ECE1355 Communication Systems 1 4QH

Introduces basic concepts of digital communication in additive white Gaussian noise (AWGN) channels. Reviews Fourier transform and Fourier series representation of signals and introduces random processes. Examines power spectrum density, geometric representation of signals and signal spaces, concepts of information sources and source coding algorithms, principles of optimum filter design for AWGN channels, correlation and matched filter receivers, and probability of error analysis for binary and M-ary signaling through AWGN channels, digital PAM transmission through bandlimited AWGN channels, zero ISI condition, system design in the presence of channel distortion, design of optimum transmitting and receiving filters, channel equalization, introduction to digital transmission via carrier modulation.

Prerequisites: ECE1333, MTH1384.

Textbooks: Proakis and Salehi, *Communication Systems Engineering.*
Proakis and Salehi, *Contemporary Communication Systems Using Matlab.*

Course Objectives:
Upon completion of this course, a student should:
1) understand the role of the basic blocks in a general digital communication system.
2) be able to use the knowledge acquired in linear system course in analysis of communication systems.
3) have an understanding of the sources and characteristics of thermal noise and methods to analyze its effect on communication systems.
4) understand the role of data compression in communication systems and the fundamental limits in both lossless and lossy compression.
5) be able to design source coding schemes based on Huffman coding and the Lempel-Ziv algorithm.
6) be able to design optimal receivers for binary and M-ary digital communication systems in the presence of AWGN.
7) be able to compute the error probability of various digital modulation systems and make a meaningful comparison between these systems based on the performance and the required physical resources (power and bandwidth).
8) understand the role of intersymbol interference in bandlimited channels and methods for compensating its effect on the communication system.

Topics Covered:

1. Review of Fourier transform and Fourier series techniques.
2. Random processes, power spectrum and filtering of random processes. Properties of white Gaussian noise.
3. Information sources, measure of information, entropy, Shannon's noiseless coding theorem. Lossless coding algorithms, Huffman coding and the Lempel-Ziv algorithm.
4. Lossy data compression, rate-distortion function and Shannon's source coding with a fidelity criterion theorem. Optimal uniform and non-uniform quantizer design.

5. PCM, differential PCM, and adaptive PCM systems and their performance.
6. Gram-Schmidt orthogonalization procedure, signal space representation of digital signaling systems, optimum receiver design, correlation and matched filter receivers, error probability for binary and M-ary communication systems, union bounding technique.
7. Signal transmission through bandlimited channels, power spectral density of digitally modulated signals, spectral shaping by precoding, intersymbol interference (ISI) and its effects on communication systems, Nyquist conditions for ISI-free communications, raised-cosine signaling, partial response signaling, equalization techniques.
8. Digital transmission by carrier modulation, PAM, PSK, FSK, and QAM modulation techniques and their performance analysis and comparison.

Class Schedule: MWTh: 9:15-10:20 am

Contribution of course to meeting the professional component:

Engineering topics:	4 QH
General engineering component:	See Relation to Program Objectives below

Relationship of course to program objectives:

Program Objective	**Assessed**
1.1 Formulate and solve EE problems (specified in course objectives)	HE: One midterm, one final and 5 quizzes graded by the instructor count 85% of the grade. Homeworks graded by TA count 15% of the grade.
1.2 Laboratory and computing tools.	H: Some homeworks contain Matlab based simulation or design problems.
1.3 Design/conduct experiment, analyze data	N/A
1.4 Design systems, components, or processes	H: Optimal receiver design, optimal code design is emphasized in homeworks.
2.1 Understand/apply mathematics	
2.11 Differential calculus	N/A
2.12 Integral calculus	N/A
2.13 Complex algebra/analysis	HE: Fourier techniques are emphasized
2.1.4 Differential/Differential Equations	N/A
2.1.5 Linear algebra	H: Matrix inversion emphasized in equalization
2.1.6 Multivariate calculus	N/A
2.1.7 Probability/Stochastic processes	HE: Emphasized throughout the course
2.2 Understand/apply physics	
2.2.1 Solid-state physics	N/A
2.2.2 Electricity and Magnetism	N/A
2.3 Apply knowledge of programming	
2.3.1 Flow-charting/program design	H: Some homeworks contain Matlab based simulation or design problems.
2.3.2 Language syntax/debugging	H: Used in Matlab programs in homeworks.
2.3.3 Output analysis	H: Analysis of simulation results and comparison with analytical results.

2.4 Connect EE subfields	HE: Linear system analysis techniques are widely used.
2.5 Information sources/literacy	H: Web is used for homework assignment and solution handout.
2.6 Connect between theory and practice	H: Matlab simulations are used to verify analytical results
2.9 Connect between classroom and work/coop	N/A
3.1 Effective written communication	N/A
3.2 Effective oral communication	N/A
3.3 Analyze information/compare alternatives	N/A
3.4 Multidisciplinary terms	N/A
4.1 Professional/ethical issues	N/A
4.2 Lifelong learning	N/A
4.3 Career Management	N/A
5.1 Social/cultural context of EE	N/A
5.2 Historical/contemporary issues of EE	N/A
5.3 Esthetics in Engineering	N/A
5.4 Esthetics in written/oral expression	N/A

Prepared by Masoud Salehi, March 13, 2000.