# San José State University
# Electrical Engineering Department
# EE251, Digital Data Transmission I, Fall 2009

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| **Instructor:** | Robert H. Morelos-Zaragoza |
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| **Office Hours:** | MW 16:30-19:00pm (tentative). Other days by appointment |
| **Class Days/Time:** | MW 19:30-20:45 |
| **Classroom:** | IS 113 |
| **Prerequisites:** | EE 210 (Linear Systems), EE 250 (Probability, Random Variables and Processes) |

## Web Page

Located at http://www.engr.sjsu.edu/rmorelos/ee251f09

## Course Description

This is the first of two graduate courses on digital communications (EE 251 and EE 252). The first part is a review of random processes, focusing on white Gaussian noise and narrowband noise. Next, the processes of sampling, quantization and baseband pulse transmission are studied. Communication over bandlimited channels and equalization are characterized. Important concepts in signal-space analysis are covered. Digital modulation techniques are studied that apply to transmission over bandlimited channels subject to additive white Gaussian noise. The course concludes with a discussion on the tradeoffs between power and transmission rate through the channel-coding theorem.

## Course Goals and Student Learning Objectives

1. Understand the basic signal processing elements of a modern digital communication system.
2. Understand and analyze noise, information and random processes in communication systems.
3. Understand the concepts of correlation function and power spectral density of stationary random processes, including additive white Gaussian noise (AWGN) signals.

4. Analyze the response of linear systems to stationary random processes.
5. Understand the process of analog-to-diigital conversion and its applications in communication systems.
6. Understand and characterize the performance of analog pulse modulation and scalar quantization.
7. Understand and analyze optimum scalar quatization and the Lloyd-Max algorithm for designing nonuniform quantizers.
8. Understand and analyze basic baseband pulse shaping techniques and their power spectral densities.
9. Understand and analyze optimum filters for linear estimation of signal parameters in AWGN.
10. Understand basic concepts of baseband pulse transmission and matched filtering.
11. Understand and analyze the performance of binary modulation over an ideal AWGN channel.
12. Analyze the effects of intersymbol interference (ISI) in communication systems over bandlimited AWGN channels,
13. Design pulses using Nyquist criterion for ISI cancellation and to use eye diagrams.
14. Understand, analyze and specify multidimensional digital modulation techniques for transmission over ideal bandlimited AWGN channels and their associated detectors.
15. Understand the fundamental tradeoffs between power, bandwidth and error performance in a digital communication system.

## Required Texts/Readings

### Textbook

S. Haykin, Communication Systems, 4th Ed., Wiley, 2001

### Other Readings

1. Proakis and Salehi, Contemporary Communication Systems Using Matlab, PWS, 1998
2. Sklar, Digital Communications, 2nd Ed., Prentice-Hall, 2001
3. Lathi, Modern Digital and Analog Communication Systems, 3rd Ed., Oxford, 1998
4. Carlson, Criilly and Rutledge, Communication Systems, 4th Ed,. McGraw-Hill, 2002
5. Proakis, Digital Communications, 4th Ed., McGraw Hill, 2001

### Other equipment / material requirements (optional)

Handouts posted on the webpage.

## Classroom Protocol

Students will turn their cell phones off or put them on vibrate mode while in class. They will not answer their phones in class. Students whose phones disrupt the course and do not stop when requested by the instructor will be referred to the Judicial Affairs Officer of the University.

### Dropping and Adding

Students are responsible for understanding the policies and procedures about add/drops, academic renewal, etc. Information on add/drops are available at http://info.sjsu.edu/web-dbgen/narr/soc-fall/rec-298.html. Information about late drop is available at http://www.sjsu.edu/sac/advising/latedrops/policy/ **.** Students should be aware of the current deadlines and penalties for adding and dropping classes.

### Assignments and Grading Policy

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| Assignments | 25 % |
| Midterm exam 1 | 25 % |
| Midterm exam 2 | 25 % |
| Final exam | 25 % |
| Total | 100% |

a. Exams: There will be two midterm exams and a final exam. All exams are OPEN book and notes.

b. Homework: Homework assignments will be given regularly and will be due one week from the assigned date. Late homework will not be accepted.

## EE 251: Digital Data Transmission I, Semester: Fall 2009, Course Schedule

| Week | Date | Topics |
|---|---|---|
| 1 | Aug 24,26 | Green sheet. Grading policy. Introduction to communication systems. Elements of a digital communication system |
| 2 | Aug 31, Sep 2 | Noise, information and random processes. Mean and autocorrelation functions |
| 3 | Sep 9 | Stationary random processes and their power spectral density. |
| 4 | Sep 14,16 | Response of LTI systems to stationary random processes. White noise and response of LTI systems to white noise |
| 5 | Sep 21,26 | A/D conversion and sampling theorem. Optimum scalar quatization and the Lloyd-Max quantizer |
| 6 | Sep 28,30 | Baseband pulse-shaping techniques and their power spectral densities |
| 7 | Oct 5,7 | Matched filter and its properties. Binary communication over an AWGN channel. |
| 8 | Oct 12,14 | Review session and midterm exam 1 |

| Week | Date | Topics |
|---|---|---|
| 9 | Oct 19,21 | Intersymbol interference (ISI) and Nyquist criterion. Raised-cosine spectrum |
| 10 | Oct 26,28 | Probability of error with ISI. |
| 11 | Nov 2, 4 | Signal space concepts. Synthesis and analysis. Geometric representation of signals. Response of a bank of correlators to AWGN |
| 12 | Nov 9 | Optimum decision rule and probability of error. |
| 13 | Nov 16,18 | Review session and midterm exam 2. |
| 14 | Nov 23,26 | Orthogonal expansion of signals and the Gram-Schmidt procedure. M-ary modulation and the union bound. |
| 15 | Nov 30, Dec 2 | Examples of bounds on the probability of error for QPSK modulation. Bandpass digital transmission: M-PSK, M-QAM and M-FSK modulations. |
| 16 | Dec 7 | Channel-coding theorem. |
| | Dec 14 | Final exam: 19:45-22:00 |

## University Policies

### Academic integrity

Students should know that the University's Academic Integrity Policy is availabe at http://www.sa.sjsu.edu/download/judicial_affairs/Academic_Integrity_Policy_S07-2.pdf. Your own commitment to learning, as evidenced by your enrollment at San Jose State University and the University's integrity policy, require you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The website for Student Conduct and Ethical Development is available at http://www.sa.sjsu.edu/judicial_affairs/index.html.

Instances of academic dishonesty will not be tolerated. Cheating on exams or plagiarism (presenting the work of another as your own, or the use of another person's ideas without giving proper credit) will result in a failing grade and sanctions by the University. For this class, all assignments are to be completed by the individual student unless otherwise specified. If you would like to include in your assignment any material you have submitted, or plan to submit for another class, please note that SJSU's Academic Policy F06-1 requires approval of instructors.

**EE Department honor code**

The Electrical Engineering Department will enforce the following Honor Code that must be read and accepted by all students.

"I have read the Honor Code and agree with its provisions. My continued enrollment in this course constitutes full acceptance of this code. I will NOT:

- Take an exam in place of someone else, or have someone take an exam in my place
- Give information or receive information from another person during an exam
- Use more reference material during an exam than is allowed by the instructor
- Obtain a copy of an exam prior to the time it is given
- Alter an exam after it has been graded and then return it to the instructor for re-grading
- Leave the exam room without returning the exam to the instructor.''

Measures Dealing with Occurrences of Cheating

Department policy mandates that the student or students involved in cheating will receive an "F" on that evaluation instrument (paper, exam, project, homework, etc.) and will be reported to the Department and the University. A student's second offense in any course will result in a Department recommendation of suspension from the University.

**Campus Policy in Compliance with the American Disabilities Act**

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 requires that students with disabilities requesting accommodations must register with the DRC (Disability Resource Center) to establish a record of their disability.