EE 567

Project

Due Monday, November 27, 2017 at 6:40 p.m.

Work all 2 Parts.

Instructions.

Your project should be typed on one side of the paper only and stapled in the upper left hand corner. You should include a cover page and an appendix where you include your Matlab code. Do not place your project inside any kind of binder. This is to be an individual effort. You may consult any written material (hard or soft copy) but you may not solicit input from any person except that you may ask the professor or TA questions regarding your project. Your project report should be self-contained, that is, the reader should be able to understand the problems and your solutions from your report without consulting the actual project assignment.

In all plots of probability of bit or symbol error vs. E_b/N_0 the x-axis should be in dB and the y-axis should be on a log scale. Also, you should plot results down to at least a BER of 10^{-5}.

Part 1.

Problem 1-1. Suppose that BPSK modulation is used for transmitting information over an AWGN channel with a power spectral density of

$$\frac{1}{2}N_0 = 10^{-10}\ W/Hz.$$

The transmitted signal energy in a bit is

$$E_b = \frac{1}{2}A^2T.$$

where T is the bit interval and A is the signal amplitude. The information rate is 1 Mbps. Plot BER vs. E_b/N_0 using analytic results.

Problem 1-2. Using Matlab simulate the scenario described in Problem 1-1. You do not have to simulate the signal generation and modulation/demodulation. You can start your simulation at the output of the demodulator where you have ± 1 bit values plus noise. Plot your simulation results and compare to the analytic results.

Problem 1-3. Suppose that QPSK modulation is used for transmitting information over an AWGN channel with a power spectral density of

$$\frac{1}{2}N_0 = 10^{-10}\ W/Hz.$$

The transmitted signal energy in a symbol is

$$E_s = \frac{1}{2}A^2T.$$

where T is the symbol interval and A is the signal amplitude. The information rate is 1 Mbps. Plot, using analytic results, SER vs. E_b/N_0 and plot BER vs. E_b/N_0 on the same graph.

Problem 1-4. Using Matlab simulate the scenario described in Problem 1-3. Again, you can start your simulation at the output of the demodulator. Plot your simulation results and compare to the analytic results.

Problem 1-5. Same setup as Problem 1-1 but now we are going to allow for an error correction code. Suppose we implement an $(n,\ k)$ code where $n = 7$ and $k = 4$ that can correct a single error.

a. Plot BER vs. E_b/N_0 using analytic results.

b. Simulate this case and plot BER vs. E_b/N_0 and compare to part (a).

c. Compare your coded results here to the uncoded case in Problem 1-1.

d. What data rate do you need now in order to have an information rate of 1 Mbps?

Part 2.

Problem 2-1. Same setup as Problem 1-3 with QPSK modulation but now we are going to allow the constellation to be rotated relative to ideal where the rotation is unknown a prior to the receiver. Suppose the constellation points are collectively rotated by a random angle that is uniformly distributed on the interval $(-\pi/4,\ \pi/4)$. Plot via simulation BER vs. E_b/N_0 for this case.

Problem 2-2. Same setup as Problem 2-1 but now we are going to utilize a training sequence to allow the receiver to estimate the rotation in the channel and implement a correction algorithm that de-rotates the constellation. Assume the information length is 4368 bits. Incorporate a training sequence known to both the transmitter and receiver and plot via simulation BER vs. E_b/N_0 utilizing various different training sequence lengths.

Problem 2-3. Same setup as Problem 2-2. Assume the information length is 4368 bits. Find via simulation the optimal length of the training sequence required to minimize the E_b/N_0 needed to achieve a BER of 10^{-3}. Show plots demonstrating how you found your optimal length by plotting some suboptimal length results along with the optimal result. How does this compare to the E_b/N_0 for the ideal case?

Problem 2-4. Same setup as Problem 2-3. Assume the information length is 4368 bits. Now find the optimal length of the training sequence in combination with the best error correction code to use to minimize the E_b/N_0 needed to achieve a BER of 10^{-3}. The code options you have are as follows: (n, k, t) code where $n = 7,\ k = 4,\ t = 1$, or $n = 15,\ k = 7,\ t = 2$, or $n = 31,\ k = 16,\ t = 3$, or $n = 63,\ k = 39,\ t = 4$ where t is the error correction capability of the code. Also, for the code you found what data rate do you need in order to have an information rate of 1 Mbps?