Assignment #4

Due: Nov. 22, Wed. 8:30, SMD 224 (beginning of the tutorial). Hard copy only, no email submissions. *Late entries will not be accepted!*

Before doing the assignment, please read appropriate sections of 6 of the course textbook (by Rappaport, 2nd edition) or any other relevant book (e.g. from the reference list).

1) Consider a binary communication system which sends the bit string 101 through an ideal channel using the raised-cosine pulses with roll-off factor $\alpha = 1/2$. The transmission rate is 50 Mb/s. Generate and plot the time-domain signal corresponding to this bit string over the time interval corresponding to ± 6 pulses. Do this for both unipolar and bipolar baseband modulation. In addition, indicate the best sampling points for the transmitted time-domain signal. If the receiver sampler has a timing jitter (inaccuracy) $\pm 10^{-9}$ s, what is the difference in the sampled voltage as compared to the ideal sampling?

2) A binary digital communication system is to be designed to support data rate of 1 Mb/s with BPSK modulation and the carrier frequency is 1 GHz. (a) What is the zero-crossing bandwidth of the modulated RF signal if rectangular pulses are used for baseband modulation? (b) What is the absolute RF bandwidth if raised-cosine pulses with roll-off factor $\alpha = 1$ are used instead? (c) How does the answer in part (b) changes if sinc pulses are used instead? (d) If a timing jitter of exactly 1 μs exists at the sampler, will this induce inter-symbol interference? Explain. What about 0.5 μs?

3) A WiFi communication system operates at 2.4 GHz carrier frequency and has the bandwidth of 20 MHz. (a) The SNR at the receiver is 20 dB. What is the largest possible data rate for this system? Hint: this rate does not exceed the channel capacity. (b) How does the answer changes if the SNR drops to 10dB? (c) How does the answer in (a) changes is the bandwidth is decreased to 10 MHz? Compare this to (b) and comment on the difference, if any.

4) Following the error probability analysis of baseband BPSK in Lecture 7, find the error probability expression for the baseband OOK. Give a brief derivation and determine the optimal threshold value. Sketch a block diagram of the optimal receiver for this modulation assuming that the pulse shape is rectangular.

5) Consider a binary bipolar baseband communication system for which $p(t) = 2 \cdot \Pi(t/T)$, the data rate $R = 1$ Mb/s, and the following bit string is transmitted: [1,0,0,0,1]. Sketch a block diagram of the optimal receiver for this sequence. Plot the transmitted waveform, find the impulse response of the matched filter and plot its output corresponding to the transmitted bit string (assume that the output is re-set to 0 at the beginning of each symbol interval), clearly indicate the optimal sampling moments. Repeat the same for the unipolar modulation.

6) Find the BER for the system in #5 assuming that the noise single-sided PSD is $2 \cdot 10^{-6}$ W/Hz. What is the difference between the BER of unipolar and bipolar modulation? Why?

Please read appropriate chapters of the textbook first, study all the examples, attempt to do them with the closed book. Remember the learning efficiency pyramid!

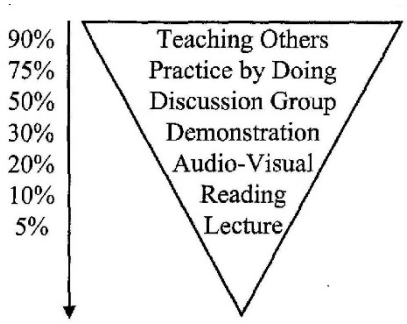

Figure 1. The Learning Pyramid, adapted from David Sousa, *How the Brain Learns*, Reston, VA, The National Association of Secondary School Principals, 1995, ISBN 0-88210-301-6.

Please include in your solutions all the intermediate results and their numerical values (if applicable). **Detailed solutions with explanations are required**, not just the final answers/equations; **all symbols used must be defined**, including units used (e.g. f = frequency [Hz], L = path loss [dB]). Missing explanations, symbol definitions/units will be penalized. Your answers should demonstrate the full extent of your knowledge and the latter will determine your marks.

Plagiarism (i.e. "cut-and-paste" from a student to a student, other forms of "borrowing" the material for the assignment) is absolutely unacceptable and will be penalized. Each student is expected to submit his own solutions. If two (or more) identical or almost identical sets of solutions are found, each student involved receives 0 (zero) for that particular assignment. If this happens twice, the students involved receive 0 (zero) for the entire assignment component of the course in the marking scheme and the case will be send to the Dean's office for further investigation.