Syllabus of EL 6023

Course Description
Wireless communication channel models and practical techniques for mitigating transmission impairments. **Channel Modeling Parameters**: Path loss; Fading: long-term vs. short-term fading, flat vs. frequency selective fading, and slow vs. fast fading; Multipath spread parameters: delay spread, angular spread and Doppler spread, Matrix Channel Modeling for Multiple Input and Multiple Output (MIMO) Systems. **Channel Parameter Estimation**: training sequence and blind approaches. **Mitigation**: Mitigation of path loss and fading: Diversity, handoff and power control; Mitigation of intersymbol interference: rake receiver and equalizer; Mitigation of time variation: pilot symbols and dynamic tracking. **Processing Techniques**: LS, zero forcing, MMSE, LMS, etc.

Prerequisites: EE 3404, MA 3012.

Course Outline

Lecture 1 Spectrum, Signals & Systems  
1a Spectrum of Radio Waves  
1b Reviews on Theories of Signals & Systems in both Time and Frequency Domains  
1c Numerical Simulations of Signals & Systems using Matlab Programming

Lecture 2 Transmission Loss (A Deterministic Approach to Narrowband Channel Modeling )  
2a Fundamentals of RF Propagations  
2b Propagation Impairments: Transmission Loss on Narrowband RF signals  
2c Narrowband Channel Models: Path Loss, Long Term Fading and Short Term Fading

Lecture 3 Multipath & Doppler Propagation Effects (A Deterministic Approach to Broad band Channel Modeling )  
3a Propagation Impairments: Multipath Propagation Effects on both Narrowband and Broadband RF Signals  
3b Propagation Impairments: Doppler Effects on both Narrowband and Broadband RF Signals in Wireless Channels  
3c Basic Multipath and Doppler Channel Models

Lecture 4 Reviews on Probability & Random Variables  
4a Reviews on Probability Theory & Random Variables  
4b Numerical Generations of Commonly Used Random Variables (Gaussian, Uniform, Rayleigh, Exponential) in Wireless Communications  
4c Numerical Simulations for Various Statistical Measurements of Random Variables

Lecture 5 Probabilistic Narrowband Channel Modeling & System Design Applications  
5a Numerical Generations of Arbitrarily Distributed Random Variables  
5b Probabilistic Modeling for Long Term Fading (Lognormal Fading or Shadow Fading)  
5c Probabilistic Modeling for Short Term Fading (Rayleigh Fading or Multipath Fading)  
5d Application Example I: Designs of Signal Coverage Area & Cell Boundaries
Application Example II: Numerical Analysis of Bit Error Rates for Various Noisy and Fading Channels

Lecture 6 Probabilistic Narrowband Channel Modeling for Multiple Transmitters and/or Receivers: Part I: Theory and Numerical Techniques
6a Narrowband Channel Model for Multiple Transmitters and/or Receivers
6b Numerical Simulations for Correlated Shadow Fading Random Variables
6c Numerical Simulations for Correlated Multipath Fading Random Variables

Lecture 7: Midterm Exam

Lecture 8 Probabilistic Narrowband Channel Modeling for Multiple Transmitters and/or Receivers: Part II: Mitigation of Channel Fading
8a Fading and Diversity Combining Techniques
8b Handoff
8c Power Control

Lecture 9 Probabilistic Broadband Channel Modeling
9a Brief Introduction to Random Processes
9b Practical Broadband Channel Modeling
9c Numerical Procedures for Simulating Time Varying Broadband Channels
   1. Direct Implementation Using Multipath Arrivals
   2. Direct Implementation in the Time Domain Using Autocorrelation
   3. Finite Impulse Response (FIR) Filter Implementation
   4. Infinite Impulse Response (IIR) Filter Implementation

Lecture 10 Narrowband Channel Estimation and Data Detection
10a Narrowband Channel Estimation using Training Sequence (LS and MMSE approaches)
10b Narrowband Channel Estimation using Pilot Symbols
10c Blind and Non-blind Narrowband Data Detection (LS and MMSE approaches)
10d Kalman Filter

Lecture 11.1 Broadband Channel Estimation and Data Detection
11a Broadband Channel Estimation (LS and MMSE approaches)
11b Broadband Data Detection (LS and MMSE approaches)

11c Iterative Approaches: Steepest Descent (SD), Least Mean Square (LMS) Approaches

Lecture 12 Mitigation of Multipath Effects (Equalizers & Rake Receivers)
12a Overview of Equalizer Techniques
12b Non-Blind Equalizer (with training sequences)
12c Blind Equalizer (Simultaneous Channel Estimation & Equalization)

Lecture 13 Matrix Channel Modeling for Multiple Input Multiple Output (MIMO) Systems
13a Introduction to Smart Antenna Systems
13b Vector & Matrix Channel Modeling
13c Space Processing & Space-time Processing

Lecture 14: Reviews
Lecture 15: Final Exam

Textbook: None. Course materials are provided.
Software: Student version of Matlab with signal processing toolbox is recommended but is not required.