ECE 642 - Final Spring 2015

Please justify all your responses (responses without justifications will not be considered). Please label your axes and plot with care.

1. (5 points) Consider a binary communication system with the following waveforms: $x_{z,0}(t) = A \cdot rect(t)$ and $x_{z,1}(t) = A \cdot rect(t)e^{j4\pi t}$, where $rect(t)$ is a rectangle of amplitude equal to one and duration 1 second (starting from time zero).

a. Calculate A as a function of E_b.

b. Calculate the squared Euclidean distance between the two waveforms as a function of E_b.

c. Derive the optimal single-correlator receiver structure including the calculation of the threshold γ.

d. Evaluate the probability of bit error for the optimal receiver when $E_b/N_0 = 10$dB (You can evaluate just the argument of the erfc or Q function).

e. Assume now that the filter is selected as $H(f) = 1$ for all frequencies f. Calculate the resulting values m_0 and m_1 of the sufficient statistic in the absence of noise. Comment on the result.

2. (5 points) We have a baseband modulator with the following waveforms

$$\begin{aligned} x_{z,0}(t) &= A(1+j) \text{ for } 0 \le t \le T_p/2 \\ x_{z,1}(t) &= A(-1-j) \text{ for } 0 \le t \le T_p/2 \\ x_{z,2}(t) &= A(1+j) \text{ for } T_p/2 \le t \le T_p \\ x_{z,3}(t) &= A(-1-j) \text{ for } T_p/2 \le t \le T_p \end{aligned}$$

where all waveforms are zero except in the intervals indicated above.

a. Calculate A as a function of E_b and T_p.

b. Evaluate the conditional distance spectra for all messages.

c. Calculate the union bound and the union bound approximation.

d. Compare this modulation scheme with 4-PSK by means of the union bound approximation: based on the union bound approximation for 4-PSK, which scheme is more energy efficient?

e. Considering also the bandwidth requirements, which modulation scheme would you choose between 4-PSK and the one studied in this problem?