EE 651: Wireless Communications
July – November 2016

Pre-requisites
Probability theory with emphasis on Gaussian random process; signal space concepts; linear algebra; basics of digital communications

Objectives
1. To provide students an understanding of the concepts related to wireless channel modelling.
2. To explore communication concepts and techniques for exploiting wireless channel characteristics and application of these concepts in a system context.
3. To familiarize students with the baseband generation software tools and the measurement instruments.

Contents
Wireless Channels: Modelling of wireless channels; physical channel modelling, time and frequency channel coherence: Doppler spread, coherence time, delay spread and coherence bandwidth; input/output channel models: discretization and discrete-time representation; the wireless channel as a random linear time varying (LTV) system; stochastic characterization of LTV systems; characterizing key parameters of wireless channels; multiple antenna channel characterization, multiple-input multiple-output (MIMO) systems

Diversity: Non-coherent and coherent reception; error probability for un-coded transmission; realizing diversity; time diversity: interleaving, constellation rotation; frequency diversity, antenna diversity, code design for wireless channels: the product distance design criterion; diversity order

Wireless Channel Capacity: Capacity of the Gaussian channel and of parallel Gaussian channels; capacity of fading channels: ergodic capacity and outage capacity; high versus low SNR regime; water-filling capacity, Capacity of MIMO systems; spatial multiplexing; space-time coding

Cellular Systems: Multiuser communications; multiple access and broadcast channels; narrow band communication system - GSM; wide band communication systems - CDMA and OFDM schemes

Laboratory Experiments
Lab 0: Laboratory Introduction (Attendance mandatory);
Lab 1: Experiment #1 - To measure the channel power of a CDMA modulated RF signal using an oscilloscope and the VSA software.
Lab 2: Experiment #2 - Measure and plot antenna radiation patterns for dipole antenna and patch antenna.
Lab 3: Experiment #3 - To analyze the signal flow through each module in the transceiver chain.
Lab 4-5: Experiment #4 - To determine the occupied bandwidth of the modulated RF signal using an oscilloscope and VSA software and measure the output power of the occupied bandwidth.
Lab 6-7: Experiment #5 - To measure the error vector magnitude (EVM) of the modulated RF signal using an oscilloscope and VSA software and analyze the performance of the demodulation in the presence of noise.
Lab 8-12: Experiment #6 - Course laboratory project: Implement a transceiver chain and demonstrate wireless data transfer for the given channel parameters. The project duration will be 6 weeks.
Lab 13: Project Evaluation/Demonstration

Learning Outcomes
1. Analyze and design point-to-point wireless communications systems, particularly with application to mobile communication networks.
2. Apply concepts and techniques from Multiple-Input Multiple-Output (MIMO) theory to communication systems.
3. Develop the ability to compare and contrast the strengths and weaknesses of various mobile networks.
4. Hands-on experience of designing and testing communication systems.

Books
Tse, D. and Viswanath, P., *Fundamentals of wireless communication*, Cambridge University Press, 2005
Goldsmith, A., *Wireless Communications*, Cambridge University Press, 2005

Simon, M. K. and Alouini, M. S., *Digital communication over fading channels*, John Wiley and Sons, 2005
Rappaport, T. S., *Wireless Communication Systems: Principles and Practice*, Prentice Hall, 2002

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E-Resources

Tse, D. and Viswanath, P., *Fundamentals of wireless communication*, Cambridge University Press, 2005. Available at: http://www.eecs.berkeley.edu/~dtse/book.html

Goldsmith, A., *Wireless Communications*, Cambridge University Press, 2005. Available at: http://www.cs.ucdavis.edu/~liu/289I/Material/book-goldsmith.pdf

Design Standards

GSM: Global System for Mobile communications (http://www.3gpp.org/specifications/specification-numbering).
IS-95: CDMA Standard.

Homework Assignments

Homework assignments are given every week, starting in the 3rd week of the semester. Each problem set is due one week after it has been handed out.

Homework Submission: Homework assignments will be submitted electronically, as pdfs. Homework reports may be prepared by hand, in LaTeX, or even using Microsoft Word. If by hand the homework need to be scanned to pdf. Note that student will need to name file "Name_hwX.pdf" (e.g. second homework file "Arun_hw2.pdf") in order to submit it.

Discussion Session

During Friday lecture every 3rd week, starting in the 5th week of the semester. In the discussion session we will review basics, investigate material covered in class from a different perspective, answer questions, and discuss recent developments in the field.

Class

Lectures	Tuesday; Wednesday; Thursday 3PM
Laboratory	Thursday 9AM
Office Hours	Thursday 4 PM-5PM
Room	Lecture 2004; Laboratory 2101

Evaluation

Homework Assignments	0%
Mid-Semester I	20%
Mid-Semester II	20%
Quizzes	0%
End-Semester	40%
Laboratory	20%

Instructor

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