CT542: Basics of Communication Systems

Lab 2

In Lab-2, you will continue the Monte Carlo Simulations that you performed in Lab-1. In this lab, the simulations will be geared toward modeling an analog-valued channel that introduces Gaussian noise to the transmitted BPSK and OOK modulated symbols.

1. Visualization of Received Signal at BPSK receiver:
   (a) Let the probability that the transmitted bit $X = 1$ is $q = 0.5$.
   (b) Generate $N = 10000$ bits and pass them through BPSK modulator that uses $a = +5$ volts to transmit $X = 1$ and $-a = -5$ volts to transmit $X = 0$. Let the transmitted signal be denoted as s.
   (c) Let Signal to Noise Ratio or SNR $\gamma_{dB} \stackrel{\text{def}}{=} 10 \times \log_{10}\left(\frac{a^2}{\sigma_n^2}\right)$ equal 20 dB.
   (d) Generate noise signal n whose variance σ_n^2 is determined given the values of a and γ_{dB}.
   (e) Generate the received signal $r = s + n$.
   (f) Generate a time-domain plot by superimposing the transmitted signal s, the noise n and the received signal r (you may have to zoom into the plot on about 50 to 100 symbols to get a good visualization of the effect of n on transmitted s).
   (g) Using the method that you have used in Lab-1, generate the conditional distribution (PDF) of r given s and compare these with the theoretical PDFs. With this, you have now generated visualization of the received signal in presence of noise in two different ways; a time-domain visualization and a probabilistic visualization.
   (h) Reduce SNR γ_{dB} from 20 dB to 0 dB in steps of 5 dB and redo the above steps. Observe the effect of reduction in SNR on r.

2. Probability of Bit Error Simulator:
   (a) Implement Bayes' Rule based demodulator for BPSK signal.
   (b) Run a Monte-Carlo simulator for $N_{sim} = 1000$ simulation trials. Calculate the probability of error in each simulation trial and average the results observed over N_{sim} trials.
   (c) Repeat the above step for SNR γ_{dB} from 0 dB to 10 dB in steps of 1 dB.
   (d) Compare the above simulation results with the theoretical result for each value of γ_{dB}, which can be evaluated using Matlab's `qfunc` function for evaluating $Q(x)$ function.

3. Effect of changing the decision threshold:

   (a) Vary the decision threshold from -5 volts to $+5$ in steps of 1 volt and evaluate the simulated bit error probability over the same range of γ_{dB} as above. For what value of decision threshold does the simulated bit error probability attain the smallest value?

   (b) Repeat the above by changing $q = 0.3$.

   (c) Reset $q = 0.5$, but use OOK modulator and demodulator to perform this experiment.