NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI
FOR M.TECH PROGRAMS

Effective from 2019-2020

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VISION

Create an Educational environment to prepare the students to meet the challenges of modern electronics and communication Industry through state of art technical knowledge and innovative approaches.

MISSION

- To create learning, Development and testing environment to meet ever challenging needs of the Electronic Industry.
- To create entrepreneurial environment and industry interaction for mutual benefit.
- To be a global partner in training human resources in the field of chip design, instrumentation and networking.
- To associate with international reputed institution for academic excellence and collaborative research.

MASTER OF TECHNOLOGY

ELECTRONICS AND COMMUNICATION ENGINEERING

Specialization: Advanced Communication Systems

SCHEME AND SYLLABI

COURSE CURRICULUM FOR THE M.TECH PROGRAMME IN

ADVANCED COMMUNICATION SYSTEMS

GRADUATE ATTRIBUTES

The Graduate Attributes (GAs) are the knowledge skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

1. Scholarship of Knowledge: Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. Critical Thinking: Analyze complex engineering problems critically; apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. Problem Solving: Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
4. Research Skill: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. Usage of modern tools: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.
6. Collaborative and Multidisciplinary work: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.
8. Communication: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. Life-long Learning: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. Ethical Practices and Social Responsibility: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. Independent and Reflective Learning: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

PROGRAM EDUCATIONAL OBJECTIVES

PEO	PROGRAM EDUCATIONAL OBJECTIVES (PEOs)
PEO1	Conceptualize and prescribe the design flow of a communication system for a given application.
PEO2	Analyze, model, design and prototype the communication systems and networks with security features to meet the specifications
PEO3	Choose economical the coding techniques and safety measures to improve the performance by considering the most appropriate models for the available channel.
PEO4	Select the modern engineering tools to innovatively solve the problems in the design and operation of communication systems and networks.
PEO5	Pursue life-long learning as a means of enhancing the knowledge base and skills necessary to serve the engineering and scientific community.
PEO6	Contribute as an individual or a member of a team in product oriented research and demonstrate leadership skills

Mapping of Mission statements with program educational objectives

Mission	**PEO1**	**PEO2**	**PEO3**	**PE04**	**PEO5**	**PE06**
To create learning, Development and testing environment to meet ever challenging needs of the Electronic Industry.	3	3	3	3		
To create entrepreneurial environment and industry interaction for mutual benefit.	1	2	2	3		
To be a global partner in training human resources in the field of chip design, instrumentation and networking.		1	1	3	2	3
To associate with international reputed institution for academic excellence and collaborative research.				2	3	3

PROGRAM OUTCOMES

PO.Nos	**Program Outcomes (POs)**
PO1	Engage in critical thinking and pursue investigations/ research and development to solve practical problems.
PO2	Communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.
PO3	Demonstrate higher level of professional skills to tackle multidisciplinary and complex problems related to advanced communication systems.
PO4	Identify modulation /demodulation techniques and coding / decoding scheme for the design of a transmitter/receiver.
PO5	Indicate the modern data communication and networking concepts and features to be incorporated for secured data transfer as per societal needs.
PO6	Analyse and evaluate a wireless communication link or network and indicate performance enhancement methods.

Mapping of POs and PEOs

PEO	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	3	3	1	3	2	3
PEO 2	3	3	2	3	2	3
PEO 3	1	3	2	3	3	1
PEO 4	1	3	2	3	3	2
PEO 5	1	2	2	2	2	2
PEO 6	1	1	3	1	2	3

1*: Slightly* *2: Moderately* 3: Substantially

COURSE CURRICULUM FOR THE M. TECH. PROGRAMME IN ADVANCED COMMUNICATION SYSTEMS

Credit Structure:

Credits	Sem.-I	Sem.-II	Sem.-III	Sem. IV	Range
Core courses	12	06	00	00	**18**
Elective Courses	06	12	00	00	**18**
Lab courses	04	04	00	00	**08**
Seminar	01	01	00	00	**02**
Comprehensive Viva-Voce	00	00	02	00	**02**
Project	00	00	09	18	**27**
Total Credits	**23**	**23**	**11**	**18**	**75**

M. Tech. 1 Year (ACS) 1 –Semester

S. No.	Course No.	Course Title	L-T-P	Credits
1	EC5301	Detection and Estimation Theory	3-0-0	3
2	EC5302	Advanced Digital Communication	3-0-0	3
3	EC5303	RF Engineering	3-0-0	3
4	EC5304	Mathematical Foundations for Communication Engineers	3-0-0	3
5		Elective-I	3-0-0	3
6		Elective-II	3-0-0	3
7	EC5391	Seminar	0-0-2	1
8	EC5305	Digital Communication Lab	0-0-4	2
9	EC5306	RF Engineering Lab	0-0-4	2
	Total			23

I Year II- Semester

S. No.	Course No.	Course Title	L-T-P	Credits
1	EC5351	Advanced Wireless Communication	3-0-0	3
2	EC5352	Mobile Networks	3-0-0	3
3		Elective-III	3-0-0	3
4		Elective-IV	3-0-0	3
5		Elective-V	3-0-0	3
6		Elective-VI	3-0-0	3
7	EC5392	Seminar	0-0-2	1
8	EC5353	Wireless Communication Lab	0-0-4	2
9	EC5354	Networks Lab	0-0-4	2
Total				23

II Year I- Semester

S. No.	Course No.	Course Title	Credits
1.	EC6342	Comprehensive Viva	2
2.	EC6349	Dissertation-Part A	9
Total			11

II Year II- Semester

S. No.	Course No.	Course Title	Credits
1.	EC6399	Dissertation-Part B	18
Total			18

Total no. of credits **75**

List of Electives

Code	Elective-I
EC5311	Wireless optical communication
EC5312	IOT
EC5313	Information theory and coding
	Elective-II
EC5314	CMOS VLSI design
EC5315	Advanced DSP
EC5316	Optimization Techniques
	Elective-III
EC5361	Optical Networks
EC5362	Secured Communications
CS5152	Machine Learning
	Elective-IV
EC5364	Cognitive radio
CS5121	Big Data Analytics
EC5366	RF System Design
	Elective-V
EC5367	5G communications
EC5368	Green wireless communications
EC5369	Multimedia communications
	Elective –VI
EC5370	Advanced Image processing
EC5371	Speech processing
EC5372	Smart Antennas for 5G communications

Detailed Syllabus

EC5301	Detection and Estimation Theory	PCC	3-0-0	3 credits

Prerequisites: Probability theory and stochastic processes, Communication systems

Course Outcomes: At the end of the course the student will be able to:

CO1	Apply discrete-time and continuous-time signal theory to estimate the signal parameters.
CO2	Extract useful information from random observations in communications.
CO3	Design and analyze optimum detection schemes.
CO4	Understand different estimation schemes such as ML, LSE and MMSE estimators.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2					
CO2		2				
CO3			2			
CO4			2			

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

Detection theory

Introduction: Detection Theory in Signal Processing; the Detection Problem; the Mathematical Detection Problem; Hierarchy of Detection Problems; Role of Asymptotics; Summary of Important PDFs (Fundamental Probability Density Functions); Monte Carlo Performance Evaluation, Number of required Monte Carlo trials.

Statistical Decision Theory: Neyman-Pearson Theorem; Receiver Operating Characteristics; Minimum Probability of Error (ML, MAP, Baye's); Multiple Hypothesis Testing.

Deterministic Signals: Matched Filters – Development of Detector, Performance of Matched Filter; Multiple Signals – Binary case, Performance of Binary Case, M-ary case.

Random Signals: Estimator-Correlator – Energy Detector; Linear Model – Rayleigh Fading Sinusoid, Incoherent FSK for a Multipath Channel; Signal Processing Example – Tapped Delay Line Channel Model.

ESTIMATION THEORY

Introduction: Estimation in Signal Processing; Mathematical Estimation Problem; Assessing Estimator Performance.

Minimum Variance Unbiased Estimation: Unbiased Estimators; Minimum Variance Criterion; Existence of the Minimum Variance Unbiased Estimator; Finding the Minimum Variance Unbiased Estimator.

Cramer-Rao Lower Bound: Estimator Accuracy Considerations; Cramer-Rao Lower Bound; General CRLB for Signals in WGN; Extension to a Vector Parameter; Signal Processing Examples – Range Estimation, Sinusoidal Parameter Estimation).

Linear Models: Definition and Properties; Linear Model Examples – Curve Fitting, Fourier Analysis, System Identification.

General Minimum Variance Unbiased Estimation: Sufficient Statistics; Finding Sufficient Statistics; Using Sufficiency to Find the MUV Estimator.

Best Linear Unbiased Estimators: Definition of the BLUE; Finding the BLUE.

Maximum Likelihood Estimation: Example – DC Level in WGN; Finding the MLE; Properties of the MLE; MLE for Transformed Parameters.

Least Squares Estimation: The Least Squares Approach; Linear Least Squares; Order-Recursive Least Squares.

The Bayesian Philosophy: Prior Knowledge and Estimation, Nuisance parameters

General Bayesian Estimators: Risk Function; Minimum Mean Square Error Estimators; Maximum A Posteriori Estimators.

Kalman Filters and Wiener Filters: Introduction, Summary, Dynamic signal models, Scalar Kalman filter, Kalman versus Wiener filter.

Books:

1. **Steven M. Kay,** "Fundamentals of Statistical signal processing, volume-1: Estimation theory". Prentice Hall 2011.

2. **Steven M. Kay,** "Fundamentals of Statistical signal processing, volume-2: Detection theory". Prentice Hall 2011.

3. **Harry L. Van Trees**, "Detection, Estimation, and Modulation Theory, Part I," John Wiley & Sons, Inc. 2011.

4. **A. Papolis and S. Unnikrishna Pillai**, "Probability, Random Variables and stochastic processes, 4e". The McGraw-Hill 2010.

EC5302	Advanced Digital Communication	PCC	3-0-0	3 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Design optimum receivers for digital modulation techniques
CO2	Compare the various modulation schemes from the point of view of bandwidth, circuit complexity and noise performance.
CO3	Determine the probability of error for a given scheme
CO4	Design an equalizer in the context of band-limited linear filter channels

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1			2		
CO2					2	
CO3					2	
CO4						2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Elements of a Digital Communication System, mathematical models for communication channels, Communication channels and their characteristics. Representation of bandpass signals and system, Signal space representations.

Representation of digitally modulated signals, Memoryless modulation methods-Pulse Amplitude Modulation, Phase Modulation schemes, Quadrature Amplitude Modulation, Multi dimensional signaling - Spectral characteristics of Digitally modulated signals .

Optimum receiver for signals corrupted by AWGN, Performance of the optimum receiver for memoryless modulation, Optimum receiver for CPM signals and signals with random phase in AWGN channel.

Signal parameter estimation, Carrier phase estimation, Symbol timing estimation, Joint estimation of carrier phase and symbol timing, Performance characteristics of ML estimators.
Characterization of band-limited channels, Signal design for band-limited channels, Probability of error in detection of PAM, Modulation codes for spectrum shaping.

Optimum Receiver for channels with ISI and AWGN, Linear equalization, Decision feedback equalization, Reduced complexity ML detectors, Iterative equalization and decoding-Turbo equalization.

Multicarrier Systems: Multi Carrier Communications, Orthogonal Frequency Division Multiplexing(OFDM), Modulation and Demodulation of OFDM system, Algorithm implementation IFFT/FFT of OFDM, Peak to average Power Ratio in multi carrier Modulation

Textbooks:

1. J.G. PROAKIS, ' Digital communications' , MGH, 4th edition, 2001
2. Upamanyu Madhow, 'Fundamentals of Digital Communication', Cambridge University Press
3. Michael Rice, Digital Communications: A Discrete-Time Approach, Prentice Hall,

EC5303	RF Engineering	PCC	3-0-0	3 credits

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

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2		
CO2			2	2		
CO3			2	2		
CO4			2	2		

Mapping code : 1: Slightly 2: Moderately 3: Substantially

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.

REFERENCES

1. D. M. Pozar, Microwave Engineering, 3rd 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.

EC5304	Mathematics for Communication Engineers	PCC	3-0-0	3 credits

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
CO5	Understand and apply the concepts of eigen values and SVD for solving engineering problems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2					
CO2		2				
CO3			2			
CO4				2		1

Mapping code : 1: Slightly 2: Moderately 3: Substantially

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.

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.

EC5305	Digital Communication Lab	PCC	0-0-4	2 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify the different line codes and infer the quality of the received signal using eye diagram
CO2	Appreciate the principle of generation and detection of BPSK, DPSK, DEPSK, MSK, GFSK, GMSK signals.
CO3	Appreciate the principle of generation and detection of QPSK, DQPSK signals.
CO4	Generate and detect rate ½ convolutional code
CO5	Use a software tool to generate time domain and frequency domain descriptions of various binary digital modulation schemes.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2				2		
CO3					2	
CO4						2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

Hardware related experiments:

1. Sampling and reconstruction of low pass signals

2. Time Division Multiplexing

3. BPSK/DPSK generation & detection

4. QPSK/OQPSK generation &detection

5. 8-QAM generation & detection

6.FSK generation and detection

Simulation based experiments: (Matlab/Labview simulation)

1. Sampling & reconstruction of low pass signals

2. BPSK Modulation & detection

3. BER of BPSK in AWGN channel

4. QPSK generation & detection

5. BER of QPSK in AWGN channel

6. QAM generation & detection

7. 16 QAM constellation diagram

8. Generation of Nyquist-I pulse

9. Designing an equalizer in the context of baseband binary data transmission
10. OFDM generation and detection

(Any of the 5 `Hardware related experiments’ and 5 more `Simulation based experiments’ are performed by all the students of M.Tech. batch).

EC5306	RF Engineering Lab	PCC	0-0-4	2 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Design of distributed microstrip filters
CO2	Design of microstrip couplers, power dividers and hybrids
CO3	Design of microwave active devices, oscillators and amplifiers
CO4	Fabrication and measurement of Microwave passive and active components

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2		
CO2			2	2		
CO3			2	2		
CO4			2	2		

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

Virtual Lab

Design and simulation of a 50 Ohm microstrip line using AWR/Keysight ADS/Ansys HFSS.
Design and simulation of microstrip low pass filter using AWR/Keysight ADS/Ansys HFSS (using stubs and stepped impedance filter).
Design and simulation of microstip bandpass filter using AWR/Keysight ADS/Ansys HFSS.
Design and simulation of microstrip branch line coupler using AWR/Keysight ADS/Ansys HFSS.
Design and simulation of microstrip coupled line coupler using AWR/Keysight ADS/Ansys HFSS.
Design and simulation of Wilkinson power divider using AWR/Keysight ADS/Ansys HFSS.
Design and simulation of low noise amplifier using AWR/Keysight ADS/Ansys HFSS.
Design and simulation of an oscillator using AWR/Keysight ADS/Ansys HFSS.

Experimentation

Measurement of passive components using Vector Network Analyzer, Spectrum Analyzer and Signal Generator.
Fabrication and testing of microstrip low pass and bandpass filter.
Fabrication and testing of a microstip branch line coupler and Wilkinson power divider.
Fabrication and testing of a low noise amplifier.
Fabrication and testing of an oscillator.

EC5311	Wireless Optical Communications	PEC	3-0-0	3 credits

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.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2				
CO2				3		
CO3	1		2		2	
CO4					1	3

Mapping code : 1: Slightly 2: Moderately 3: Substantially

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.

EC5312	IOT	PEC	2-1-0	3 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand IOT design requirements
CO2	Compare various technologies and protocols
CO3	Study Cloud storage and intelligent analytics
CO4	Analyze security requirements along with threat model
CO5	Design and experiment various applications

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2		2				3
CO3				3		
CO4					3	
CO5						3

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Architectures: IoT and the connected world, Architecture of IoT, Security issues, Opportunities for IoT
Relavance of Internet to network of Things, network management, security, mobility and longevity, desirable features of a distributed architecture for a system of things

Technologies: Wireless protocols, Connectivity options, Low-power design, range extension techniques, data-intensive IoT, MAC and routing aspects.

Data storage and analysis: Managing high rate sensor data, Processing data streams, Data consistency in an intermittently connected or disconnected environment,
Identifying outliers and anomalies

Security in IOT: Threat models, Defensive strategies and examples

Cloud Computing: Introduction, Types of Cloud Computing, Cloud Computing: A Paradigm Shift? Price and Value Models, Security and Governance, IAAS AND PAAS, SAAS, AWS, Azure, IBM Watson

Reference Books:
1. Adrian McEwen, Hakim Cassimally, “Designing the Internet of Things”, Wiley 2013
2. Naveen Balani, “Enterprise IoT”, CreateSpace Independent Publishing Platform 2016
3. NAYAN B. RUPARELIA, “Cloud Computing”, MIT Press 2016

EC5313	Information Theory and Coding	PEC	3-0-0	3 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify the major classes of error detecting and error correcting codes and how they are used in practice.
CO2	Specify specific error detecting and error correcting codes in a precise mathematical manner.
CO3	Develop and execute encoding and decoding algorithms associated with the major classes of error detecting and error correcting codes.
CO4	Construct codes capable of correcting a specified number of errors

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1			2		
CO2					2	
CO3					2	
CO4						2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction: Entropy, Relative Entropy, Mutual Information Inequalities, Entropy rate. Asymptotic Equipartition Property (AEP): Consequences of the AEP, Typical Sequences, Shannon McMillan Breiman Theorem.

Channel capacity: Discrete Memory less Channel, Joint Typicality, Channel Coding Theorem and its converse, Feedback capacity, Source Channel Separation Theorem. Differential Entropy: Definition, Properties. Gaussian Channel: Definition, Parallel Gaussian Channels, Channels with Colored Gaussian Noise, Gaussian Channels with Feedback, Limits to Communication.

Linear Block Codes: Groups, Fields and Vector Spaces, Construction of Galois Fields of Prime Order Syndrome Error Detection, Standard Array and Syndrome Decoding, Hamming Codes, LDPC Codes.

Cyclic Codes: Polynomial Polynomial Representation of Codewords, Generator Polynomial, Systematic Codes, Generator Matrix, Syndrome Calculation and Error Detection, Decoding of Cyclic Codes, Meggit decoder, BCH codes, generator polynomials with minimal polynomials, BCH decoding, non BCH codes(RS codes), RS decoding.

Convolutional Codes: Convolutional Encoder Representation, Tree, Trellis, and State Diagrams, Distance Properties of Convolutional Codes, Punctured Convolutional Codes and Rate Compatible Schemes, Decoding of Convolutional Codes: Maximum Likelihood Detection, The Viterbi Algorithm

Textbooks:

1.T.M. Cover and J.A. Thomas, *Elements of Information Theory*, John Wiley & Sons.
2. Todd K. Moon, Error Correction coding, John Wiley, 2005
3. Shu lin/ Daniel J.Costello Jr., Error Control Coding, Prentice Hall series in computer applications in electrical engineering series (2/e) 2005.
4. Ranjan Bose, Information Theory, coding and cryptography (2/e), McGraw Hill.

EC5314	**CMOS VLSI Design**	**PEC**	**3-0-0**	**3 credits**

Course Outcomes: At the end of the course the student will be able to:

CO1	Model the behaviour of a MOS Transistor
CO2	Understanding CMOS Inverter
CO3	Design combinational and sequential circuits using CMOS gates
CO4	Identify the sources of power dissipation in a CMOS circuit.
CO5	Analyze SRAM cell and memory arrays

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2	2		
CO2			2			
CO3			2	2		
CO4			2			
CO5						2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

MOS Transistors, CMOS Logic, CMOS Fabrication and Layout, Design Partitioning, Fabrication, Packaging, and Testing, MOS transistor Theory, Long Channel I-V Characteristics, C-V Characteristics, Non-Ideal I-V Effects, DC Transfer Characteristics. The CMOS Inverter:

The Static CMOS Inverter -An Intuitive Perspective, Evaluating the Robustness of the CMOS Inverter: The Static Behavior, Performance of CMOS Inverter: The Dynamic Behavior.

CMOS Processing Technology, CMOS Technologies, Layout Design Rules, CMOS Process Enhancements, Technology-Related CAD Issues, Manufacturing Issues, Circuit Simulation- A SPICE Tutorial, Device Models, Device Characterization, Circuit Characterization, Interconnect Simulation. Combinational Circuit Design, Circuit Families, Silicon-On-Insulator Circuit Design, Sub Threshold Circuit Design, Sequential Circuit Design, Circuit Design of Latches and Flip-Flops, Static Sequencing Element Methodology, Sequencing Dynamic Circuits, Synchronizers, Wave Pipelining.

Power, Sources of Power Dissipation, Dynamic Power, Static Power, Energy-Delay Optimization, Low Power Architectures, Robustness, Variability, Reliability, Scaling, Statistical Analysis of Variability, Variation-Tolerant Design. Delay, Transient Response, RC Delay Model, Linear Delay Model, Logical Effort of Paths, Timing Analysis Delay Models, Datapath Subsystems,Addition/Subtraction, One/Zero Detectors, Comparators, Counters, Boolean Logical Operations, Coding, Shifters, Multiplication.

Array Subsystems, SRAM, DRAM, Read-Only Memory, Serial Access Memories, Content-Addressable Memory, Programmable Logic Arrays, Robust Memory Design, Special-Purpose Subsystems.

CMOS Testing-The need for testing, Manufacturing test principles, Design strategies for test, Chip level test techniques, System level test techniques, Layout design for improved testability.

Text Books:

1. CMOS VLSI Design – A Circuits and Systems Perspective, Neil H.E. Weste, David Harris, Ayan Banerjee, , 3rd Edition, Pearson Education, 2006.

2. Principles of CMOS VLSI DESIGN:A Systems Perspective, Neil H. E. Weste , Kamran Eshraghian, 2nd Edition., Pearson Education, 2006.

Reference Books:

1. Jan M RABAEY, Digital Integrated Circuits, 2nd Edition, Pearson Education, 2003.

2. Douglas A. Pucknell, Kamran Eshraghian, Basic VLSI Design, 3rd Edition., PHI,1994.

EC5315	Advanced Digital Signal Processing	PEC	2-1-0	3 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the properties, functioning of DCT, KLT and wavelet transforms for 1-D and 2-D signals.
CO2	Implement adaptive filter algorithms for applications in noise cancellation, de-convolution, enhancement and channel equalization.
CO3	Apply higher order spectra for solving Non-Gaussian, non-linear stochastic problems
CO4	Design a decimator or interpolator for the given specifications
CO5	Understand the operation of TMD 320 C5x/6x DSP processors for application problems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2					
CO2		2	1			
CO3			2			
CO4				2		

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction: Review of Discrete time Signals and Systems, Discrete Time Fourier Transform, Z-Transform

Transform techniques: Discrete cosine transforms(DCTs), Discrete sine transforms(DSTs), KL transforms, Hadamard transforms, Walsh transforms and Wavelet transforms, Applications of DCTs and Wavelets.

Adaptive Filter theory: Stochastic gradient based algorithms LMS algorithm, stability analysis, Mean-squared error behavior. Convergence analysis, Normalized LMS algorithm, Gradient adaptive lattice algorithm. Prediction, filtering and smoothing, adaptive equalization, noise cancellation, blind deconvolution, adaptive IIR filters, RLS algorithms-GRLS, Gauss- Newton and RML.

Multirate signal processing: Decimation, Interpolation, polyphase filters and their structures, Subband coding of speech signals, filter banks, Quadrature mirror filters.

Optimum linear filters: Wiener filters for filtering and prediction, FIR wiener filter, orthogonality principle in LMS estimation, IIR wiener filter, state-space (Kalman) filters, Method of least squares, data windowing, principle of orthogonality, Innovation process, statement of the kalman filtering problem, Estimation of the state using innovations process, Riccati equation, filtering, kalman filter as the unifying basis for RLS filters.

Reading:

1. DSP Principles, Algorithms and Applications JG Proakis, DG Manolakis, 3rd Edition, PHI Private Ltd., 2001.
2. Adaptive Filter Theory S. Haykin, 2nd Edition, PRENTICE HALL., 2001
3. Modern Digital Signal Processing-2nd Edition, V.Udayashankara, PHI, 2012.

References:

1. Modern spectral estimation, SM Kay, PH Int, 1997
2. Advanced digital signal processing, Proakis, C. M. Rader, Fuyun, Ling CL., Mcmillan Publishing Company, NY, 1992.
3. Modern Digital signal processing An Introduction Prabhakar S. Naidu, Narosa Publishing House,2003.
4. Adaptive Signal processing B. Widrow & D. Stearns, PH Int 1987 Optimum Signal Processing; An Introduction, S.J.Orfanidis, Second Edition, McGraw Hill Book Company, 1992.

EC5316	Optimization Techniques	PEC	3-0-0	3 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Ability to formulate mathematical models of real world problems
CO2	Understand the major limitations and capabilities of deterministic operations
CO3	Handle, solve and analyze problems using linear programming and other mathematical programming algorithms.
CO4	Solve various multivariable optimization problems.
CO5	Use search techniques methods to find optimal solutions of Non-Linear Problems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3					
CO2			3			
CO3						3
CO4	3					
CO5	3					

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Introduction: Statement of an optimization problem, Classification of optimization problems, Overview of various optimization Techniques, Classical optimization techniques: Single variable optimization, Multivariable optimization, Unconstrained optimization and Constrained optimization**.**

Genetic algorithm (GA): Fundamentals of Genetic algorithm, History, Basic concepts, working principle, Encoding, Design of Fitness function, Reproduction, Crossover, Mutation operator in GA, Applications of GA for standard Bench mark test functions Fundamentals.

Swarm intelligence: Main inspiration source, Basic particle swarm optimization, Initialization techniques, Theoretical investigations and parameter selection, Design of PSO algorithm using computational statistics, Termination conditions, Application of PSO, Standard test function optimization, new modifications of PSO.

Differential Evolution: Classical differential evolution- An outline, Mutation, cross over, new modifications of DE.

Teaching Learning Based Optimization (TLBO), Applications of TLBO for standard Bench mark test functions, Case studies Basic Steps in Differential Evolution algorithm

Wavelet Mutation:
Basic Wavelet Theory, wavelet theory in mutation operation, Wavelet Mutation (WM) to improve further the optimization performance of Evolutionary Optimization Techniques through mutation.

Hybridization: Hybridization of GA, PSO, DE etc.

Reference Books:

1. S Rajasekharan, G.A Vijaya Lakshmi Pai, Neural Networks, Fuzzy logic, and Genetic algorithms, Synthesis and Applications, Prentice hall of India, 2007
2. K. Deb,"Optimization for Engineering DesignAlgorithms and Examples",Prentice-Hall of India Pvt. Ltd., New Delhi, 1995.
3. D.K. Pratihar, "Soft Computing" ,Narosa Publishing House, New Delhi, 2008
4. Milani Mitchel, An introduction to Genetic algorithms, MIT Press, 1998.
5. Richard W Daniels, An Introduction to Numerical Methods and Optimization Techniques, Elsevier North Holland Inc
6. AE Eiben and J.E Smith, Introduction to Evolutionary Computing, Springer 2010

EC 5351	Advanced Wireless Communication	PCC	3-0-0	3 credits

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

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1			2		
CO2					2	
CO3					2	
CO4						2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

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.

.**REFERENCE 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

EC5352	**Mobile Networks**	**PCC**	**3-0-0**	**3 credits**

Course Outcomes: At the end of the course the student will be able to:

CO1	Assess the wireless network performance and trade-offs
CO2	To understand the various technologies in wireless networks.
CO3	Suggest the architectures for wireless wide area networks
CO4	Handle the planning and design issues for Adhoc wireless networks

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3	3	3
CO2	3		3	3	3	3
CO3	3		3	3	3	3
CO4	3		3	3	3	3

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Wireless Area Networks :
WPAN: System model - protocol stack of IEEE 802.15; Bluetooth: Network architecture - operation- specification and application models; Radio Frequency Identification (RFID): Types and specifications; ZIGBEE and WBAN: Standard and architecture; WLAN: Network architecture - protocol stack of IEEE 802.11 - physical layer and MAC layer mechanism (CSMA/CA and WiFi MAC overview; Wide bandwidth channel access techniques (802.11n/ac) ; Energy efficiency and rate control); WiMAX: BWA(Broadband Wireless Access) - issues and challenges of WiMAX - network architecture - protocol stack of IEEE 802.16 - differences between IEEE 802.11 and IEEE 802.16

WIRELESS WIDE AREA NETWORKS: GSM, 3G wireless systems : Concept of Spread Spectrum - System Processing Gain - Direct-Sequence Spread Spectrum - Frequency-Hopping Spread Spectrum Systems - Requirements of Spreading Codes- evolution of IS 95 to CDMA 2000- Downlink (Forward) (BS to MS) - Uplink (Reverse) (MS to BS) - Power Control in CDMA –WCDMA.

Wireless Internet
IP for wireless domain - mobile IP - IPv6 advancements –IPV6 network layer in the internet; mobility management functions - location management - registration and handoffs; TCP in wireless domain: TCP over wireless - types - mobile transaction - impact of mobility; Wireless security and standards.

Wideband Wireless Technologies
UWB Radio Communication: Fundamentals of UWB - major issues - operation of UWB systems - comparisons with other technologies - advantages and disadvantages

Adhoc wireless networks: Characteristics of Adhoc Networks, Classifications of MAC Protocols - Table driven and Source initiated On Demand routing protocols, DSDV, AODV, DSR and Hybrid Protocols.

Fourth Generation Systems and New Wireless Technologies- 4G Vision - 4G Features and Challenges - Applications of 4G; 4G Technologies - LTE FDD vs TDD comparison; frame structure and its characteristics; Smart Antenna Techniques - OFDM-MIMO Systems - Adaptive Modulation and Coding with Time-Slot Scheduler - Bell Labs Layered Space Time (BLAST) System - Software-Defined Radio - Cognitive Radio.

TEXTBOOKS:

1) Theodore Rappaport ―Wireless Communication, Prentice Hall, 2nd Edition.
2) William Stallings ―Wireless Communications and Networks, Prentice Hall.
3) Schwartz ―Mobile Wireless Communications, Cambridge University Press.
4) Mark and Zhuang ―Wireless Communications and Networking, Prentice Hall.
5) Vijay Garg K, "Wireless Communications and Networks", 2ndEdition, Morgan Kaufmann Publishers (Elsevier), 2007.
6) Clint Smith and Daniel Collins, "3G Wireless Networks", 2nd Edition, Tata McGraw Hill, 2007.
7) AmitabhaGhosh and RapeepatRatasuk, "Essentials of LTE and LTE-A," Cambridge University Press, 2011.
8) Dharma Prakash Agrawal and Qing-An Zeng, "Introduction to wireless mobile systems" Thomson India, 2007.
9) Siva Ram Murthy C and Manoj B S, "Ad Hoc Wireless Networks: Architectures and Protocols", Prentice Hall, 2004.

Hyperlink:

1. http://doktora.kirbas.com/Kitaplar/Wireless%20Networking%20Complete.pdf
2. www.tutorialspoint.com/wimax/
3. http://www.infotech.monash.edu.au/units/archive/2012/s2/fit5083.html
4. http://www.utdallas.edu/~venky/

EC5353	Wireless Communication Lab	PCC	0-0-4	2 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Estimate the path loss
CO2	Calculate the uplink and downlink SNR .
CO3	Assess the effects of flat and frequency fading
CO4	Design, implement, and distribute stand-alone applications using LabVIEW
CO5	Apply single- and multiple-loop design patterns for application functionality

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1						
CO2	1	1				
CO3		2				
CO4			2			2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

VIRTUAL LAB

1. Introduction to the labview
2. Baseband QAM Modulation and Detection design
3. Performance of Baseband QAM/QPSK Under AWGN Channel
4. STO estimation-maximum energy for QAM/QPSK modulation
5. Implementation of channel estimation for multipath environment
6. Frame detection and CFO estimation using Frank sequence
7. Multitap indirect channel equalization
8. Multitap direct channel equalization
9. OFDM modulation and demodulation and single tap equalization
10. Preamble aided synchronization for OFDM system

EC5361	Optical Networks	PEC	2-1-0	3 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify the building blocks of an optical network for the given application
CO2	Recognize the trade off issues in the design of optical networks
CO3	Select the components to suit the performance in an optimized way
CO4	Manage and control the optical network following the safety norms

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2			2
CO2	3	3	3			2
CO3	3			2	2	3
CO4	1	2	2	1		2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

Optical Networking Components/Building Blocks- Optical transmitters, laser diode, tunable and fixed laser, laser characteristics, photo-detectors, optical filters, multiplexers, de-multiplexers channel/gain equalizers, optical amplifiers and its characteristics, Raman amplifier, Erbium doped fiber amplifier, Hybrid EDFA-Raman amplifiers, ROPA-Subsea amplifier, various switching elements, ROADM, OXC-WSS, CLOS architecture, MEMS, wavelength converters.

Client Layers - Introduction to SONET/SDH/OTN – Multiplexing, SONET/SDH/OTN layers, framestructure, physical layer, adaptation layers, quality of service, flow control, signaling and routing, IP – Routing and forwarding, QoS, MPLS/GMPLS,Gigabit Ethernet, problems

Industrial Optical Networks: Dense Wavelength Division Multiplied (DWDM) networks, Elastic Optical Networks (EON), Spatial Division Multiplied (SDM) networks, Passive Optical Networks (PON)-Fiber Ethernet.

Optical line system engineering- system model, power penalty, transmitter, receiver, optical fibers, linear and nonlinear impairments, optical amplifiers, crosstalk, dispersion, wavelength stabilization, spectrum equalization, repeater and amplifier spacing, overall design considerations.

Optical Network Design-Cost trade-offs, RWA/RSA/RCMSA problems, Dimensioning DWDM/EON/SDM, statistical dimensioning models, dynamic dimensioning models, machine learning oriented models, problems

Network Control and Management- control and management – network management system, optical layer services and interfacing, layers within the optical layer, multivendor interoperability, performance and fault management, configuration management, optical safety, problems.

Text Books:

1. R RAMASWAMY, KN SIVARAJAN, Optical Networks: A Practical Perspective, Elsevier, 2009.
2. JUN ZHENG, Optical WDM Networks, John Wiley, 2004.
3. Optical WDM Networks, Biswanath Mukharjee, Springer, 2006.

Reference Books:

1. The Handbook of Optical Communication Networks, MohammadIlyas, Hussein T. Mouftah, CRC Press, 2003.
2. Optical WDM Networks - Principles and Practice, Krishna M. Sivalingam, Suresh Subramaniam, Springer, 2010.
3. Next Generation Intelligent Optical Networks - From Access to Backbone, Stamatios V. Kartalopoulos, Springer, 2008

EC5362	**Secured Communications**	**PEC**	**3-0-0**	**3 credits**

Course Outcomes: At the end of the course the student will be able to:

CO1	Have a fundamental understanding of the objectives of cryptography and network security.
CO2	Become familiar with the cryptographic techniques that provide information and network security
CO3	Be able to evaluate the security of communication systems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1				2		
CO2						2
CO3						3

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Security attacks, CIA model, Symmetric ciphers, number theory, AES, Block cipher operation, PRBS generation and stream ciphers, Asymmetric ciphers, PKC and RSA, ECC, Data Integrity Algorithms, Hash functions, MACs, Digital signatures, key management and distribution, User authentication, digital envelope, transport level security, WLAN security, E-mail security, IP security, IDS, Malicious software, firewalls, WSN security.

Reading:

1. William Stallings, Cryptography and Network Security, Pearson, 2011.
2. Bruice Schneier, Applied Cryptography, 2nd Edition, Wiley India Pvt. Ltd. 2009.

CS5152	Machine Learning	PEC	3-0-0	3 credits

Syllabus to be defined: as per CSE department syllabus

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify instance based learning algorithms
CO2	Design Multi-Layer neural network to solve supervised learning problems
CO3	Use radial basis functions for classification problems
CO4	Apply Genetic algorithm for optimization problems
CO5	Understand the deep learning architectures which are appropriate for various types of learning tasks.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		1	1	2	
CO2	2	2	2	2	1	2
CO3	3	2	1	2	2	
CO4	2	3		2	1	
CO5	2		2		1	2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

INTRODUCTION –Well defined learning problems, Designing a Learning System, Issues in Machine Learning; -THE CONCEPT LEARNING TASK -General-to-specific ordering of hypotheses, Find-S, List then eliminate algorithm, Candidate elimination algorithm, Inductive bias -DECISION TREE LEARNING -Decision tree learning algorithm-Inductive bias-Issues in Decision tree learning; -ARTIFICIAL NEURAL NETWORKS –Perceptron, Gradient descent and the Delta rule, Adaline, Multilayer networks, Derivation of back-propagation rule-Back-propagation Algorithm-Convergence, Generalization; –EVALUATING HYPOTHESES –Estimating Hypotheses Accuracy, Basics of sampling Theory, Comparing Learning Algorithms; --COMPUTATIONAL LEARNING THEORY –Sample Complexity for Finite Hypothesis spaces, Sample Complexity for Infinite Hypothesis spaces, The Mistake Bound Model of Learning; -INSTANCE-BASED LEARNING –k-Nearest Neighbor Learning, Locally Weighted Regression, Kernel Methods -Dual Representations, Constructing Kernels, Radial basis function networks, Gaussian Processes for Regression and Classification;Case-based learning -GENETIC ALGORITHMS –an illustrative example, Hypothesis space search, Genetic Programming, Models of Evolution and Learning; Sparse Kernel Machines-Maximum Margin Classifiers, Multi class SVMs, REINFORCEMENT LEARNING -The Learning Task, Q Learning, Nondeterministic rewards and actions, Temporal difference learning, Generalizing from examples, relationship to Dynamic Programming.INTRODUCTION TO DEEP LEARNING –Introduction to Perceptron, Multilayer networks, Back-propagation Algorithm,Deep Feed Forward network, regularizations,training deep models, dropouts, Convolutional Neural Networks (CNNs), Autoencoders.APPLICATIONS TO NATURAL LANGUAGE PROCESSING AND VISION ANALYTICS –Object recognition, sparse coding, computer vision, natural language processing.

Reading:

1. Tom M .Mitchell, *Machine Learning*, McGraw Hill, 1997.
2. Christopher Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
3. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016.

EC5364	**Cognitive Radio**	**PEC**	**3-0-0**	**3 credits**

Course Outcomes: At the end of the course the student will be able to:

CO1	An understanding on cognitive radio components, functions and capabilities.
CO2	An ability to evaluate different spectrum sensing mechanisms in cognitive radio.
CO3	An ability to analyze the spectrum management functions using cognitive radio systems and cognitive radio networks.
CO4	An understanding on software defined radio architecture and design principles.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1					2	
CO2			2			
CO3			2			
CO4					2	

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

Unit 1: Introduction to Cognitive Radios: Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, dynamic spectrum access (DSA), components of cognitive radio, spectrum sensing, spectrum analysis and decision, potential applications of cognitive radio.

Unit 2: Spectrum Sensing: Spectrum sensing and identification, primary signal detection. energy detector, cyclostationary feature detector, matched filter, cooperative sensing, spectrum opportunity, spectrum opportunity detection, fundamental trade-offs: performance versus constraint, sensing accuracy versus sensing overhead.

Unit 3: Dynamic Spectrum Access and Management: Spectrum broker, Dynamic spectrum access architecture- centralized dynamic spectrum access, distributed dynamic spectrum access, Inter- and intra-RAN dynamic spectrum allocation, Spectrum management, Spectrum sharing, Spectrum mobility issues

Unit 4: Cognitive Radio Networks: Cognitive radio networks (CRN) architecture, terminal architecture of CRN, diversity radio access networks, routing in CRN, Control of CRN, Self-organization in mobile communication networks, security in CRN, cooperative communications, cooperative wireless networks, user cooperation and cognitive systems.

Unit 5: Software Defined Radio (SDR): Essential functions of the SDR, SDR architecture, design principles of SDR, traditional radio implemented in hardware and SDR, transmitter architecture and its issues, digital radio processing, reconfigurable wireless communication systems.

Text Books:

1. Ekram Hossain, Dusit Niyato, Zhu Han, “Dynamic Spectrum Access and Management in Cognitive Radio Networks”, Cambridge University Press, 2009.
2. Kwang-Cheng Chen, Ramjee Prasad, “Cognitive radio networks”, John Wiley & Sons Ltd., 2009.
3. https://www.cmsoc.org/publications/best-readings/cognitive-radio

Reference books:

1. Alexander M. Wyglinski, Maziar Nekovee, and Y. Thomas Hou, “Cognitive Radio Communications and Networks - Principles and Practice”, Elsevier Inc., 2010.
2. Jeffrey H. Reed “Software Radio: A Modern Approach to radio Engineering", Pearson Education Asia.

CS5121	**Big Data Analytics**	**PEC**	**3-0-0**	**3 credits**

Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze big data challenges in different domains including social media, transportation, finance and medicine
CO2	Explore relational model, SQL and capabilities of emergent systems in terms of scalability and performance
CO3	Apply machine learning algorithms for data analytics
CO4	Analyze the capability of No-SQL systems
CO5	Analyze MAP-REDUCE programming model for better optimization

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2		3
CO2	3		3	2		3
CO3	3		3	2		3
CO4	2		3	2		3
CO5	2		3	2	2	3

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Overview of Big Data, Map Reduce basics, Overview of Hadoop, Map Reduce Algorithm Design, Inverted Indexing for Text Retrieval, Graph Algorithms, Data Mining with Big Data, No SQL databases, Stream Computing Challenges, Stages of analytical evolution, Big Data Analytics in Industry Verticals, Data Analytics Lifecycle, Operationalizing Basic Data Analytic Methods Using R, Analytics for Unstructured Data.

Reading:

1. Bill Franks, *Taming The Big Data Tidal Wave*, 1st Edition, Wiley, 2012.
2. Jure Leskovec, Anand Rajaraman, J D Ullman, Mining Massive Datasets.
3. Jimmy Lin and Chris Dyer, Data Intensive Text Processing with Map Reduce, Pre-production manuscript, Downloadable from Internet.
4. Johannes Ledolter, Data Mining and Business Analytics with R, Wiley, 2013.

EC5366	**RF system design**	**PEC**	**3-0-0**	**3 credits**

Prerequisite: RF Engineering

Course Outcomes: At the end of the course the student will be able to:

CO1	Design RF amplifier, oscillators and other related circuits.
CO2	Simulate RF Systems using modern microwave/RF design packages.
CO3	Design and evaluate RF and Microwave amplifiers and oscillators using packages.
CO4	Design a RF mixer circuit

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1						3
CO2	2			3		3
CO3	2					3
CO4						3

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

UNIT 1 BASIC CONCEPTS IN RF DESIGN

Non linearity, effects of non linearity, harmonic distortion, gain compression, cross modulation, intermodulation, cascaded non-linear stages, sensitivity and dynamic range, noise.

UNIT 2 TRANSMITTER AND RECEIVER ARCHITECTURES

General considerations, basic heterodyne receivers, direction conversion receivers, Image reject receivers: Hartley receiver and Weaver receivers. Transmitter general considerations, Direct conversion transmitter and heterodyne transmitter.

UNIT 3 MICROWAVE TRANSISTOR AMPLIFIER DESIGN

Types of amplifiers, power gain equations. Stability considerations, Constant gain circles, unilateral case and bilateral case, constant noise circles, Low noise amplifier design and high power amplifier design.

UNIT 4 MICROWAVE OSCILLATOR DESIGN

One port and two port negative resistance oscillators. Oscillator’s configurations, Oscillator design using large signal measurements, Introduction to Microwave CAD Packages, Microwave integrated circuits, MIC design for lumped elements.

UNIT 5 MICROWAVE MIXER DESIGN

Basic operation of a mixer, mixer spectral products, conversion gain/loss, types of mixer circuits, Single ended mixer, single balanced mixer, Image reject mixer, and sub harmonic mixer.

REFERENCES

1. B. Razavi, RF Microelectronics, 2nd Edition, Prentice hall, 2012.
2. González, G. Microwave transistor amplifiers: analysis and design. 2nd ed. Englewood Cliffs, N.J.: Prentice-Hall, 1997.

3. Reinhold Ludwig and Gene Bogdanvov, ―RF Circuit Design – Theory and Application‖, 2nd Edition, Pearson, 2012.
4. I. Bahl and P. Bhartia, Microwave solid state circuit design, John Wiley.
5. David.M.Pozar, ―Microwave Engineering‖, John Wiley and Sons, Third Edition

EC5367	5G Communications	PEC	3-0-0	3 credits

Course outcomes: At the end of the course the student will be able to

CO1	Learn 5G Technology advances and their benefits
CO2	Learn the key RF, PHY, MAC and air interface changes required to support 5G
CO3	Learn Device to device communication and millimeter wave communication
CO4	Implementation options for 5G

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1			2		
CO2					2	
CO3					2	
CO4						2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

Overview of 5G Broadband Wireless Communications: Evaluation of mobile technologies 1G to 4G (LTE, LTEA, LTEA Pro) , An Overview of 5G requirements, Regulations for 5G,Spectrum Analysis and Sharing for 5G.

The 5G wireless Propagation Channels: Channel modeling requirements, propagation scenarios and challenges in the 5G modeling, Channel Models for mmWave MIMO Systems.

Transmission and Design Techniques for 5G: Basic requirements of transmission over 5G, Modulation Techniques – Orthogonal frequency division multiplexing (OFDM), generalized frequency division multiplexing (GFDM), filter bank multi-carriers (FBMC) and universal filtered multi-carrier (UFMC), Multiple Accesses Techniques – orthogonal frequency division multiple accesses (OFDMA), generalized frequency division multiple accesses (GFDMA), non-orthogonal multiple accesses (NOMA).

Device-to-device (D2D) and machine-to-machine (M2M) type communications – Extension of 4G D2D standardization to 5G, radio resource management for mobile broadband D2D, multi-hop and multi-operator D2D communications.

Millimeter-wave Communications – spectrum regulations, deployment scenarios, beam-forming, physical layer techniques, interference and mobility management, Massive MIMO propagation channel models, Channel Estimation in Massive MIMO, Massive MIMO with Imperfect CSI, Multi-Cell Massive MIMO, Pilot Contamination, Spatial Modulation (SM),

Textbooks:

1. Martin Sauter "From GSM From GSM to LTE–Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband", Wiley-Blackwell.
2. Afif Osseiran, Jose.F.Monserrat, Patrick Marsch, "Fundamentals of 5G Mobile Networks" , Cambridge University Press.
3. Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos, "New Directions in Wireless Communication Systems from Mobile to 5G", CRC Press.
4. Theodore S.Rappaport, Robert W.Heath, Robert C.Danials, James N.Murdock "Millimeter Wave Wireless Communications", Prentice Hall Communications.

References

1. Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks", John Wiley & Sons.
2. Amitabha Ghosh and Rapeepat Ratasuk "Essentials of LTE and LTE-A", Cambridge University Press.

EC5368	**Green Wireless Communications**	**PEC**	**3-0-0**	**3 credits**

Course Outcomes: At the end of the course the student will be able to:

CO1	Recognize the challenges in energy efficiency and spectral efficiency for digital data transmission
CO2	Suggest the methods to manage the dynamic loads of mobile communications for energy saving
CO3	Indicate the design practices for power minimization at cellular base station
CO4	Practise cell deployment strategies for efficient network management
CO5	Conceptualize Smart city essentials
CO6	Design and develop IoT centric products for smart city applications

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3	3	3
CO2	3		3	3	3	3
CO3	3		3	3	3	3
CO4	3		3	3	3	3
CO5	1		1		2	2
CO6	2			2	2	2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

1. Green Wireless Communications :
Introduction - Effective Capacity and Energy Per Information Bit - Variable-Rate/Variable-Power and Variable-Rate/Fixed-Power Transmissions - Fixed-Rate/Fixed-Power Transmissions - Transmissions over Imperfectly-Known Wireless Channels - Energy Efficiency in the Low-Power Regime - Energy Efficiency in the Wideband Regime

2. Energy Efficiency-Spectral Efficiency Trade-off in Cellular Systems :
Spectral Efficiency; Energy Efficiency; Energy Efficiency-Spectral Efficiency Trade-Off; Idealistic vs. Realistic Power Consumption Model ; MIMO vs. SISO: An Energy Efficiency Analysis ; Power Model Implications

3. Energy Savings for Mobile Communication Networks through Dynamic Spectrum and Traffic Load Management :
Dynamic Spectrum and Traffic Load Management ; Power Saving by Dynamically Powering Down Radio Network Equipment ; Power Saving by Propagation Improvement ; Power Saving by Channel Bandwidth Increase or Better Balancing Performance Assessment ; Power Saving by Propagation Improvement.

4. Minimizing Power Consumption to Achieve More Efficient Green Cellular Radio Base Station Designs :
Explosive Traffic Growth - Cellular Scenarios - Energy Metrics; Energy Reduction Techniques for High Traffic Load Scenarios; Energy Reduction Techniques for Low Traffic Load Scenarios, Other Energy Reduction Techniques.

Green Wireless Access Networks :
Energy Efficiency and Network Technologies ; Cell Deployment Strategies; Relaying Techniques; Base Station Coordination and Cooperation ; Adaptive Network Reconfiguration ; Radio Resource Management; Future Architectures ; Green Ad Hoc and Sensor Networks; Energy Harvesting Techniques.

5. Fundamental Technologies implementing Smart cities :Criteria for smart cities, Ubiquitous computing, Big Data, Networking, Internet of Things, Cloud computing, Service-oriented architectures, Cyber security architectures.

Reference Books:

1. Green Communications: Theoretical Fundamentals, Algorithms, and Applications
Jinsong Wu, SundeepRangan, Honggang Zhang
2. Green Communications and Networking :F. Richard Yu, Xi Zhang, Victor C.M. Leung ; CRC press, 2012.
3. Carlo Ratti and Matthew Claudel, ―The City of Tomorrow: Sensors, Networks, Hackers, and the Future of Urban Life (The Future Series)‖, Yale University Press.
4. Stephen Goldsmith, Susan Crawford, ―The Responsive City: Engaging Communities through Data-Smart Governance‖, 1st Edition Jossey Bass – Wiley.
5. EkramHossain, Vijay Bhargava K and Gerhard Fettweis P, "Green Radio Communication Networks", Cambridge University Press, New York, 2012.
6. Mazin Al Noor, "Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access", GRINVerlag, 2012.
7. Mohammad Obaidat S, AlaganAnpalagan and Isaac Woungang, "Handbook of Green Information and Communication Systems", 1st Edition, Academic Press, 2012.
8. Jinsong Wu, SundeepRangan and Honggang Zhang, "Green Communications: Theoretical Fundamentals, Algorithms and Applications", CRC Press, 2016.
9. Ramjee Prasad, Shingo Ohmori and Dina Simunic, "Towards Green ICT", River Publishers, 2010.

Hyperlinks:

1. http://www.comsoc.org/webcasts/view/wireless-green-networking
2. http://home.ku.edu.tr/~nwcl/green.html
3. http://mypage.zju.edu.cn/en/honggangzhang/607861.html

EC5369	**Multimedia Communications**	**PEC**	**3-0-0**	**3 credits**

Prerequisites:
1) Communications.
2) Image processing.
3) Audio and video signals.

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the audio, video and text interaction
CO2	Explain various audio, video and joint coding techniques
CO3	Understand multimedia communication standards
CO4	Identify the requirements of real time multimedia transfer on IP networks

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	1
CO2	1	2	1	3	2	2
CO3	1	2	3	1	2	2
CO4	3	2	2	2	2	2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus:

Chapter 1
Introduction and tools used for MM content development , Media interaction, Biomodality of human speech, Lip reading, speech driven talking heads, Lip synchronisation, Lip tracking

Chapter 2
Biomodal person verification, Joint AV coding, Multimedia processing, Challenges in MM processing, Perceptual coding of Digital Audio, CBIR

Chapter 3
Introduction to audio, Image, video coding, Water marking techniques, Storage and retrieval issues, Multimedia processors

Chapter 4
Distributed MM systems, Multimedia OS, Multimedia communication standards, MPEG approach, ITU-T standards for audio visual, video and speech coding

Chapter 5
Real time multimedia across Internet, packet audio/video multimedia transport across IP/ATM Network, Wireless multimedia, mobile multimedia access for internet, multimedia PCS

Text Book:

1. Multimedia Communication Systems: Techniques and Standards, KR RAO et al, Pearson, 2002.
2. Insight into Mobile Multimedia Communication : D. BULL et al, Academic Press, 1999
3. Multimedia Systems Design : PK ANDLEIGH , K. THAKKAR, PHI,2002
4. Multimedia-Making it Work, TAY VAUGHAN,5/e, TMH, 2001

EC5370	Advanced Image Processing	PEC	3-0-0	3 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Interpret, Analyze, model and Process the Image data using appropriate methods, algorithms and software tools.
CO2	Analyze and evaluate an image processing system and suggest enhancements to improve the system performance.
CO3	Apply suitable tools to develop, simulate and demonstrate the working of image processing systems as per the application needs.
CO4	Specify and design optimal processing techniques for the given Imaging problem to efficiently use the available hardware and software tools.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2					
CO2		2	1			
CO3			2			
CO4				2		2

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

Review of Digital Image Processing: Image Acquisition, Image Enhancement.

Image Segmentation and Morphological Operations : Image Segmentation: Point Detections, Line detection, Edge Detection-First order derivative – Prewitt and Sobel. Second order derivative – LoG, DoG, Canny. Edge linking, Hough Transform, Thresholding – Global, Adaptive. Otsu‟s Method. Region Growing, Region Splitting and Merging.

Image Morphological Operations : Morphological Operations: Dilation, Erosion, Opening, Closing, Hit-or-Miss transform, Boundary Detection, Thinning, Thickening, Skeleton.

Image Representation and Description Representation – Chain codes, Polygonal approximation, Signatures. Boundary Descriptors – Shape numbers, Fourier Descriptors, Statistical moments. Regional Descriptors – Topological, Texture. Principal Components for Description.

Image Restoration: Image restoration. Image observation models. Methods to estimate the degradation. Image de-blurring.

Object Recognition and Applications : Digital image analysis systems. Region of interest (ROI) selection. Salient features identification and feature extraction. Common features extraction: histogram-based features; intensity features; color features. Patterns and Pattern Classes, Representation of Pattern classes, Types of classification algorithms, Minimum distance classifier, Correlation based classifier, Bayes classifier. Applications: Biometric Authentication, Character Recognition, Content based Image Retrieval, Remote Sensing, Medical application of Image processing , Concepts of machine vision and learning.

Text Books:

1. Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, Fourth Edition, - Pearson Education
2. M. Sonka, V. Hlavac, R. Boyle, Image Processing, Analysis, and Machine Vision, Thomson Learning, 2007 S Sridhar, “Digital Image Processing”, Oxford University Press.

Reference Books:

1. Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins, “Digital Image Processing Using MATLAB”, Second Edition, - Tata McGraw Hill Publication
2. S Jayaraman, S Esakkirajan, T Veerakumar, “Digital Image Processing”, Tata McGraw Hill Publication

EC5371	Speech Processing	PEC	3-0-0	3 credits

Course Outcomes: At the end of the course the student will be able to:

CO1	Formulate the vocal tract model based on the speech production mechanism
CO2	Understand and extract the Time Domain speech features.
CO3	Develop the Feature Extraction techniques in Frequency Domain.
CO4	Use the LPC coefficients for Pitch, Formant detection, and Analyze Homomorphic, Cepstrum analysis in various speech applications.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3				
CO2	3	3				
CO3			2	2		
CO4	2		1		1	

Mapping code : 1: Slightly 2: Moderately 3: Substantially

Detailed Syllabus

Fundamentals of Digital Speech Processing

Anatomy & Physiology of Speech Organs, The process of Speech Production, The Acoustic Theory of Speech Production – Uniform lossless tube model, effect of losses in vocal tract and radiation at lips, Digital models for speech signals.

Time Domain Methods for Speech Processing

Time domain parameters of speech, methods for extracting the parameters: Zero crossings, Auto-correlation function, pitch estimation.

Frequency Domain Methods for Speech Processing

Short time Fourier analysis, Filter bank analysis, Spectrographic analysis, Formant extraction, and Pitch extraction.

Linear predictive Coding (LPC) for Speech

Formulation of linear prediction problem in time domain, solution of normal equations, Interpretation of linear prediction in auto correlation and spectral domains, Method of Solution of the LPC Parameters: Pitch Detection using LPC Parameters, Formant Analysis using LPC Parameters.

Homomorphic Speech Processing

Introduction Homomorphic Systems for Convolution: Properties of the Complex Cepstrum, Computational Considerations, The Complex Cepstrum of Speech, pitch Detection and Formant Estimation; Applications of speech processing – Speech Enhancement, Speech recognition, Speech synthesis and Speaker Verification.

Text Books:

1. ,Digital Processing of Speech Signals – L.R. Rabiner S. W. Schafer. Pearson Education,1979.
2. Speech Communications: Human &Machine – Douglas O' Shaughnessy, 2nd Ed., Wiley-IEEE Press.
3. Theory and Application of Digital Speech Processing by Lawrence Rabiner and Ronald Schafer, 2011

Reference Books:

1. Discrete Time Speech Signal Processing: Principles and Practice – Thomas F. Quatieri, 1st Ed., Pearson Education.
2. Speech and Audio Signal Processing: Processing and Perception of Speech and Music – Ben Gold & Nelson Morgan, 1st Ed., Wiley.

EC5372	Smart Antennas for 5G applications	PEC	3-0-0	3 credits

Course outcomes: After completion of the course 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.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2		2	1
CO2			2		1	1
CO3			3		2	1
CO4	3		3		2	1

Mapping code : 1: Slightly 2: Moderately 3: Substantially

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