EE 484

Homework 2

Due Monday, January 29, 2018

Work all 3 problems.

Note: For any Matlab exercises you should submit your Matlab code along with the rest of your solution to the given problem.

Problem 1. This is a Matlab exercise. Consider the carrier signal, denoted as $s(t) = A \cdot sin(2\pi f_c t)$ and a message waveform $m(t) = M \cdot \cos(2\pi f_m t + \phi)$. Let $x(t) = [1 + m(t)] \cdot s(t)$ represent an amplitude modulated (AM) signal.

a. Let $t = n\Delta t$, $f_c = 1$ Hz, $f_m = 0.1$ Hz, and $\varphi = \pi/2$, then generate a plot of $x(n) = x(n\Delta t)$ in Matlab for A = 1.0 and M = 0.5, M = 1.0, and M = 1.5. Plot $x(n)$ for five cycles of the message waveform in each case.

b. Derive the Fourier Transform of x(t) analytically.

c. Generate and plot the magnitude of the Fourier Transform of $x(n)$ in Matlab for the three cases of M identified in part a. Include the frequency axis in each plot.

d. Which of the three values of M is most suitable for transmission of information and why?

Problem 2. This is a Matlab exercise.

a. Generate the complex signal

$$s(n) = A \cdot cos(2\pi f_c \Delta t \cdot n) + jA \cdot sin(2\pi f_c \Delta t \cdot n),$$

for $f_c = 1$, A=1.0, $\Delta t = 0.01$, and $1 \leq n \leq 10,000$. Plot this signal with the in-phase values (real part) on the x-axis and the quadrature components (imaginary part) on the y-axis. What is the magnitude of this signal?

b. Define the complex noise sequences $k_1(n) \sim N(0,0;0.1/s,0.1/s)$, $k_2(n) \sim N(0,0;0.5/s,0.5/s)$, $k_3(n) \sim N(0,0;1.0/s,1.0/s)$, where $s = 2$, for $1 \leq n \leq 10,000$. Let $r_1(n) = s(n) + k_1(n)$, $r_2(n) = s(n) + k_2(n)$, and $r_3(n) = s(n)+k_3(n)$ be the complex signal plus noise vectors for each of the three difference noise sequences. Calculate the magnitude of each of these signals, then generate the histograms. Describe the distribution that each of these signals follows. What distribution(s) does the phase of the signals follow?

Problem 3. In class we said that for BPSK modulation the probability of an uncoded bit error is

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right),$$

where $Q(x)$ is the Gaussian tail function:

$$Q(x) = \int_x^\infty \frac{1}{\sqrt{2\pi}} e^{-u^2/2} du.$$

Plot P_b vs. $\frac{E_b}{N_0}$ for $\frac{E_b}{N_0}$ ranging from 0 to 12 dB (your x-axis should be in dB). Note

$$\frac{E_b}{N_0}(dB) = 10 \times \log_{10}\left(\frac{E_b}{N_0}\right).$$