

Communication Systems
(ECE4572)
Fall 2011

Homework 9

Assigned Nov. 21, due Nov. 28 (Dec.1st).

Objective: Understand the concept of bit error rate (BER) in a digital communication system.

Preparation:

- Review the concepts taught in class: Derive the expression for the bit error probability in a BPSK and QPSK system, $P_b = Q\sqrt{\frac{2E_b}{N_0}}$.
- Review the concept of differential PSK (DPSK): Make sure you understand the motivation for using differentially coherent detection, in which the decision variable is $y(n)y^*(n-1)$ instead of just the matched filter output $y(n)$, and deduce the differential encoding rule. You do not have to derive the bit error probability for this case; it is given by $P_e = \frac{1}{2}e^{-E_b/N_0}$ for binary DPSK.

Task: Simulate a PSK communication system in Matlab:

- Generate a stream of N i.i.d. data symbols belonging to a PSK constellation. Encode differentially if needed.
- Set the bit SNR, E_b/N_0 , and add noise (zero-mean, Gaussian, with independent real/imaginary parts of equal variance corresponding to the given bit SNR). Explain how you determined the noise variance. Do *not* use any built-in functions other than **randn**.
- Observe the scatter plot and generate the corresponding symbol decisions.
- Count the errors, and estimate the probability of bit error. Note: you will have to choose N so as to make sure that you have counted at least ten errors; otherwise your BER estimate will not be reliable.
- Repeat for a different E_b/N_0 . Consider a range of bit SNRs between 0 and 10 dB.
- Do the above for BPSK, QPSK, DBPSK and DQPSK.

Summarize your simulation results in a single plot showing BER vs. bit SNR for the four different methods considered. On top of the simulation results, plot the theoretical curves for the BER of these methods (except the one for DQPSK which we have not derived in class, but for which we know to be about 2.5 dB away from QPSK). If you do not see an agreement, look for a bug in your code (or a misunderstanding of theoretical concepts). Include also two scatter plots showing the decision variables for the same modulation method (e.g. QPSK) but two different SNR, and comment on the effect of noise.

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. " E_b/N_0 [dB]")
- appendix containing your Matlab code.