EEL 6535 Study Guide for Exam II

Notes:

1. Items marked with (*) may be emphasized on the closed-book part of the exam.
2. You may use two formula sheets on the open-notes part of the exam so that you can reuse the formula sheet from exam I.

**COHERENT DETECTION OF M-ARY PHASE-SHIFT KEYING**

- (*) Represent signals in a signal space: draw signal constellations, provide basis waveforms, signal vectors, etc.
- (*) Enumerate Gray coded bit labellings
- Calculate nearest neighbor bounds
- Calculate error performance with imperfect receiver (like the problem with BPSK with a phase reference error on Homework 2
- Represent symbol or bit error probabilities as sums of single integrals using Craig’s approach
- Compare bandwidth and energy efficiency of PSK to other modulations, such as QAM and M-FSK

**COHERENT DETECTION OF M-ARY ORTHOGONAL SIGNALS**

- (*) Know how to generate orthogonal signal sets using FSK or orthogonal amplitude modulation
- (*) Give equations for orthogonal signal sets using FSK or orthogonal amplitude modulation and show that they are orthogonal. Identify any approximations that must be made.
- (*) Know the minimum frequency separation for FSK for orthogonal signaling under different assumptions about the phases of the signals
- Calculate the minimum frequency separation for FSK for orthogonal signaling under different assumptions about the phases of the signals
- Calculate union bound on symbol error probabilities
- (*) Understand the impact of bit labelings on the bit error probability of M-ary orthogonal modulation
- Know how to calculate bit error probabilities from symbol error probabilities
- Derive expression for exact symbol error probability
• Give an expression that can be used to derive the optimal spacing of binary FSK signal for coherent detection

**Noncoherent Detection of M-ary Orthogonal Signals**

• Understand and be able to apply concepts from the derivation of the optimal noncoherent detector for orthogonal signals

• Sketch the optimal detector for noncoherent detection of orthogonal signals

• Determine the types of random variables involved in the decision process and give their density functions

• (*) Calculate the union bound on the symbol error probabilities. Use it to give an approximation for the bit error probabilities.

• Calculate the exact symbol and bit error probabilities for noncoherent detection of M-ary orthogonal modulation

**Differentially Encoded PSK**

• (*) Know error probability for noncoherent detection of DPSK

• (*) Explain why noncoherent detection of DPSK performs 3 dB better than noncoherent detection of BFSK

• (*) Perform differential encoding and decoding of data

• Sketch the optimal demodulator structure for a demodulator that makes decisions based on two consecutive symbols

• Give integral expressions for the bit or symbol error probs. of noncoherently detected M-DPSK

• Use approximations or bounds on the error probability for M-DPSK to compare the performance with other modulation schemes

• (*) Why would differential encoding be used with coherent detection

• (*) Exact and approximate error probs. for coherent detection of DPSK

**Simulation of Communication Systems**

• Determine the noise variance that should be used for a decision statistic at a particular $E_b/N_0$

• Determine the number of random variables that needs to be generated to simulate the error probability performance of a communication system
**Material from Previous Exam**

Much of the material from Exam I is necessary to do performance analysis of the modulations covered by Exam II. In particular, be sure to review the following topics:

**Apply Signal Space Representations to Communications**

- Calculate error probabilities for binary signal sets with matched filter+ML detection
- Determine an optimal demodulator for an M-ary signal set
- Use the signal constellation to determine the exact symbol or bit error probabilities
- (*) Use the signal space constellation to determine union or nearest neighbors bounds on the error probabilities
- (*) Express error probabilities in terms of the average symbol energy-to-noise density ratio $E_s$ or the average bit energy-to-noise density ratio $E_b/N_0$
- (*) Apply Gray coding to a signal set to minimize the probability of symbol error
- (*) Approximate the bit error probability for a Gray-coded signal constellation

**Presentation of Data**

- Convert from decibels to linear units and back
- Express differences in energy efficiency between signal constellations or receiver structures in decibels
- Plot data with $E_b/N_0$ in decibel units on a linear x-axis and the error probabilities on a logarithmic y-axis