the condition for which the message signal m(t) may be recovered from the $y(t)$. (Hint: What's the ratio of the wanted signal to the distortion, and how to keep the ratio large?)

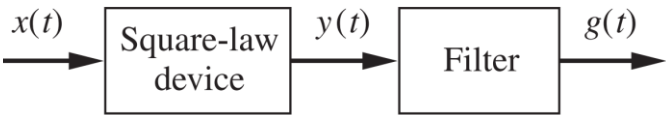

Figure 3