First Course Handout

EE 670A Wireless Communications-With PYTHON Projects

Fall Semester, 2022

Department of Electrical Engineering

Indian Institute of Technology Kanpur

Course Website: http://www.iitk.ac.in/mwn/ee670_F22/

1. Objectives:

Course will also include, assignments, live problem discussion/ PYTHON coding sessions

The course has both theoretical and practical flavors. It aims to explain the fundamental concepts and insights behind the development of modern 4G/ 5G wireless communication technologies. As part of the course, precise analytical models will be presented for various wireless systems followed by detailed performance analysis. The course intends to cover several key 4G/ 5G wireless technologies such as **SIMO/ MISO**, **OFDM, MIMO, MIMO-OFDM** in significant detail. This will also lay the foundation for advanced wireless communication techniques such as **Cooperative Communication, Massive MIMO and mmWave**. A key component will also be ***hands-on simulation studies*** of all technologies using **PYTHON**. Finally, students working in groups of two are expected to prepare a term paper that will focus on an in-depth study and analysis of any cutting edge wireless technology of their choice.

2. Prerequisites:

- EE320 for B.Tech students in EE department at IIT Kanpur.
- No prerequisite for M.Tech/ Ph.D. students enrolled in EE department at IIT Kanpur.
- Instructor consent for all other students.

Students are expected to be familiar with basic concepts of

- Digital Communications Systems
- Probability, Random Variables and Random Processes
- Calculus, Differentiation/ Integration
- Linear Algebra, Properties of Matrices etc.

3. Course Contents:

Wireless Communications and Diversity	**No. of Lectures**
Multipath Propagation, Wireless Channel Modeling – Passband/ Baseband, Fading Nature of the Wireless Channel	2
Rayleigh Fading Wireless Channel, Probability Density Function of Amplitude and Phase	2
Bit Error Rate (BER) Performance in AWGN Communication Channel – Analysis	1
BER Performance in Fading Wireless Channel – Analysis	2
Deep Fade Phenomenon in Wireless Channels	1
Diversity in Wireless Systems	
Multiple Antenna Wireless Systems, System Model	1
Optimal Receiver Combining – MRC Derivation, SNR Performance	1
BER Performance with Diversity – Analysis, Diversity Order	2
Types of Diversity: Antenna, Frequency, Time; Antenna Spacing Requirement	½
Deep Fade Analysis with Diversity	½
Wireless Channel Modeling	
RMS Delay Spread, Max Delay Spread, Inter Symbol Interference	2
Coherence Bandwidth – Flat versus Frequency Selective Fading	1

Mobility - Doppler Shift and Channel Modeling	1
Jakes Model, Autocorrelation Function, Jakes Spectrum	1
CDMA Technology	
Introduction to CDMA - Walsh codes, Orthogonality	1
PN Sequences, Generation using LFSR, Properties of PN Sequences	1
Advantages of CDMA – Jammer Rejection, Graceful Degradation, Universal Frequency Reuse	1
Multipath diversity, RAKE Receiver	1
CDMA for Multi-User Systems with Interference	1
OFDM and OFDMA Technologies	
Introduction to Multicarrier Modulation (MCM) and OFDM	1
Sampling MCM Signal, IFFT Generation and Cyclic Prefix	2
OFDM System Model, IFFT/ FFT Transceiver Model	1
OFDM - SNR and BER performance	1
Multi-user OFDM, OFDMA Systems for UL and DL, SC-FDMA	1
Multiple Input Multiple Output (MIMO) Technology	
Introduction to MIMO, System Model	1
MIMO Zero-Forcing and Minimum Mean Square Error (MMSE) Receivers	2
Introduction to Singular Value Decomposition (SVD), Examples of SVD and Eigenmodes of the MIMO Channel	1
MIMO Channel Capacity, Optimal Waterfilling Power Allocation	1
MIMO Diversity – Alamouti, Orthogonal Space-Time Block Codes (OSTBC)	1

MIMO Beamforming – Maximum Ratio Transmission (MRT)	1
MIMO-OFDM System Model and Analysis	1
Multi-user MIMO – Block Diagonalization, Successive Optimization	1
Wireless Standards	
Introduction to LTE, LTE-A Standards and Technology Specs	1
5G Technology	
Introduction to 5G Wireless Technologies – Massive MIMO, mmWave, NOMA, FBMC and Full Duplex	1

4. Special Emphasis:

- Multi-Antenna Systems
- OFDM
- MIMO, MIMO-OFDM
- Multi-user MIMO Systems

5. Lecture, Tutorial & Lab Schedule & Venue:

- Venue: L14
- Timings:
- Monday – 12:00 – 1:15 PM
- Thursday – 12:00 – 1:15 PM

6. Office Hours or, recommended mode of contact beyond formal contact hours:

- Saturday 12 noon via skype.
- Students can also contact both instructor as well as TAs via e-mail.

7. Evaluation Components & Policies:

	Weightage
Assignments (Theory + PYTHON)	15%

Mid-Sem	20%
Quiz-I	10%
Quiz-II	10%
Term Paper	10%
End-Sem	25%
Attendance Minimum 75% attendance	10%

Exam/ Assignment/ Term Paper Policy: If a student misses any one or more of Quiz-I/ Quiz-II/ Mid-sem, marks will be pro-rated based on remaining ones, if valid reason is provided along with supporting documents. If a student misses the end-sem exam, he/ she can apply to DOAA for makeup examination. Assignment solution or term paper submission is due by 12 Noon of respective due date. 15% Marks will be deducted for late submission. No makeup or prorating will be done for missed assignment submissions or term paper.

8. **Course Policies: Attendance, Honesty Practices, Withdrawal (within the limits of DOAA Guidelines)**

Attendance Policy: Minimum 75% attendance is required to score the 10% marks specified for attendance as per **Evaluation Policies** in Section 7. Attendance will be recorded in every session. Each student is expected to take notes

9. **Books & References: Properly Formatted along with listing of possible internet sources.**

Text Book	
Principles of Modern Wireless Communications	Aditya K. Jagannatham McGraw Hill Education - 2015 http://www.mheducation.co.in/9781259029578-india-principles-of-modern-wireless-communications-systems
Reference Books	

Fundamentals of Wireless Communication	David Tse and Pramod Viswanath Cambridge University Press, 2005 http://www.eecs.berkeley.edu/~dtse/book.html
Wireless Communications	Andrea Goldsmith Cambridge University Press

10. Instructor and TA Information

Instructor	
Prof. Aditya K. Jagannatham	**ACES 205D** **Mailbox on 2nd floor ACES Building.** **e-mail: adityaj@iitk.ac.in** **Ph: 7494**
Course TAs	
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