

EE 442 Digital Communications

Credits: 3

Categorization of credits: engineering topic

Instructor(s): Professors Narayana Santhanam

Textbook and Other Required Materials:

“Fundamentals of Digital Communication” by U. Madhow; and course handouts, notes and illustration problems solved in class by students under the supervision of the instructor.

Designation: Elective

Catalog Description: EE 442 Digital Communications (3) Baseband transmission, precoding and pulse shaping, spectral description of random processes, bandpass modulation and complex baseband equivalents, synchronization, signal space concepts, coherent and non-coherent reception, analysis and comparison of error performance of modulation schemes, introduction to wireless systems. Pre: 343 and 342; or consent.

Prerequisites: EE 343 “Introduction to Communication Systems” and EE 342 “Probability and Statistics”.

Class/Lab Schedule: 3 lecture hours per week in Spring Semester

Topics Covered:

The following plan is for Spring semesters (15 weeks). The total planned duration is 14 weeks to account for 3 holidays (MLK day, Presidents day and Good Friday).

1. Review of probability theory and basics of signals and systems (2 weeks).
2. Fundamentals of spectral descriptions of random processes using baseband transmission as examples, pulse shaping and precoding from a bandwidth control perspective (3 weeks)
3. Bandpass transmission systems and the complex baseband equivalent, Synchronization and introduction to coherent and non-coherent reception (3 weeks).
4. Signal space concepts, Gram-Schmidt orthogonalization, Spectral and probabilistic characterization of Additive White Gaussian Noise (AWGN) (2 weeks)
5. Analysis of coherent and non-coherent detection for binary and non-binary signaling systems over AWGN channels using signal space concepts (2 weeks)
6. Introduction to multipath, fading and Doppler effects, brief introduction to equalizers (2 weeks)

Course Objectives and Relationship to Program Objectives:

This course has multiple objectives. The first is for the students to build on and combine material learned in EE342 and EE315 to understand the spectral behavior of random processes, and therefore to formalize an understanding of communication systems covered in EE343. Second, students are taught how to understand detection of signals in noise based on fundamentals of

signal space methods which are applicable to problems even beyond the communication domain. The final objective is to make engineering decisions that combine (i) the spectral behavior of random processes (ii) signal space and detection methods and (iii) knowledge of communication systems (partly carried over from EE343, but also fresh material taught in EE442) to build a complete point to point communication link between two computers using modulated sound waves, and using the speakers and microphones of the computers as “antennas”. Both in theory and in practice, EE442 will highlight how prior fundamentals from earlier courses are used, as well as strongly emphasize how fundamentals apply to future problems both in and outside communication systems. As a result, EE442 addresses Program objectives [1,2,3 and 4].

Course Outcomes and Their Relationship to Program Outcomes

- Understanding spectral properties of random processes, detection, signal space methods, and theory of communication systems [1]
- Using theory learnt in class to model the computer to computer sound channel [1, 6]
- Building the point-point link over sound, and in turn making informed tradeoffs between bandwidth available, performance, power used and rate of communication as well as presenting the same the progress of the project throughout the semester [1, 2, 3]
- Understanding generally how prior fundamentals from earlier courses are used, and how fundamentals taught here translate to problems beyond the course [4, 7]

Contribution of Course to Meeting the Professional Component

"Engineering topics: 100%"

Computer Usage:

Students have a concurrent project that spans more than half the semester. This project will involve extensive use of design tools in MATLAB as well as substantial coding in MATLAB or any another language the student may choose (python/C).

Design Credits and Features:

EE442 has 0.5 design credit. As mentioned above, in addition to homeworks, students do an extended project involving designing a point to point, real-life communication link.

Person(s) Preparing Syllabus and Date: Narayana Santhanam, Jan 30, 2015. Y. Dong, June 14, 2021.