WIRELESS COMMUNICATION
ENEX 415

Lecture: 3 **Year: IV**
Tutorial: 1 **Part: I**
Practical: 1.5

COURSE OBJECTIVES:
The objective of this course is to provide students with a comprehensive understanding of the principles and operations of generation wise evolved wireless and cellular communication systems. Students will develop analytical and practical skills to model wireless channels, evaluate system performance, and design communication networks using contemporary simulation tools.

1 Evolution of wireless and Cellular Communication (**4 hours**)

1.1 Evolution of wireless systems
1.2 Generation of Wireless Networks (1G to 6G and Beyond) overvie
1.3 Basic Terminology, Mobile Communication Basis, GSM Architecture
1.4 Frequencies for Radio Transmission

2 Cellular Concept (6 hours)

2.1 Cellular Fundaments: Definition, Cellular Shape, Frequency reuse, Channel Assignment Strategies
2.2 Handoff Strategies: Concept of Handoff Techniques, Dropped Call Definition, Types of Handoff, Intersystem Handoff, Prioritizing Handoff, And Practical Handoff Consideration.
2.3 Interference and System Capacity, Channel Planning for Wireless Systems, Adjacent Channel and Co-Channel, Successive Interference, Power Control for Reducing Interference.
2.4 Trunking and Grade of Service
2.5 Improving Coverage and Capacity in Cellular Systems, Cell Splitting, Sectoring, Microcell Zone

3 Mobile Radio Propagation : Large Scale Path Loss (6 hours)

3.1 Review of Free Space Propagation Model, Radiated Power and Electro-magnetic field.
3.2 Review of Basic Propagation Mechanism, Reflection, Ground Reflection, Diffraction and Scattering.
3.3 Practical Link Budget Design Using Path Loss Model
3.4 Outdoor Propagation Models (Okumura, Hata, Cost-231 Hata Model, Cost-231 Walfish-Ikegami Model)

3.5 Indoor Propagation Model (Partition Losses (Same floor). Partition Losses Between Floors, Long-Distance Path Loss Model, Ericsson Multiple Breakpoint Model, Attenuation Factor Model)

3.6 Signal Penetration into Building, Ray Tracing and Site-Specific Modeling

4 Mobile Radio Propagation : Small Scale Fading and Multipath (5 hours)

4.1 Small Scale Multipath propagation (Influencing Factors, Doppler-shift)

4.2 Impulse Response Model of a multipath Channel

4.3 Small Scale Multipath Measurements, Parameters of Mobile Multipath Channels

4.4 Types of Small-Scale Fading (Flat Fading, Frequency Selective Fading, Fast Fading, Slow Fading)

4.5 Statistical Models for Multipath Fading (Rayleigh Fading, Rician Fading, Nakagami-m Fading, Log-Normal Shadowing, Suzuki Model)

5 Equalization Diversity and Channel Coding (10 hours)

5.1 Fundamentals of Equalization, Equalization in Communication Receiver

5.2 Basic Structure of Adaptive Equalizer , Optimum weight Solutions

5.3 Linear Equalization (Zero Forcing, Mean-Squared Error Linear Equalization),

5.4 Non-Linear Equalization (Overview of Decision feedback, Maximum Likelihood Sequence Estimation (MLSE) Equalization

5.5 Overview of Adaptive Equalization algorithm

5.6 Diversity Technique, Advantages of Diversity, Types of Diversity (Microscopic, Macroscopic)

5.7 Other Diversity Techniques Types: Space Diversities and its types, Polarization, Time, Frequency, Overview of Rake Receiver

5.8 Fundamentals of Channel Coding, Convolution Coding and Decoding

5.9 Trellis Coded Modulation, Turbo Codes

6 Voice Coding and Multiple Access Techniques (8 hours)

6.1 Voice Coding: Introduction, Characteristic of Speech/Voice Signal, Frequency Domain, Vocoder, Linear Predictive Coder, Selection of Coders for Mobile Communication, GSM Codes(Encoder, Decoder)

6.2 Multiple Access : Introduction, FDMA, TDMA and SDMA in Wireless Communication

6.3 CDMA: Concept of Spread Spectrum, Spread Spectrum Modulation Techniques, Basic Principles, Encoding, Decoding

6.4 OFDM: Basic Principles of Orthogonality, Single vs Multicarrier System, OFDM Block Diagram Overview.

7 Advances in Wireless Networking and Emerging Technologies (6 hours)

7.1 MIMO: Introduction, Comparison of Channel Capacities of SIMO, MISO and MIMO System, Smart Antenna System, Auto Beam Forming and MIMO, MIMO-Based System Architecture, Overview of Massive MIMO

7.2 5G Architecture Overview: 5G Radio Access Network, 5G Core Network, Concepts of mm Wave and Beamforming, Spectrum Challenges in 5G

7.3 Overview of 6G and AI/ML- enabled Wireless

7.4 Overview of Mobile Network and Networking Protocols, Network Vertualization, Concepts of Wireless Sensor Networks, SDWN, Open BTS, Open Cellular Networks

Tutorial **(15 hours)**

1. Differentiate among 1G to 5G network with their respective characteristic.
2. Write short notes on Quantization, PCM and DPCM.
3. Explain two parameters that describe a time varying nature of channel
4. Write the importance of Cell Site Controllers and Hardware.
5. Illustrate GMSK modulation techniques. How is it different from MSK modulation?
6. Describe the performance comparison of FDMA, TDMA and CDMA.
7. Explain Viterbi Algorithm with suitable example.
8. Illustrate NFV framework and SDN architecture for 5G Network Architecture.

Practical **(22.5 hours)**

1. Amplitude AWGN Channel and BER analysis to understand relation between noise power and communication reliability
2. Rayleigh and Rician fading channel simulation to identify how multipath and LOS condition affect performance
3. Performance of diversity techniques to learn how diversity mitigates fading effects.
4. OFDM System Design and Analysis to understand orthogonal subcarrier transmission and its robustness to multipath
5. Fundamental MIMO System Simulation to learn how multiple antenna enhance capacity reliability

Final Examination

The question will cover all chapters of the syllabus. The evaluation scheme will be as indicated in the table:

Chapter	Hours	*Marks
1	4	5
2	6	8
3	6	8
4	5	7
5	10	13
6	8	11
7	6	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References:

1. Dalal, U. (2009). Wireless communications. Oxford University Press.
2. Osseiran, A., Monserrat, J. F., & Marsch, P. (Eds.). (2016). 5G mobile and wireless communications technology. Cambridge University Press.
3. Rappaport, T. S. (2002). Wireless communications: Principles and practice (Latest ed.). Prentice Hall.
4. Sharma, S. (2013). Wireless and cellular communication. S. K. Kataria & Sons (Katson Books).