New Jersey Institute of Technology
ECE 425/644 Wireless Communications: From Fundamentals to 5G

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: Joerg Kliewer, jkliewer@njit.edu
Office Hours: by appointment
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Hours: by appointment

Pre-requisites:
For 425: ECE 421
For 644: ECE 321 or Math 333 + recommended to have taken a communications systems course such as ECE 421 or ECE 642.

Textbook:
Textbook is not mandatory.
Recommended textbook: Rappaport, *Wireless Communications: Principles and Practice*, 2/e

Class notes and assignments are available on Canvas.

Assessment:

- Class attendance mandatory
- Midterm: 2 hours; 35% of grade; Modules 1-5; Materials allowed: equations - one
- side of one sheet.
- Final: 2 hours; 35% of grade; Modules 6-9; Materials allowed: equations - one
- side of one sheet.
- ECE 425 Term project 20% Simulation of BPSK communication link
- ECE 644 Term project 20% Simulation of QPSK communication link
- Homework assignments 10% of grade

Homework assignments and midterm project
All the assignments have been posted on Canvas. Check submissions deadlines. Late submission of homeworks and project will receive zero points (absolutely no exceptions).
Problem sets associated with a module are to be submitted on Canvas according to the schedule for each assignment. All submissions are electronic on Canvas. No hardcopies.

Matlab
Basic Matlab skills 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

Course Plan

Classes take place on Mondays 2:30-5:20, ECEC 115

- Week 1, 9/8: Module 1
- Week 2, 9/15 Module1, Module 2
- Week 3, 9/23: Module 2 submit A1
- Week 4, 9/29: Module 3 submit A2
- Week 5, 10/6: Module 4 submit A3
- Week 6, 10/13: Module 4, Module 5
- Week 7, 10/20: Module 5, submit A4
- Week 8, 10/27: Module 6, midterm review, submit A5
- Week 9, 11/3: Midterm - Modules 1-4
- Week 10, 11/10: Module 6, term project review
- Week 11, 11/17: Module 7 submit A6
- Week 12, 11/24: Module 8 submit A7,
- Week 13, 12/1: Modules 8, 9 submit term project report
- Week 14, 12/8: Module 9, final review submit A8
- Final exam – Modules 5-9, date and location TBD