Spring 2024

ECE 425: Wireless Communication Systems

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ECE 425 Wireless Communications: From Fundamentals to 5G

3 hours/week
3 credits

This course is focused on the technical challenges and solutions to physical and link layer design of wireless communication systems. Course topics include characterization of the wireless channel, the cellular concept, digital modulation techniques, spread spectrum, multiple access techniques including CDMA and OFDM, diversity techniques. Advanced techniques such as LTE, MIMO, 5G NR technologies are introduced. Matlab is used for examples and assignments.

Instructor: Alexander Haimovich, haimovic@njit.edu

Instructional material

Recommended textbook: Rappaport, *Wireless Communications: Principles and Practice*, 2/e
Class notes and assignments are posted on Canvas.

Course learning outcomes ECE 425

1. Understand the basics of propagation of radio signals
2. Gain an understanding of the design principles of cellular systems
3. Understand how radio signals can be used to carry digital information in a spectrally efficient manner.
4. Gain knowledge of multiple access techniques based on frequency division, time division and code division.
5. Gain insights into how diversity afforded by radio propagation can be exploited to improve performance
6. Gain knowledge of the basics of wireless standards such as LTE and 5G NR.

Assessment:

- Class attendance mandatory – missing up to 3 classes does not require excuse
- Midterm, 2 hours, 35% (materials allowed: equations - one side of one sheet)
- Final, 2 hours, 35% (materials allowed: equations - one side of one sheet)
- ECE 425 Term project 20% Simulation of BPSK communication link
- Homework assignments 10%

Matlab Basic Matlab skills are required

Syllabus

Module 1 - Pathloss models (class notes, Rappaport book § 4.1, 4.2, 4.6, 4.9, 4.10.3, 4.10.4): Power diagram, dB units, noise figure, sensitivity, free space model, two-ray model, Hata model, shadowing, cell coverage area.

Module 2 - Multipath channel model (class notes, Rappaport book § 5.1-5.6): Rayleigh fading, frequency selective fading, time varying channels – Doppler effect.

Module 3 - Cellular concept (class notes, Rappaport book, § 3.1-3.5, 3.6): Cellular concept, hexagonal geometry, number of cells in cluster, SIR calculations.

Module 4 - Basics of digital communications (class notes, Rappaport book, §6.6): Match filter, detection theory, probability of error computations, Nyquist pulse shapes.

Module 5 - Digital modulations (class notes, Rappaport textbook § 6.4, 6.7, 6.8.1, 6.83, 6.8.4, 6.9.1, 6.10): Signal space and basis functions, BPSK, constellation mapping, QPSK, MPSK, QAM modulations.

Module 6 - Diversity methods (class notes, Rappaport textbook § 7.1, 7.2, 7.10.1-7.10.3, 7.12, 7.13): Diversity methods for Rayleigh fading, BER performance, equalization, channel coding.

Module 7 - Spread spectrum, CDMA, 3G (class notes): Direct sequence spread spectrum, suppression of narrowband interference, CDMA, orthogonal codes, near-far problem, 3G WCDMA

Module 8 - OFDM, LTE, 4G (class notes): OFDM, concept of cyclic prefix, LTE: frame structure, DL transmission scheme, reference signals and equalization concept, introduction to 5G NR.

Module 9 – MIMO (class notes): MIMO channel model, open loop transmit diversity, transmit diversity in LTE, spatial multiplexing, closed loop techniques, layers, codebook coding.