ECE4304 Homework Assignment Number 3

Due by 4:50pm on Friday 2-Feb-2007

1 Required Reading

- Haykin Chapter 4.1-4.3, and 4.7

2 Analysis Problems

80 points total. You must show all of your work and your work must be neat to receive credit for a problem. Complete the following problems:

1. 15 points. Haykin 4.3

2. 25 points total. Consider a binary 2-PAM communication system that uses the rectangular pulse $g(t)$ described in Haykin 4.3. Assume that the information to be transmitted is composed of equally likely binary ones and zeros. The digital modulator transmits

$$s(t) = \begin{cases} g(t) \text{ if binary one} \\ -g(t) \text{ if binary zero} \end{cases}$$

   (a) 10 points. Derive an expression for the bit error probability for this communication system assuming an optimum matched-filter receiver and an additive white Gaussian background noise channel with power spectral density $S_N(f) = N_0/2$ for all f. Your answer should be in terms of T, A, and N_0.

   (b) 5 points. Plot the error probability of the system over the range $0 < A \leq 1$ assuming $T = 10^{-5}$ seconds and $N_0/2 = 10^{-7}$ Watts/Hz. Use the Matlab command `semilogy` to produce a nice looking plot. Label all axes.

   (c) 5 points. Plot the error probability of the system over the range $10^{-8} < T \leq 10^{-3}$ assuming that $A = 1$ and $N_0/2 = 10^{-7}$ Watts/Hz. Use the Matlab command `loglog` to produce nice looking plot. Label all axes.

   (d) 5 points. Comment on your results. What does it mean to change A in this communication system? What does it mean to change T?

3. 10 points. Repeat problem 2(a) except assume now that the digital modulator transmits

$$s(t) = \begin{cases} g(t) \text{ if binary one} \\ 0 \text{ if binary zero} \end{cases}$$

   Compare your answer to problem 2(a) of Problem 3. Is there any difference? Can you explain why or why not?

4. 15 points. Repeat problem 3 except assume now that binary ones are transmitted with probability $p = 0.7$ and binary zeros are transmitted with probability $p = 0.3$. Discuss how the receiver should be modified to account for these *a priori* bit probabilities and derive an expression for your new receiver's bit error probability.

5. 15 points. Consider a binary 4-PAM communication system that uses the rectangular pulse $g(t)$ described in Haykin 4.3. Assume that the information to be transmitted is composed of equally likely binary ones and zeros. The digital modulator transmits

$$s(t) = \begin{cases} 3g(t) \text{ if symbol is binary one/one} \\ g(t) \text{ if symbol is binary one/zero} \\ -g(t) \text{ if symbol is binary zero/zero} \\ -3g(t) \text{ if symbol is binary zero/one} \end{cases}$$

Derive an expression for the *symbol* error probability for this communication system assuming an optimum matched-filter receiver and an additive white Gaussian background noise channel with power spectral density $S_N(f) = N_0/2$ for all f. Your answer should be in terms of T, A, and N_0. Can you estimate the *bit* error probability in this case? Discuss any tradeoffs in this 4-PAM communication system with respect to the 2-PAM communication system in problem 2.