ECE 457
HOMEWORK #2
Due January 28, 2005

- Read Chapter 3.1.1
- Office Hours: W, 11:30-1:00 p.m., Th, 9:30-11:00 a.m. 2210EB.

1. [20] The message signal $m(t)$ is given by $m(t) = \sin c(100t)$. The message signal is modulated by the carrier $\cos(2\pi f_c t)$ where $f_c = 250Hz$ to produce a DSB signal, y(t).

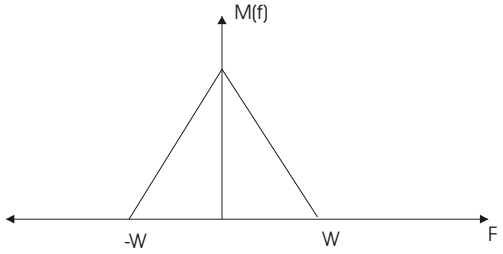
a) Plot the spectrum for the message signal.
b) Plot the spectrum for the DSB signal, $y(t)$.
c) What's the bandwidth of the DSB modulated signal?

2. [25] The message signal $m(t) = 2\cos(2000\pi t) + 4\cos(8000\pi t)$ is modulated by the carrier $x_c(t) = 50\cos(2\pi f_c t)$, where $f_c = 50kHz$.
   a) Using MATLAB, plot the DSB modulated signal.
   b) Sketch the amplitude and phase spectrum of the DSB signal. Verify your results using MATLAB. Include your script and plots of the amplitude and the phase spectra.
   Hint: This is similar to the example on the web page.
   c) Compute the power of the DSB signal.

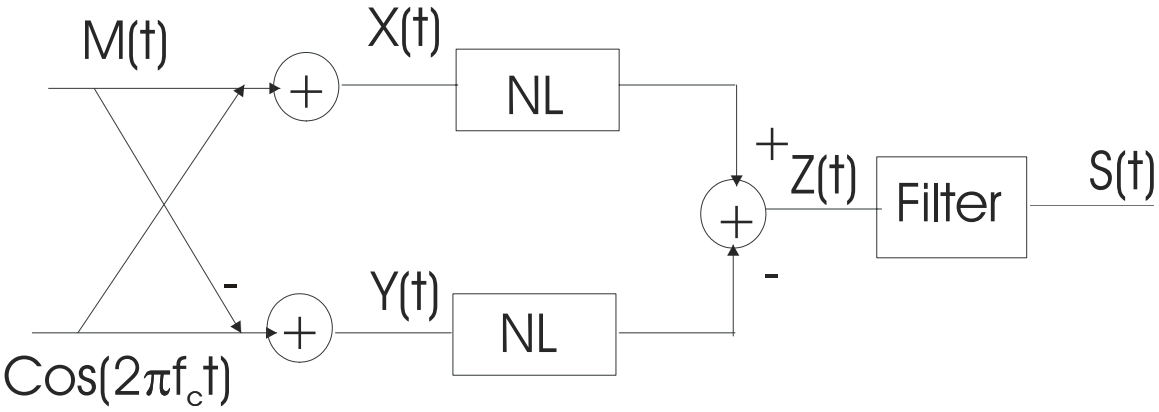
3. [20] A DSB modulated signal $y(t) = Am(t)\cos(2\pi f_c t)$ is mixed (multiplied) with a local carrier $\cos(2\pi f_c t + \theta)$, and the output is passed through a lowpass filter with a bandwidth equal to the bandwidth of the message signal, $m(t)$. The signal power at the output of the lowpass filter is denoted by P_{out}. The modulated signal power is denoted by P_Y. Find the ratio $\frac{P_{out}}{P_Y}$ and plot it as a function of θ for $0 \le \theta \le \pi$ using MATLAB.

4. [15] Consider a message signal $m(t)$ with the spectrum shown in the figure. The message bandwidth $W = 1kHz$. This signal is applied to a product modulator with carrier wave $A_c\cos(2\pi f_c t)$, producing the DSB modulated signal $s(t)$. The modulated signal is next applied to a coherent demodulator discussed in class. Determine the spectrum of the demodulator output when:
   a. The carrier frequency is 1.25kHz.
   b. The carrier frequency is 0.75kHz.

c. What's the lowest carrier frequency for which each component of the modulated signal $s(t)$ is uniquely determined by $m(t)$?



5. [20] There are different ways to implement a modulator. One way is to use nonlinear devices such as a diode or a transistor. Consider the following scheme, which uses two identical nonlinear elements shown by boxes, marked NL. Let the input-output characteristics of these nonlinear elements be approximated by $v(t) = au(t) + bu^2(t)$, where u(t) is the input and v(t) is the output.



Assuming m(t) to be a message signal with bandwidth W, we want to design the filter such that the output of the system is a DSB modulated signal.

a) Give an expression for z(t).
b) Sketch the spectrum of z(t). Assume the spectrum of m(t) is as given in the previous question.
c) Specify the filter such that the output is a DSB signal, i.e. you should state the type of the filter (lowpass/higpass/bandpass), bandwidth, and cutoff frequencies.