

ECE542 Digital Communication Theory

Spring 2004

Goal:

To learn the fundamentals of digital communications including modulation, detection, source and channel coding, synchronization, and equalization techniques for dispersive channels.

Catalog course description:

Review of probability and stochastic processes. Source coding. Characterization of communication signals and systems. Optimum receiver for additive white Gaussian noise channels. Channel capacity. Synchronization. Communication through dispersive channels, equalization. Modeling and performance of time-varying fading multipath channels.

Prerequisites:

ECE541 or equivalent.

Instructor:

Dr. Majeed M. Hayat, Associate Professor
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Classroom & time

Building: TAPY; Room: 220; TR: 11:00–12:15

Office hours

M: 2:00–3:00 & W: 3:00–4:00.

Textbook:

Digital Communications, fourth edition, by J. Proakis. McGraw Hill, 2001. Required.

Topics:

1. **Introduction to digital communications** (Ch. 1).
2. **Review of concepts from probability and stochastic processes** (Ch. 2).
3. **Elements of information theory and source coding** (Ch. 3 and handouts):
Classification of information sources, entropy, Statement of Shannon's source coding Theorem.
Examples of compression techniques: Huffman codes, linear predictive codes, decoding, compression efficiency.
Coding for analog sources.
Quantization methods, quantization noise, optimum quantization, rate-distortion function.

4. **Signal representation and modulation** (Ch.4):
 Bandpass representation and vector-space representation, the Gram-Schmitt procedure.
 Linear and nonlinear digital modulation techniques, including ASK, QAM, FSK, PSK, QPSK, DPSK, and MSK.
 Continuous phase modulation (CPM).
 Power spectra of digitally-modulated signals; bandwidth efficiency.
5. **Optimum receivers for signals in additive colored Gaussian noise** (Ch. 5 and handouts):
 Elements of Bayesian M-ary decision theory.
 Structure of Optimum receivers and the Karhunen-Loeve expansion.
 Performance analysis of coherent and noncoherent receivers for various modulation schemes.
 Link budget analysis.
6. **Synchronization** (Ch. 6):
 Relevant estimation theory.
 Carrier phase estimation.
 Timing estimation.
7. **Channel capacity** (Ch. 7 and handouts):
 Capacity of discrete memoryless and AWGN channels, Blahut's algorithm (if time permits).
 Performance of equal-energy orthogonal signals on AWGN channels: a manifestation of Shannon's channel coding Theorem.
8. **Channel coding** (Ch. 8):
 Examples of linear block codes, decoding and performance analysis.
 Convolutional codes, the Viterbi decoding algorithm, performance analysis.
 Introduction to turbo codes.
9. **Communication in noisy intersymbol-interference channels** (Chs. 9 & 10):
 Bandlimited-channel characterization.
 Signal design and optimum receivers.
 Performance analysis.
 Linear equalization techniques.
10. **Communication through slow fading channels** (Ch. 14 and handouts):
 Rayleigh fading channels.
 Performance of digitally modulated signals in Rayleigh channels.
 Use of path diversity to reduce fading.

Computer usage:

Some homework assignments require the simulation of noise and random signals, and the empirical assessment of the performance of certain communication systems. Generation and performance analysis of certain error-correcting codes and source codes also require computer programming. Students are expected to be familiar with Matlab, or FORTRAN or C.

Course requirements

- 20% Homework & computer assignments. Assignments are due in class in the beginning of the period. Late homework and other irregularities can be subject to penalty (up to 20%).

- 50% Two midterm examinations.
- 30% Final examination.

Tentative grading policy

90–100: A
 80–89: B
 60–79: C
 59 or below: F

Important dates and events

Last day to withdraw without a grade: Feb. 27.
 Last class period: Thursday, May 6.
 Midterm I: Feb. 19.
 Midterm II: Apr. 8.
 Final examination: Tuesday, May 11, 10:00 – 12:00.
 No class on Mar. 16 and 18 (Spring Break).

Additional references:

Stephen G. Wilson, *Digital Modulation and Coding*. Prentice Hall, 1995. Recommended.

Ferrel G. Stremmer, *Introduction to Communication Systems*, 3rd Ed. Addison-Wesley Publishing Company. This is an excellent introductory course to communications.

Rodger E. Ziemer & Roger L. Peterson, *Introduction to Digital Communication*, Second Edition, Prentice Hall, 2001.

Rodger E. Ziemer & Roger L. Peterson, *Introduction to Spread Spectrum Systems*. Prentice-Hall, 1995.

H. V. Poor, *An Introduction to Signal Detection and Estimation*. Springer-Verlag, 1994. This book has a good treatment of statistical decision theory.

Andrew J. Viterbi & Jim K. Omura, *Principles of Digital Communication and Coding*. McGraw Hill, 1978. This is a more advanced information-theoretic-based text on digital communications.

Edward A. Lee & David G. Messerschmitt, *Digital Communication*, 2nd Ed. Kluwer Academic Publishers, 1988.

Academic honesty

All students are expected to demonstrate personal integrity. Although discussions and interaction among students regarding homework assignments are strongly encouraged, each student must show his/her individual effort. Exchange of information during examinations is strictly prohibited. Students exhibiting any form of academic dishonesty will be subjected to penalties in accordance with UNM's policies.