Communication Systems
(ECE4572)
Fall 2013

Homework 6
Assigned Oct. 24, due Oct.30.

Objective: To understand the process of digital modulation.

Description: A message from a source (discrete or continuous) is encoded into a string of logical zeros and ones, and the so-obtained bit stream is fed to a digital modulator. In this exercise, we will study linear modulation of the pulse amplitude type (PAM), beginning with M=2 levels (binary PAM) and moving to a higher level ($M > 2$). In each case, the bits are first mapped into symbols; the symbols are then mapped into baseband waveforms using a rectangular pulse of duration T, and the baseband signal is finally modulated onto a carrier of frequency f_c. Your task is to implement this system in Matlab, and to observe the various signals and their properties.

Tasks:

1. Generate a logical (0/1) bit sequence corresponding to the message of your choice. Let the message have at least a 1000 bits. (Hint: Use a random number generator to generate a sequence of equally likely zeros and ones.)

2. Map the bits into symbols $d(n)$. Do this for the binary PAM first. In that case, the symbols will have values ± 1. Once you have completed the remaining tasks, come back to this point and generate the symbols for PAM with M=8 levels. In that case, the symbols will have values $\pm 1, \pm 3, \pm 5, \pm 7$.

3. Assuming that the symbol rate is $R = 1/T$ =1000 symbols per second, choose the sampling frequency as 16 times this value. Use this sampling frequency to generate the transmitter pulse $g(t)$ as a rectangular pulse of duration T and energy $E_g = 1$.

4. Generate the baseband signal
$$u(t) = \sum_n d(n)g(t - nT) \tag{1}$$
Plot this signal (zoom in on the first 10 or so symbol intervals).

5. Plot the signal spectrum. Does it agree with the theoretical expression for the power spectral density $S_u(f)$ of the signal $u(t)$?

6. Generate the modulated signal $s(t)$ using a carrier frequency $f_c = 100R$. Plot the signal spectrum. What is the relationship between this spectrum and the spectrum of the modulating signal?

7. Assuming that the received signal is identical to the transmitted signal (no noise, no distortion), implement the receiver as follows: (i) multiply the received passband signal by the local carrier; (ii) integrate (sum) the result over successive intervals of length T. Plot the signal at this point. Can you make decisions as to which data symbols were transmitted? Do your decisions match the transmitted sequence?

8. Repeat the modulation/detection process for M=8.

Report: Your typed report should contain:

- a cover page with your name
- a few paragraphs of text describing the problem, your work, and your conclusions
- figures that support your conclusions and to which you referred in text (figures must have captions; axes must be properly labeled and have adequate units, e.g. "time [s]")
- appendix containing your Matlab code.