GUJARAT TECHNOLOGICAL UNIVERSITY

WIRELESS & MOBILE COMMUNICATION
SUBJECT CODE: 3710508
ME 1st Semester

Type of course: Core Subject

Prerequisite:

- Higher Engineering Mathematics,
- Fundamental knowledge of Signals and Systems
- Antenna and Wave Propagation
- Digital Communication theory
- Probability and random processes
- Programming skills in Simulation Exercises

Rationale:

The purpose of this course is to provide an understanding of modern digital mobile and wireless communication systems. Topics include: overview of cellular concept; interference and traffic analysis for cellular networks; wireless fading channel modeling and characterization; modulation and detection performance over fading channels; multi-carrier systems; receiver and transmitter diversity techniques; information theory of wireless channels; OFDM, MIMO, Massive MIMO and space-time communications; and cooperative communications; Mobile ad-hoc networks; 2G standards (e.g. GSM, CDMA), 3G standards and introduction to 4G and 5G standards.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE(E)	PA (M)	PA (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Sr. No.	Content	Total Hrs	%Weight
1	**The Cellular Concept-System Design Fundamentals:** Cellular structure, Frequency Reuse, Frequency management, Channel Assignment Strategies, Handoff Strategies- Interference and system capacity, Co channel Interference Co-channel Interference reduction and system capacity, Adjacent Channel interference , Channel planning for Wireless Systems, , Power Control for Reducing interference, Improving Coverage & Capacity in Cellular Systems- Cell Splitting, Sectoring, Mobile Antennas, Antennas at cell site and Cellular System Design Considerations, GSM architecture and interfaces, GSM architecture details, GSM subsystems, GSM Logical Channels, Data Encryption in GSM, Mobility Management, Call Flows in GSM. Wireless Network planning, Link budget and power spectrum calculations.	7	17%
2	**Mobile Radio Propagation Model, Small Scale Fading:** Large scale path	7	17%

	loss:-Free Space Propagation loss equation, Path-loss of NLOS and LOS Systems Reflection, 2-Ray Ground reflection Model, Diffraction, Scattering, Link budget design, Max. Distance Coverage formula, Empirical formula for path loss, Indoor and outdoor propagation models, Small scale multipath propagation, Impulse model for multipath channel, Delay spread, Feher's delay spread upper bound Small scale, Multipath Measurement parameters of multipath channels, Types of small scale Fading, Rayleigh and Rician distribution, Statistical for models multipath fading channels		
3	**Equalization & Diversity:** Equalizers in communication receiver, Algorithms for adaptive equalization, Diversity Techniques: Derivation of selection Diversity improvement, Derivation of Maximal Ratio Combining improvement, Practical Space Diversity Considerations, Frequency Diversity, and Time Diversity, RAKE Receiver, Interleaving	**6**	**14%**
4	**OFDM and MIMO:** Introduction to OFDM, Multicarrier Generation of sub-carriers using the IFFT OFDM signal processing and Trans-receiver blocks; Peak Power Problem: PAP reduction schemes, SNR performance, Introduction to MIMO, MIMO Spatial Multiplexing, MIMO Channel Capacity, MIMO applications, and Massive MIMO.	**8**	**19%**
5	**Mobile Ad-hoc Networks:** Ad-hoc wireless network-features and Challenges, MAC protocols in Ad-hoc Wireless networks (MACAW) Internet-based mobile ad-hoc networking communication strategies, Routing algorithms – Proactive, Reactive and Hybrid Routing Protocols, Energy management in ad-hoc wireless networks, Security issues and QoS in wireless networks, Vehicular to Vehicular Communication, Introduction to wireless sensor networks.	**8**	**19%**
6	**Recent Wireless Technology:** Overview of WCDMA, and Wi-MAX, Higher Generation Cellular Standards: 4G , enhanced 4G and 5G standards, Cognitive Radio, NOMA, Massive IoT	**6**	**14%**

Reference Books:

1. Wireless Communications: Principles and Practice, 2nd Edition, By Theodore S. Rappaport
2. Wireless Communication, By Molisch-Wiley India
3. Advanced Wireless Networks (Technology and Business Models): By Savo Glisic-Wiley
4. Wireless Communications ,Andrea Goldsmith Cambridge University Press, 2007
5. Mobile Cellular Telecommunications (Analog and Digital Systems), 2nd Edition, By William C.Y. Lee-McGraw Hill
6. David Tse and Pramod Viswanath Fundamentals of Wireless Communication ,Cambridge University Press 2005
7. Wireless Communication Systems: By Ke-Lin DU and M.N.S. Swamy
8. MIMO Wireless Communications – Ezio Biglieri – Cambridge University Press.
9. Principle and Application of GSM", V.K.Garg, J.E.Wilkes Pearson Education.
10. "A GSM system Engineering" Asha Mehrotra, Artech House Publishers
11. Richard Van Nee & Ramjee Prasad., 'OFDM for Multimedia Communications' Artech House Publication, 2001.

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Reference Papers:

1. Vaduvur Bharghavan, A. Demers, S. Shenker, and L. Zhang, "MACAW: A Medium Access Protocol for Wireless LAN's". In the Proc. ACM SIGCOMM Conference (SIGCOMM '94), August 1994, pages 212-225
2. C. Perkins C., and P. Bhagwat, "Highly Dynamic Destination-Sequence Distance Vector Routing (DSDV) for Mobile Computers," ACM SIGCOMM Computer Communication Review, Vol. 24, No. 4, October 1994, pp. 234-244.
3. "Charles E. Perkins and Elizabeth M. Royer "Ad hoc On-Demand Distance Vector Routing." Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications, New Orleans, LA, February 1999, pp. 90-100.
4. "David B. Johnson, David A. Maltz, and Josh Broch, "DSR: The Dynamic Source Routing Protocol for Multi-Hop Wireless Ad-Hoc Networks", in Ad-Hoc Networking, edited by Charles E."Perkins, Chapter"5, pp."139-172, Addison-Wesley, 2001. Invited paper.
5. "Samir R. Das, Charles E. Perkins, and Elizabeth M. Royer "Performance comparison of two on-demand routing protocols for ad-hoc networks," Proceedings of the IEEE Conference on Computer Communications (INFOCOM), Tel Aviv, Israel, March 2000, p. 3-12.
6. A.J Paulraj, Gore, Nabar and Bolcskei, "An Overview of MIMO Communications – A Key to Gigabit Wireless", IEEE Trans Comm, 2003
7. Simon Haykin: Cognitive Radio: Brain Empowered Wireless Communications, IEEE Journal on selected areas in communication Vol. 23 No.2 Feb-2005
8. Simon Haykin, David J. Thomson, Jefery H. Reed: Spectrum Sensing for Cognitive Radio, Proceedings of IEEE Vol. 97 No.5 May-2009.
9. MIMO-OFDM Systems for High Data Rate Wireless Networks", Whu

Course Outcome:

By the end of this course, the student will be able to:

1. Design a mobile cellular network
2. Optimize a radio channel system
3. Select the apt diversity scheme for a given wireless system to improve the performance.
4. Perform efficient spectral allocation using multiple access techniques such as CDMA, and OFDM.
5. Select the correct MAC protocol and routing algorithm for mobile ad-hoc networks.
6. Optimize the mobile ad-hoc network-MAC protocols and routing algorithms as per application.
7. Gain knowledge of underlying mobile standards and the future mobile technologies such as WCDMA, Wi-Max; and also the coming 4G and 5G mobile standards

Course Outcomes:

At the end of this course, students will be able to

- Design appropriate mobile communication systems.
- Apply frequency-reuse concept in mobile communications, and to analyze its effects on interference, system capacity, handoff techniques
- Distinguish various multiple-access techniques for mobile communications e.g. FDMA, TDMA, CDMA, and their advantages and disadvantages.
- Analyze path loss and interference for wireless telephony and their influences on a mobile-communication system's performance.
- Analyze and design OFDM and MIMO system functioning, advantages and disadvantages of the technology.
- Understand upcoming Mobile technologies like Massive MIMO, Massive IoT, NOMA
- Understand upcoming Mobile technologies like enhanced 4G and 5G etc.

List of Experiments:

Sr. No.	Experiment Name
1	To study different mobile communication standards.
2	To study and perform channelization scheme and measure adjacent and co-channel interference in cellular system
3	To study different diversity schemes and measure RF signal strength.
4	To study and measure path loss exponent for different environment.
5	To study and perform GSM AT commands
6	To study Trunking theory and generate ERLANG table.
7	To study and generate PN sequence using matlab.
8	To study the phase linearity of GMSK.
9	Implement Rayleigh fading channel in Simulink.
10	Implement OFDM IEEE 802.11a in Simulink.
11	Implementing Wi-Max 2004 in Simulink.

List of Assignments:

1. May learn and develop concepts of Software Radio in real time environment by studying the building blocks like Base band and RF section, convolution encoder, Interleaver and De-Interleaver.
2. May study and analyze different modulation techniques in time and frequency domain using SDRkit.

Design based Problems (DP)/Open Ended Problem:

1. Show that if n=4, a cell can be split into four smaller cells, each with half the radius and 1/16 of the transmitter power of the original cell. If the extensive measurements show that the path loss exponent is 3, how should the transmitter power be changed in order to split a cell into four smaller cells? What impact will this have on the cellular geometry? Explain your answer and provide drawings that show how the new cells would fit within the original macrocells.
2. Assume that a cell named Radio Knob has 57 channels, each with an effective radiated power of 32 W and a cell radius of 10 km. The path loss is 40 dB/ decade. The grade of service is established to be a probability of blocking of 5%. Assume the average call length is 2 minutes, and each user averages two calls per hour. Further, assume the cell has just reached its maximum capacity in the same area.
    a. What is the current capacity of Radio Knob cell?
    b. What is the radius and transmit power of the new cells?
    c. How many channels are needed in each of the new cells to maintain the frequency reuse stability in the system?
    d. If the traffic is uniformly distributed, what is the new traffic carried by each new cell?
    e. Will the probability of blocking in these new cells be below 0.1 % after the split?

    Assume 57 channels are used at the original BS and the split cells.
3. In a two-ray ground reflection model, assume that θ_Δ must be kept below 6.261 radians for phase cancellation reasons. Assuming a receiver height of 2m, and given a requirement that θ_i be less than 5^O, what are the minimum allowable values for the T-R separation distance and the height of the transmitter antenna? The carrier frequency is 900 MHz
4. Using computer simulation, create a Rayleigh fading simulator that has three independent Rayleigh fading multipath components, each having variable multipath time delay and average power. Then convolve a random binary bit stream through your simulator and observe the time waveforms of the output stream. Observe the effects of multipath spread as you vary the bit period and time delay of the channel.
5. Analyze any wireless network of your choice using different routing algorithms covered in syllabus using NS-2

C. List of Software:

Matlab, NS-2

Learning website:

www.nptel, **ocw.mit.edu** **(MIT Open-Course Ware)**

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.