NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL



Honors in

Advanced Communication Systems

(for Students of B.Tech., ECE)

(w.e.f. 2021-22)

Department of

Electronics and Communication Engineering

SCHEME OF INSTRUCTION

Honors Program – Advanced Communication Systems

S.No	Course Code	Course Title	L	T	P	Credits	Sem
1	EC5303	RF Engineering	3	0	0	3	V
2	EC5304	Mathematical Foundations for Communication Engineers	3	0	0	3	V
3	EC5351	Advanced Wireless Communication	3	0	0	3	VI
4	EC5368	Smart Antennas for 5G communications	3	0	0	3	VI
5	EC5311	Wireless optical communication	3	0	0	3	VII
6	EC5369	Machine Learning for Next Generation Communication Networks	3	0	0	3	VIII
		Total				18	

Course code : EC5303	RF Engineering	Credits 3-0-0: 3

Course Outcomes:

At the end of the course, the student will be able to

CO1	Simulate passive circuits in microstrip line technology
CO2	Design microstrip lowpass, high pass, bandpass and bandstop filters.
CO3	Design microstrip based couplers and power dividers
CO4	Ability to use and measure S-parameters using microwave instruments

Detailed Syllabus:

UNIT 1 SCATTERING PARAMETERS

Scattering and chain scattering matrices, Generalized scattering matrix, Analysis of two port Networks, scattering matrix, representation of microwave components (directional coupler, circulators, hybrids, and isolators).

UNIT 2 PLANAR TRANSMISSION LINE

Microstrip lines: Geometry of microstrip, quasi-TEM mode of propagation, Static-TEM parameters, Characteristic impedance, effective permittivity, synthesis formulae, analysis formulae, dispersion in microstrip.

UNIT 3 HIGH FREQUENCY FILTER DESIGN

Filter design using Insertion loss method, characterization by power loss ratio, Maximally flat low pass filter, Equal-ripple low pass filter, Filter transformations: impedance and frequency scaling, bandpass and bandstop transformations, Filter implementation: Richard's transformation, Kuroda's identities.

UNIT 4 POWER DIVIDERS AND DIRECTIONAL COUPLERS

Basic properties of dividers and Couplers. Even mode and odd mode analysis, Wilkinson power divider, quadrature hybrid, and coupled line directional coupler.

UNIT 5 MICROWAVE MEASUREMENT SYSTEMS

Instrumentation concepts and measurement techniques in Spectrum analyzer, Signal generator, Vector network analyzer, and Noise figure analyzers.

Readings:

1. D. M. Pozar, Microwave Engineering, 3nd Edition, John Wiley & Sons.

2. R. Sorrentino and G. Bianchi, Microwave and RF Engineering, John Wiley & Sons.

3. Reinhold Ludwig and Gene Bogdanvov, ―RF Circuit Design – Theory and Application, 2nd Edition, Pearson, 2012.

4. E.da Silva, ―High Frequency and Microwave Engineering, Butterworth Heinmann publications, Oxford, 2001.

5. T. C. Edwards, Foundations of Interconnects and Microstrip lines, John Wiley & Sons.

Course Code: EC5304	Mathematical Foundations for Communication Engineers	Credits 3-0-0: 3

Pre-requisites: Basic Mathematics

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand the mathematical concepts related to probability theory and random processes
CO2	Formulate and solve communication problems involving random processes
CO3	Understand the fundamental concepts in vector spaces, linear operators, matrices
CO4	Apply the concepts of inner product spaces to orthogonality and approximation problems

Detailed Syllabus:

PROBABILITY AND RANDOM VARIABLES: Meaning of probability, Axioms of Probability, Conditional Probability, Concept of a Random Variable, Expected values for discrete and continuous random variables, Function of one Random Variable, Two Random variables, conditional probability density functions.

RANDOM PROCESSES: Classification, Auto Correlation, Cross Correlation, Stationary and wide sense stationary random process, Gaussian random process, Poisson random process.

LINEAR ALGEBRA: Vector spaces, Linear combination of vectors, Linear dependence, Basis and dimensions, finite dimensional vector spaces, Linear Transformations.
Norms and normed vector spaces, Inner products and inner product spaces.

LINEAR OPERATORS AND MATRIX INVERSES: Matrix factorizations, LU factorization, unitary matrices and QR factorization. Eigen values and Eigen vectors, Linear dependence of Eigen vectors, diagonalization of matrix. Singular value decomposition, pseudo inverses and the SVD.

Reading:

TEXT BOOKS:

[1]. A. Papoulis and S. Unnikrishnan Pillai, ``Probability, Random Variables and Stochastic Processes," Fourth Edition, McGraw Hill. (Indian Edition is available).
[2]. Gibert Strang," Linear Algebra and its applications", Thomson Learning Inc, 4th Edition.

REFERENCES:

[1]. H.Stark and J. Woods, 'Probability and Random Processes with Applications to Signal Processing," Third Edition, Pearson Education. (Indian Edition is available).
[2]Steven M. Kay, " Intuitive Probability and Random Process using Matlab", Springer Publications.
[3]. Todd K Moon, Wynn C. Stirling" Mathematical Methods and Algorithms for Signal Processing, Prentice Hall.

Course Code: EC5351	Advanced Wireless Communication	Credits 3-0-0:3

Course Outcomes:

At the end of the course, the student will be able to

CO1	Model the wireless channel to estimate the path loss
CO2	Evaluate the performance of digital modulation techniques over wireless channels using software and hardware techniques
CO3	Suggest the possible techniques to improve the performance of wireless systems using modern tools
CO4	Identify the advantages of multicarrier modulation

Detailed Syllabus:

WIRELESS CHANNELS: Radio wave propagation, Physical modeling for wireless channels, Path loss and Shadowing, outage probability under path loss and shadowing, time and frequency coherence, Statistical multipath channel models, narrowband fading models, wideband fading models, Discrete-time model, Space-time channel models.

CAPACITY OF WIRELESS CHANNELS:AWGN channel capacity, capacity of flat fading channels, channel distribution Information known at transmitter or receiver and both capacity comparisons, Capacity of frequency selective fading channels-time invariant- time variant.

PERFORMANCE OF DIGITAL MODULATION OVER WIRELESS CHANNELS: SNR and bit/symbol energy, error probability for BPSK, QPSK, MPSK, MPAM, MQAM , Index Modulation over fading channels. Error probability for FSK and CPFSK, error probability approximation for coherent modulations and differential modulation, Q-function representation, outage probability, average probability of error, inter symbol interference.

DIVERSITY: Receiver diversity: selection combining (SC), threshold combining, maximal ratio combining (MRC), equal gain combining (EGC), transmitter diversity: channel known at the transmitter, channel unknown at the transmitter, Alamouti scheme, moment generating functions(MGF) in diversity analysis ,diversity analysis using MGF for SC-EGC-MRC, diversity analysis for non-coherent and differentially coherent modulation.

EQUALIZATION: equalizer noise enhancement, equalizer types, zero forcing equalizer, MMSE equalizer, maximum likelihood sequence estimation, decision feedback equalization, adaptive equalizers.

Reading:

Text books:

1. Andrea goldsmith, `Wireless Communication`, South Asia Edition 2015, Cambridge University Press

2. Theodore S. Rappaport, 'Wireless Communications Principles and Practice," Third Edition, Pearson Education. (Indian Edition is available).

3. David Tse, Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press

4. Todd K Moon, Wynn C. Stirling" Mathematical Methods and Algorithms for Signal Processing, Prentice Hall

Course Code: EC5368	Smart Antennas for 5G communications	Credits 3-0-0:3

Course Outcomes:

At the end of the course, the student will be able to

CO1	To Familiarize with smart and adaptive antennas.
CO2	Apply different adaptive algorithms for 5G antenna.
CO3	Understanding the concept of direction of arrival and angle of arrival
CO4	Design of antenna array architectures to meet 5G requirement.

Detailed Syllabus:

5G Concepts

5G Objectives and Usage Scenarios, 5G Activities, Channel Access Method/Air Interface, 5G Policy, 5G Timelines, 4G/5G Radio Access Network, 5G system concept, LTE-Advanced, LTE-Advanced Pro, 5G NR, The 5G architecture, Spectrum Analysis and Regulations for 5G

Introduction to smart antenna

Introduction to Smart Antennas, Architecture of a Smart Antenna System: Transmitter and Receiver, Types of Smart Antennas, Benefits and Drawbacks of Smart Antennas, Applications of Smart Antennas.

Smart Antenna Configurations

Fixed Sidelobe Canceling, Retrodirective Arrays, Beamforming, Adaptive Arrays, Butler Matrix, Spatial Filtering with Beamformers, Switched Beam Systems, Multiple Fixed Beam System. Uplink Processing, Diversity Techniques, Angle Diversity, Maximum Ratio Combining, Adaptive Beamforming, Fixed Multiple Beams versus Adaptive Beamforming, Downlink Processing.

Angle-of-Arrival Estimation

Fundamentals of Matrix Algebra, Array Correlation Matrix, AOA Estimation Methods: Bartlett AOA Estimate, Capon AOA Estimate, Linear Prediction AOA Estimate, Maximum Entropy AOA Estimate, Pisarenko Harmonic Decomposition AOA Estimate, Min-Norm AOA Estimate, MUSIC AOA Estimate, ESPRIT AOA Estimate.

MIMO Antennas

Introduction, Multiple-Antenna MS Design, RAKE Receiver Size, Mutual Coupling Effects, Dual-Antenna Performance Improvements, Downlink Capacity Gains, Principles of MIMO systems: SISO, SIMO, MISO,MIMO, Hybrid antenna array for mmWave massive MIMO: Massive Hybrid Array Architectures, Hardware Design for Analog Subarray.

Text Books:

1. Ahmed El Zooghby, ‘Smart Antenna Engineering’, ARTECH HOUSE, INC, 2005.
2. Frank B. Gross, ‘Smart antenna with MATLAB’, 2nd Edition, McGraw-Hill, 2015.
3. Lal Chand Godara , “SMART ANTENNAS” , CRC PR ESS, 2004
4. Shahid Mumtaz, Jonathan Rodriguez, Linglong Dai mmWave Massive MIMO: A Paradigm for 5G

Course Code: EC5311	Wireless Optical Communication	Credits 3-0-0: 3

Course Outcomes:

At the end of the course, the student will be able to

CO1	Learn the principles of wireless optical communication (WOC) and the light transmission through the air, it must contend with a complex and not always predictable channel - the atmosphere.
CO2	Understand about the modulation and demodulation techniques used in WOC systems
CO3	Expose atmospheric/free-space channel characterization with different atmospheric conditions
CO4	Design transmitter and receiver for WOC link and analyse the link feasibility interms of error performance and channel capacity.

Detailed Syllabus:

Introduction to wireless optical communication (WOC), wireless optical channels: atmospheric channel, underwater optical channel, atmospheric losses, weather condition influence, atmospheric turbulence effects i.e. scintillation, beam spreading, etc. wireless optical communication application areas, WOC challenges.

Optical sources and detectors: LED structure, planar and dome LED, LED efficiencies, LASER diode, Modes and Threshold conditions, structure of common Laser Types: Fabry–Perot Laser, distributed feedback Laser. PIN Photo detector, avalanche photo diode, photo detection noises, comparison of photo detectors.

Channel modeling: linear time invariant model, channel transfer function, models of turbulence induced fading such aslog-normal turbulence model, exponential, K distribution, gammagammadistribution,indoor optical wireless communication channel: LOS propagation model, Non-LOS propagation model, spherical model.

Modulation techniques: analogue intensity modulation, digital baseband modulation techniques: baseband modulations, on–off keying, error performance on Gaussian channels, power efficiency, BW efficiency, bit versus symbol error rates, different modulation schemes such as M-PPM, DPPM, DAPPM schemes, subcarrier modulation, optical polarization shift keying: binary PolSK, bit error rate analysis.

Detection techniques: direct detection optical receivers, PIN/APD, coherent techniques i.e. homodyne and heterodyne, bit error rate evaluation in presence of atmospheric turbulence, spatial diversity receivers, effect of turbulence and weather conditions i.e. drizzle, haze fog on error performance and channel capacity.

References:

1. Z.Ghassemlooy, W.Popoola, S.Rajbhandari, Optical Wireless Communications, CRC Press,2013.
2. Gerd Keiser, Optical Fiber Communication, 4th Edition, Tata McGraw-Hill Ltd., 2008 (Indian Edition).
3. L.C.Andrews, R.L.Phillips, Laser Beam Propagation through Random Media, SPIE Press,USA, 2005.

Course code: EC5369	Machine Learning For Next Generation Communication Networks	Credits 3-0-0:3

Pre-requisites: Advanced digital communication

Course Outcomes:

At the end of the course, the student will be able to

CO1	Design machine learning algorithms for spectrum access and sharing
CO2	Design reinforcement algorithms for resource allocation
CO3	Design deep learning algorithms for optimizing coverage and channel capacity
CO4	Apply machine learning algorithms for optimizing energy efficiency, modulation, coding, channel equalization and signal detection.

Detailed Syllabus:

Machine Learning for Spectrum Access and Sharing: Online Learning Algorithms for Opportunistic Spectrum Access, Performance Measures of the Online Learning Algorithms, Random and Deterministic Approaches, the Adaptive Sequencing Rules Approach, Structure of Transmission Epochs, Learning Algorithms for Channel Allocation, Distributed Learning

Machine and Reinforcement Learning for Resource Allocation in Cognitive Radio Networks: Use of Q-Learning for Cross-layer Resource Allocation, Deep Q-Learning and Resource Allocation, Cooperative Learning and Resource Allocation, Decentralized Resource Minimization, Resource Minimization Approaches, Optimized Allocation

Deep Learning–Based Coverage and Capacity Optimization: Related Machine Learning Techniques for Autonomous Network Management, Data-Driven Base-Station Sleeping Operations by Deep Reinforcement Learning, Deep Q-Learning Preliminary and its Applications to BS Sleeping Control, Dynamic Frequency Reuse through a Multi-Agent Neural Network Approach

Machine Learning in Energy Efficiency Optimization: Self-Organizing Wireless Networks, Traffic Prediction and Machine Learning, Cognitive Radio and Machine Learning, Deep Learning, Positioning of Unmanned Aerial Vehicles, Traffic Prediction, Mobility Prediction

Machine Learning–Based Adaptive Modulation and Coding (AMC) Design: Overview of ML-Assisted AMC, k-NN-Assisted AMC, Algorithm for k-NN-Assisted AMC, Performance Analysis of k-NN-Assisted AMC System, RL-Assisted AMC

Machine Learning for Joint Channel Equalization and Signal Detection: Overview of Neural Network-Based Channel Equalization, Multilayer Perceptron-Based Equalizers, Functional Link Artificial Neutral Network-Based Equalizers, Radial Basis Function-Based Equalizers, Deep-Learning-Based Equalizers

Reading:

1. Fa-Long Luo," Machine Learning for Future Wireless Communications", John Wiley and Sons, 2020
2. Ruisi He, Z Ding, “Applications of Machine Learning in Wireless Communications”, IET Telecommunication series 81.
3. K. K. Singh, A. Singh, K. Cengiz**,** Dac-Nhuong Le**,** “Machine Learning and Cognitive Computing for Mobile Communications and Wireless Networks”, **Wiley 2020.**