ECE 243A Project: Performance Evaluation of Equalization Techniques

Assigned: May 22
Due: June 8 by noon (in rm 3111, HFH)
Reading: Chapter 5, Section 4.5.1

In this project, you are to evaluate the performance of the DFE and MLSE by simulation, and to compare the results with analytical expectations. Expressing time in units of the symbol time, we take the symbol rate to be 1 symbol per unit time. We consider Gray-coded QPSK; for consistency across the entire class, use $\{\pm 1 \pm j\}$ as your constellation. The transmit filter has impulse response

$$g_{TX}(t) = I_{[0,1]}(t)$$

The channel impulse response is

$$g_C(t) = j\delta(t-1) - (2+j)\delta(t-1.5) + \delta(t-2.4)$$

The receive filter is matched to the cascade of the transmit and channel filters, and is sampled at the symbol rate so as to generate sufficient statistics for symbol demodulation.

Your project report should supply all the relevant information and formulas required for reproducing your results. A copy of your simulation software should be attached. The range of error probabilities of interest is $10^{-1} - 10^{-5}$, and the range of E_b/N_0 of interest is 0-30 dB. In plotting your results, choose your range of E_b/N_0 based on the preceding two factors. For all error probability computations, average over multiple 500 symbol packets (enough to get a good estimate of the BER), with enough additional symbols at the beginning and end to ensure that MLSE starts and ends with a state consisting of $1+j$ symbols. In all your plots, include the error probability curve for QPSK over the AWGN channel without ISI for reference.

(a) Set up a discrete time simulation, in which, given a sequence of symbols and a value of received $\frac{E_b}{N_0}$, you can generate the corrresponding sampled matched filter outputs $\{z_n\}$. To generate the signal contribution to the output, first find the discrete time impulse response seen by a single symbol at the output of the sampler. To generate the colored noise at the output, pass discrete time WGN through a suitable discrete time filter. Specify clearly how you generate the signal and noise contributions in your report.

(b) Compute the coefficients of an MMSE-DFE with length of feedforward filter equal to the length of the discrete time response to a single symbol, so that you the entire energy of the desired symbol falls within the observation interval. Choose the number of feedback taps equal to the number of past symbols falling within the observation interval. Simulate the performance for QPSK. Plot the BER (log scale) versus $\frac{E_b}{N_0}$ (dB), and compare with the no-ISI benchmark.

(c) What is the noise enhancement (in dB) at high SNR due to the feedforward correlator in the DFE? How well does this predict the dB penalty in DFE performance relative to the no-ISI benchmark?

(d) Find the BER of MLSE by simulation, again considering QPSK with Gray coding. Compare with the results from (b).

(e) Can you explain the performance of the MLSE relative to the no-ISI benchmark based on the theoretical performance analysis you have learnt in class?