Communication Systems
(ECE4572)
Fall 2013

Homework 7
Assigned Oct. 31, due Nov.7.

Objective: To experiment with quadrature modulation.

Description: In this exercise, we will study quadrature amplitude modulation (QAM), phase shift keying (PSK) and differential PSK with M=4 levels. As in the previous exercise, in each case, the logical bits 0/1 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. If you feel inspired, you can also develop a 16-QAM and an 8-PSK system.

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. You can use random number generator to generate a sequence of equally likely zeros and ones.

2. Map the bits into symbols $d(n)$. For 4-QAM, the symbols will have values $\{\pm 1 \pm j\}$. For 4-PSK (also called QPSK), the symbols will have values $\{e^{j0}, e^{j\pi/2}, e^{j\pi}, e^{j3\pi/2}\}$. For differential QPSK, there will be an additional step of differential encoding.

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
$$u(t) = \sum_n d(n)g(t - nT) \tag{1}$$

5. Generate the modulated signal $s(t) = Re\{u(t)e^{j2\pi f_c t}\}$ using a carrier frequency $f_c = 100R$.

6. 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. Note that the carrier is now complex-valued, and so is the output of integration (or equivalently, demodulation is performed in phase and quadrature). For differential PSK, do the additional step of differential decoding. Plot the signal at this point. Note that this signal is also complex-valued. To plot it, you can place the signal points on top of one another in the complex plane. A plot of this type is called a scatter plot. In Matlab, if the vector containing the signal points is `x`, use the command `plot(x,'*')`. Can you decide which data symbols were transmitted? Do your decisions match the transmitted sequence?

7. Repeat the modulation/detection process using a local carrier with a phase offset θ_e. Try several different values, e.g. $\theta_e = 10°, 20°, \ldots$. At what value of θ_e do you start to make wrong decisions? Answer this question separately for each modulation method.

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.