ECE-GY 6023 Wireless Communications

Course Description

This course covers the fundamentals of wireless communications including statistical descriptions of the wireless channel (path loss models, large-scale and small-scale fading), digital communication over fading channels (channel estimation, receiver design and performance, Shannon theory of time-varying channels, channel coding, diversity and related MAC-layer concepts), introduction to cellular systems and multiple access (frequency reuse, OFDM, CDMA, capacity analysis and basics of multiuser information theory) and MIMO communications. Examples will be provided from state-of-the-art cellular and wireless LAN standards.

Prerequisite

ECE-GY 6013

Textbook

Andrea Goldsmith, "Wireless Communications" Cambridge University Press (isbn: 9780521837163)
http://www.cs.ucdavis.edu/~liu/289I/Material/book-goldsmith.pdf

Class notes (sent to you by emails)

5G papers (references)

Software (Optional)

Matlab (can be installed if you bring your computer to the Helpdesk)

Grading Policy

Final: 30%
Final Project: 30%
Weekly Quiz: 30%
Homework and Class Participation: 10%

Instructor:

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Course Outline (14 lectures)

Lecture 1 Intro to Wireless Communications (**Notes 1a-e;** ch.1, 14.2, 15.1-3)

a. Syllabus and Lecture plan (**Note 1A**)

b. Multiple Access (**Note 1B**; Sections 14.2 & 15.3 of textbook)

c. Cellular Principle (**Note 1C**; Sections 15.1-2 of textbook)

d. Noise and Interference Limited Systems (**Note 1D**)

e. History and Relevant Issues (**Note 1E**; chapter 1 of textbook)

Lectures 2-4 Propagation Impairments and Wireless Channel Modeling

2: Spatial features: (**Notes 2a-c**; chapter 2 of textbook)

a. Transmission Loss and space dependent Fading,
   Empirical Transmission Loss Models
b. Probabilistic Modeling for Long Term Fading (Lognormal Fading or Shadow Fading)
   Probabilistic Modeling for Short Term Fading (Rayleigh Fading or Multipath Fading)
   Application Example I: Link Budget Analysis
   Application Example II: Designs of Signal Coverage Area & Cell Boundaries
   Application Example III: Numerical Analysis of Bit Error Rates for Various Noisy and Fading Channels

3. Time and/or Frequency Dispersive Features (**Notes 3a-c**; chapter 3 of textbook)

a. Probabilistic Modeling of multiple transceiver locations

b. Multipath and Doppler Effects

4. Overview on Channel Impairments & Modeling (**Notes 4a-c**)

a. Probabilistic Broadband Channel Modeling

(a-1 & a-2 are optional)

a-1. Numerical Approach 1 of Practical Broadband Channel Models (e.g., Jakes' Model)

a-2. Numerical Approach 2 of Practical Broadband Channel Models (e.g., Jakes' Model)

b. Overview of Channel impairments

c. Overview of Channel Modeling

Lecture 5 Applications on Channel Modeling

a. Fading and Diversity (**Note 5a;** Sections 6.1.6，6.3.1，6.3.2，7.2，7.3 of textbook)

c. Handoff (**Note 5b**)

c. Power Control (**Note 5c**)

Lectures 6 Channel Estimation and Data Detection (Notes 6A, 6B)

6a Narrowband Channel Estimation & Data Detection (Note 6A)

i. Channel Estimation using Training Sequence or Pilots

ii. Least Square, MMSE, Steepest Descent, and Least Mean Square Approaches

iii. Kalman Filter

6b Broadband Channel Estimation & Data Detection (Note 6B)

i. Channel Estimation using Training Sequence or Pilots

ii. Least Square, MMSE, Steepest Descent, and Least Mean Square Approaches

Lectures 7 Broadband Equalization (**Notes 7A-C**; chapter 11 of textbook)

a. Overview of Equalizer Techniques

b. Non-Blind Equalizer (with training sequences)

c. Blind Equalizer (Simultaneous Channel Estimation and Equalization) (*Stretched Goal*)

Lecture 8: Spread Spectrum and Code Division Multiple Access (**Notes 8A-F,** chapter 13 of textbook**)**

a. Spread Spectrum Techniques (**Note 8A**; section 13.1 of textbook)

b. DSSS (**Note 8B**; section 13.2 of textbook)

c. Spreading codes (**Notes 8C-E**)

d. Multiuser DSSS (section 13.4 of textbook)

e. Capacity (**Note 8F**)

Lectures 9-10 MIMO Channel Modeling and Transceiver Design (**Notes 9A-B, 10A-B**; chapter 10 of textbook)

a. Matrix Reviews (**Note 9A**)

b. Multiple Data Stream in MIMO System: Multiplexing (**Note9B**; Sections 10.1 & 2 of the textbook)

d. MIMO Diversity Gain: Beamforming (**Notes 9B**; Section 10.4 of the textbook)

e. MIMO Precoding & Decoding designs (**Note 10A**)

f. Space-Time Coding (**Note 10B**; Section 10.6 of textbook) (Stretched Goal)

Lectures 11-12: Orthogonal Frequency Division Multiplexing (**Notes** 11A-D, 12A-C; chapter 12 of textbook**)**

a. Spectrum Analysis of OFDM Signals and DSP Implementation of OFDM Systems (**Note 11A**; sections 12.1-2 of textbook)

b. Capacity Analysis and Practical OFDM Systems (**Note 11B**; section 12.6)

c. Multipath Effects - Frequency Selective Fading and Inter-symbol interference (**Note 11C**; sections 12.3-4 of textbook)

d. Detection (**Note 11D**)

f. Carrier-Frequency Synchronization and Timing Estimation (**Note 12A**; section 12.5.2 of textbook)

g. Peak to Average Power Ratio Analysis and Mitigation (**Note 12B**; section 12.5.1 of textbook)

h. Doppler Effects- Time Selective Fading and Intercarrier Interference (**Note 12C**)

i. RF Impairments and Mitigations (**Note 12D**)

Lectures 13-14 Selected Topics in 5G technology

Week 15 Final Exam