HOMEWORK ASSIGNMENT #3

Due Fri. Jan. 25, 2008 (in class)

Reading:

1. Ch. 3.1–3.5.

Problems:

1. Coherent AM Computer Experiment:

   Thoughout, assume sampling rate $\frac{1}{Ts} = 1000$ Hz.

   (a) Generate a random message signal $m(t)$ with length $t_{\max} = 1$ sec and single-sided bandwidth $W = 25$ Hz. To do this, lowpass filter a $t_{\max}$-long random signal (generated via `randn`). I suggest designing the LPF using `fir2` with a passband edge of $W/4$, a stopband edge of W, and a group delay of $t_o = 50$ msec. Finally, plot the message signal in time and frequency domains using `plottf`. Does the message look as expected?

   (b) Modulate the message using suppressed-carrier AM with carrier frequency $f_c = 200$ Hz. Plot the transmitted signal in time and frequency domains using `plottf`. Does the transmitted signal look as expected?

   (c) Coherently AM-demodulate the transmitted signal. For this, use a receiver LPF designed using `fir2` with a passband edge of W, a stopband edge of $2f_c - W$, and a group delay of $t_o = 10$ msec. Plot the recovered signal in the time domain using `plottf`, then superimpose the original message on the same plot using

   ```
   hold on; hh = plottf(m,Ts,'t'); hold off;
   set(hh,'LineStyle','--','Color','Red');
   ```

   (Make sure you use the latest version of `plottf.m` from the course webpage.) How does the recovered signal compare to the original message?

   (d) Repeat part (c) assuming the receiver has a carrier frequency offset of $f_o = 1$ Hz, and comment on the effect.

2. Non-Coherent AM Computer Experiment:

   (a) Repeat 1(a) to generate a message signal (but without plots). Then modulate the message using large-carrier AM with carrier frequency $f_c = 200$ Hz and pilot amplitude $A = 0.5$. Plot the transmitted signal in time and frequency domains using `plottf`. Does the transmitted signal look as expected?

   (b) Non-coherently demodulate the transmitted signal using an envelope detector. For this, use a receiver LPF designed using `fir2` with a passband edge of W, a stopband edge of f_c, and a group delay of $t_o = 10$ msec. Plot the recovered signal in the time domain using `plottf`, then superimpose the original message on the same plot using the method of 1(c). (Remember to remove the DC offset from the LPF output.) How does the recovered signal compare to the original message?

(c) Repeat parts (b)-(c) using a pilot amplitude of $A = 0.1$, and comment on the effect of this change.

3. Coherent QAM Computer Experiment:

   (a) Repeat 1(a) to generate two message signals, $m_{\mathrm{I}}(t)$ and $m_{\mathrm{Q}}(t)$ (but without plots). Then simultaneously QAM-modulate the messages using carrier frequency $f_c = 200$ Hz. Plot the transmitted signal in time and frequency domains using `plottf`. Does the transmitted signal look as expected? Comment on the frequency-domain symmetry.

   (b) Coherently QAM-demodulate the transmitted signal using the same LPF designed in 1(c), then superimpose plots of the recovered and original message signals (using the method of problem 1(c)). How do the recovered signals compare to the original messages?

   (c) Repeat part (c) assuming the receiver has a carrier phase offset of $\pi/2$ radians, and comment on the effect.

4. Say that a friend of yours proposed to modulate message $m(t)$ with single-sided bandwidth W Hz as follows:

$$s(t) = [m(t) + A]\sin(2\pi f_c t), \text{ where } f_c \gg W.$$

   (a) Describe all details of a coherent receiver (i.e., a receiver which is perfectly frequency/phase synchronized to the transmitter). What is the recommended value for A?

   (b) Describe all details of a non-coherent receiver (i.e., one where f_c is not known). What is the recommended value for A?