ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.E. COMMUNICATION SYSTEMS

REGULATIONS – 2023

CHOICE BASED CREDIT SYSTEM

VISION

To be recognized as a benchmark and trend setter in Electronics and Communication Engineering domain keeping in phase with rapidly changing technologies through effective partnership with reputed academic institutions, research organizations, industries and community.

MISSION

- Create highly motivated, technologically competent human resource by imparting high quality technical education through flexible student centric updated curricula suited to students with diverse backgrounds
- Adopt best teaching and learning practices and establish state-of-the-art facilities to provide quality academic ambience for innovativeness, research and developmental activities
- Enhance collaborative activities with academic institutions and industries for evolving indigenous technological solutions to meet societal needs and nurture leadership and entrepreneurship qualities with ethical means.
- Facilitate adequate exposure to the students, faculty and staff through training in the state-of-the-art technologies, efficient administration, global outreach and benchmarking against referential institutions

1. **PROGRAMME EDUCATIONAL OBJECTIVES(PEOs):**

I. Graduates will evince comprehensive knowledge in concepts of communication theory, system design, networks and stride towards successful career

II. Graduates will demonstrate technical proficiency in communication system design and remain committed for sustainable societal development

III. Graduates will pursue learning and deliver innovative solutions through acquired complex problem solving skills

2. **PROGRAMME OUTCOMES(POs):**

PO#	PROGRAMME OUTCOMES
1	An ability to independently carry out research/investigation and development work to solve practical problems
2	An ability to write and present a substantial technical report/document
3	Students should be able to demonstrate a degree of mastery over Communication System design and analysis.
4	An ability to apply advanced concepts of communication Engineering and design with state of art tools
5	An ability to evolve customizable and implementable Communication and Networks systems
6	An ability to provide paradigm solution in the development of customized prototypes and networks in communication systems which have social and global relevance

3. PEO/PO Mapping:

PEO	PO					
	1	**2**	**3**	**4**	**5**	**6**
I.	3	-	3	3	2	2
II.	3	2	3	2	2	2
III.	3	2	3	2	2	2

PROGRAM ARTICULATION MATRIX OF M.E. COMMUNICATION SYSTEMS

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Advanced Applied Mathematics						
		Signal Processing and Baseband Techniques	1	3	2	2	1	
		Digital Modulation and Coding Techniques	3	2	1.8	2	1	1
		Advanced Wireless Communication	3	2	2	2.4	2	1
		Advanced Radiation Systems	2.4		2			2.5
		Research Methodology and IPR						
		Analog and Digital Electronic System Design	1	2	1	1	1	1
		Seminar	3	3	3	3	3	3
	SEMESTER II	Wireless Communication Techniques for 5G and Beyond	1		1.8	1.8	1	1
		Radio Frequency Transceiver Design	1	3	2	1.2	1	
		Microwave Integrated Circuits	3	3	2		2	2
		Advanced Optical Communication and Networks	3	3	3	2	1	1
		Professional Elective I						
		Professional Elective II						
		RF PCB Fabrication and EMI/EMC Testing	2	1.2	1.5	2	2	1.8
YEAR II	SEMESTER III	Professional Elective III						
		Professional Elective IV						
		Professional Elective V						
		Project work I	3	3	3	3	3	3
	SEMESTER IV	Project Work II	3	3	3	3	3	3

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UNIVERSITY DEPARTMENTS
M.E. COMMUNICATION SYSTEMS
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULA AND SYLLABI
SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3152	Advanced Applied Mathematics	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	CU3101	Signal Processing and Baseband Techniques	PCC	2	0	2	4	3
4.	CU3102	Digital Modulation and Coding Techniques	PCC	2	0	2	4	3
5.	CU3103	Advanced Wireless Communication	PCC	2	0	2	4	3
6.	CU3104	Advanced Radiation Systems	PCC	3	0	0	3	3
7.	CU3105	Analog and Digital Electronic System Design	PCC	3	0	2	5	4
PRACTICAL								
8.	CU3111	Seminar	EEC	0	0	2	2	1
			TOTAL	**18**	**1**	**10**	**29**	**24**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CU3201	Wireless Communication Techniques for 5G and Beyond	PCC	2	0	2	4	3
2.	CU3202	Radio Frequency Transceiver Design	PCC	3	0	0	3	3
3.	CU3203	Microwave Integrated Circuits	PCC	2	0	2	4	3
4.	CU3204	Advanced Optical Communication and Networks	PCC	2	0	2	4	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.		Professional Elective II	PEC	3	0	0	3	3
PRACTICAL								
7.	CU3211	RF PCB Fabrication and EMI/EMC Testing	PCC	1	0	4	5	3
			TOTAL	**16**	**0**	**10**	**26**	**21**

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SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1		Professional Elective III	PEC	3	0	0	3	3
2		Professional Elective IV	PEC	3	0	0	3	3
3		Professional Elective V	PEC	3	0	0	3	3
PRACTICAL								
4	CU3311	Project work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICAL								
1	CU3411	Project work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 72

PROGRAM ELECTIVE COURSE (PEC)

Sl. No.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			CONTACT PERIODS	CREDITS
				L	T	P		
1.	CU3001	Telecommunication System Modeling and Simulation	PEC	3	0	0	3	3
2.	CU3002	RADAR Signal Processing	PEC	3	0	0	3	3
3.	CU3003	Massive MIMO and mmWave Systems	PEC	3	0	0	3	3
4.	CU3004	Machine Learning in Communication Networks	PEC	3	0	0	3	3
5.	CU3005	Multimedia Communication Techniques	PEC	3	0	0	3	3
6.	CU3006	Wireless Sensor Networks and WBAN	PEC	3	0	0	3	3
7.	CU3007	Security for Wireless Communication Networks	PEC	2	0	2	4	3
8.	CU3008	Cognitive Radio Communications	PEC	3	0	0	3	3
9.	CU3009	Satellite Communications and Navigation Systems	PEC	3	0	0	3	3

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10.	AP3057	Signal Integrity for High Speed Design	PEC	3	0	0	3	3
11.	CU3010	Electromagnetic Interference and Compatibility in System Design	PEC	3	0	0	3	3
12.	CU3011	Micro Electro Mechanical Systems	PEC	3	0	0	3	3
13.	CU3012	High Speed Switching and Networking	PEC	3	0	0	3	3
14.	CU3013	Communication Network Design	PEC	3	0	0	3	3
15.	CU3014	Convex Optimization	PEC	3	0	0	3	3
16.	CU3015	Signal Detection and Estimation	PEC	3	0	0	3	3
17.	CU3016	Speech Processing	PEC	3	0	0	3	3
18.	CU3017	Co-operative Communication	PEC	3	0	0	3	3
19.	CU3018	Optical Sensors and Applications	PEC	3	0	0	3	3
20.	CU3019	Artificial Intelligence and Internet of Things	PEC	3	0	0	3	3
21.	CU3020	Image Processing and Pattern Recognition	PEC	3	0	0	3	3
22.	AP3054	Nonlinear Signal Processing	PEC	3	0	0	3	3
23.	AP3055	RF Integrated Circuit Design	PEC	3	0	0	3	3
24.	VL3151	Digital CMOS VLSI Design	PEC	3	0	0	3	3
25.	VL3012	Signal Processing in VLSI Design	PEC	3	0	0	3	3

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER			CREDITS	SEMESTER
			L	T	P		
1.	MA3152	Advanced Applied Mathematics	4	0	0	4	1
					TOTAL CREDITS	4	

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	CU3101	Signal Processing and Baseband Techniques	2	0	2	3	1
2.	CU3102	Digital Modulation and Coding Techniques	2	0	2	3	1
3.	CU3103	Advanced Wireless Communication	2	0	2	3	1
4.	CU3104	Advanced Radiation Systems	3	0	0	3	1

5.	CU3105	Analog and Digital Electronic System Design	3	0	2	4	1
6.	CU3201	Wireless Communication Techniques for 5G and Beyond	2	0	2	3	2
7.	CU3202	Radio Frequency Transceiver Design	3	0	0	3	2
8.	CU3203	Microwave Integrated Circuits	2	0	2	3	2
9.	CU3204	Advanced Optical Communication and Networks	2	0	2	3	2
10.	CU3211	RF PCB Fabrication and EMI/EMC Testing	1	0	4	3	2
					TOTAL CREDITS	**31**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
					TOTAL CREDITS	**3**	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	CU3111	Seminar	0	0	2	1	1
2.	CU3311	Project work I	0	0	12	6	3
3.	CU3411	Project work II	0	0	24	12	4
					TOTAL CREDITS	**19**	

SUMMARY

	NAME OF THE PROGRAMME: M.E. COMMUNICATION SYSTEMS					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	4				4
2.	PCC	16	15			30
3.	PEC		6	9		15
4.	RMC	3				3
5.	EEC	1		6	12	19
6.	**TOTAL CREDIT**	**24**	**21**	**15**	**12**	**72**

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MA3152 **ADVANCED APPLIED MATHEMATICS** **L T P C**
4 0 0 4

UNIT I LINEAR ALGEBRA 12

Vector spaces – norms – Inner Products – Eigenvalues using QR transformations – QR factorization - generalized eigenvectors – Canonical forms – singular value decomposition and applications - pseudo inverse – least square approximations --Toeplitz matrices and some applications.

UNIT II ONE DIMENSIONAL RANDOM VARIABLES 12

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT III RANDOM PROCESSES 12

Classification – Auto correlation - Cross correlation - Stationary random process – Markov process –- Markov chain - Poisson process – Gaussian process.

UNIT IV LINEAR PROGRAMMING 12

Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT V FOURIER TRANSFORM FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Fourier transforms: Definitions, properties-Transform of elementary functions, Dirac Delta functions – Convolution theorem – Parseval‘s identity – Solutions to partial differential equations: Heat equations, Wave equations, Laplace and Poisson‘s equations.

TOTAL: 45+15=60 PERIODS

COURSE OUTCOMES:

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

CO1 Apply the concepts of linear algebra to solve practical problems.

CO2 Use the ideas of probability and random variables in solving engineering problems.

CO3 Classify various random processes and solve problems involving stochastic processes.

CO4 Formulate and construct mathematical models for linear programming problems and solve the transportation and assignment problems.

CO5 Apply the Fourier transform methods of solving standard partial differential equations.

REFERENCES:

1. Andrews, L.C. and Philips.R.L., “Mathematical Techniques for engineering and scientists”, Printice Hall of India, New Delhi, 2006.
2. Bronson, R., “Matrix Operation”, Schaum‘s outline series, Tata McGrawHill, New York, 2011.
3. O‘Neil P.V., “Advanced Engineering Mathematics”, Cengage Learning, 8th Edition, India, 2017.
4. Oliver C. Ibe, “Fundamentals of Applied Probability and Random Processes”, Academic Press, Boston, 2014.
5. Sankara Rao, K., “Introduction to partial differential equations”, Prentice Hall of India, pvt, Ltd, 3rd Edition, New Delhi, 2010.
6. Taha H.A., “Operations Research: An introduction”, Ninth Edition, Pearson Education, Asia, 10th Edition, New Delhi, 2017.

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CO-PO Mapping:

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

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

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REFERENCES:
1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

CU3101 SIGNAL PROCESSING AND BASEBAND TECHNIQUES

L	T	P	C
2	0	2	3

UNITI REVIEW OF DISCRETE TIME SIGNALANALYSIS TOOLS 6

Review of DTFT, DFT, Z- Transformation: properties, applications in discrete time signal and system analysis

UNITII SPECTRUM ESTIMATION 6

Estimation of spectra from finite duration signals, Nonparametric methods – Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods – ARMA, AR and MA model based spectral estimation, Yule-walker method for AR model parameters, Model order selection for AR Models

UNITIII LINEAR PREDICTION AND OPTIMUM FILTERS 6

Filtering Random Processes, Special types of Random Processes: ARMA, AR, MA models, Yule-Walker equations, forward and backward linear prediction, Levinson-Durbin Algorithm, AR lattice structure, FIR Wiener filter.

UNITIV ADAPTIVE FILTERS 6

Applications of adaptive filters- system identification, channel equalization, echo cancellation, noise cancellation, prediction. FIR adaptive filters – Steepest descent adaptive filter, LMS algorithm, RLS adaptive algorithm, Kalman filter

UNITV DETECTION, ESTIMATION AND SYNCHRONIZATION 6

Detection rules: MAP, ML rules, detection of M-ary signals, MMSE estimation: Signal amplitude estimation, carrier frequency and phase estimation, symbol timing estimator, joint estimation of carrier phase and symbol timing.

LIST OF EXPERIMENTS: 30 PERIODS

1. Spectral Characterization of communication signals (using Spectrum Analyzer)
2. Power Spectrum Estimation using non-parametric / parametric methods (Bartlett, Welch / AR Model)
3. Optimum filter design for stationary signal processing
4. Realization of digital filters using lattice structure

5. Adaptive channel equalizer/ prediction filter / echo canceller (steepest descend/LMS / RLS)
6. BER estimation in AWGN and fading channels (ML and MAP detection)
7. MMSE Estimation (with / without knowledge on CSI)
8. Symbol, Carrier synchronization Techniques

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1 Reinforcing of basics mathematical principles required for digital signal processing and system analysis

CO2 Learning the techniques to estimate the spectrum of random signals in the presence of noise

CO3 Exploring the techniques to equalizer for stationary signals and design lattice structure for the system

CO4 Exploring the design techniques of adaptive systems for non-stationary signals

CO5 Studying the techniques to recover the desired signal parameters to stabilize the receiver systems and techniques of information decoding from the signal corrupted by noisy channel

REFERENCES:

1. John J. Proakis, Dimitris G. Manolakis, "Digital Signal Processing", 4/e, Pearson Education, 2014.
2. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley and Sons, Inc, Singapore,2002.
3. Bernard Sklar and Pabitra Kumar Roy, "Digital Communications: Fundamentals & Applications", Pearson Education India, 2nd Edition,2009.
4. John G. Proakis., " Digital Communication" , McGraw Hill Publication, 4th Edition,2001.
5. John G. Proakis, MasoudSalehi, "Communication Systems Engineering", Prentice Hall, 1994.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1		1	2		
CO2	1		1	2		
CO3	1		3	2	1	
CO4	1	3	3	2	1	
CO5	1	3	2	2	1	
Avg	**1**	**3**	**2**	**2**	**1**	

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CU3102 DIGITAL MODULATION AND CODING TECHNIQUES

L	T	P	C
2	0	2	3

UNIT I REVIEW OF DIGITAL MODULATION TECHNIQUES 6

Linear and nonlinear modulation techniques, M-ary modulation techniques; Spectral characteristics of digital modulation signal, Spread spectrum modulation techniques.

UNIT II RECEIVERS FOR AWGN AND FADING CHANNELS 6

Optimum receivers for AWGN channel – Correlation demodulator, matched filter detector, maximum likelihood sequence detector ; Characterization of fading multipath channels, RAKE demodulator, Multiuser detection techniques.

UNIT III ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING 6

OFDM- Signal Generation using IFFT; Guard Time and Cyclic Extension; Windowing; Peak to Average Power reduction schemes; Resource Grid Mapping Examples.

UNIT IV ORTHOGONAL TIME FREQUENCY SPACE MODULATION 6

OTFS Introduction, OTFS Signal Generation, Receivers for OTFS, Performance in AWGN and Time Varying Wireless Channels.

UNIT V TURBO CODING AND LDPC 6

Introduction to Turbo Coding, Iterative Turbo Decoding Principles; Modified MAP Algorithm-Soft-Output Viterbi Algorithm (SOVA); Turbo Coding for AWGN and Rayleigh Channels; LDPC Codes.

THEORY : 30 PERIODS

LIST OF LABORATORY EXPERIMENTS :

(Using DSP / MATLAB / SIMULINK / System View / BWSIM / 5G Tool Kit or Equivalent)

1. Simulation and analysis of digital modulation techniques
2. Implementation of digital modulation techniques on an SDR platform
3. CDMA signal generation and RAKE receiver implementation
4. OFDM transceiver Simulation and Analysis
5. OFDM transceiver implementation in SDR platform
6. OTFS Scheme Simulation and Analysis
7. Block and Convolutional Coding - Simulation and BER Analysis
8. Simulation and BER Analysis of Turbo coding and SOVA

LABORATORY : 30 PERIODS

TOTAL : 60 PERIODS

COURSE OUTCOMES:

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

CO1 Demonstrate an understanding of the trade-offs involved in the design of modulation signals

CO2 Identify best receiver configuration based on the channel and signal characteristics

CO3 Demonstrate an understanding and analyse the issues involved in the design of multi carrier modulation signals

CO4 Demonstrate an understanding and analyse the mapping of time, frequency and space resources for realizing performance gains in frequency selective, time varying channels

CO5 Implement coding and decoding using advances coding/decoding strategies and evaluate performance in AWGN and fading channel conditions

REFERENCES:

1. Bernard Sklar., “Digital Communications” , Pearson Education, Second Edition, 2001.
2. John G. Proakis., “Digital Communication”, McGraw Hill Publication, Fourth Edition, 2001.
3. Richard Van Nee &Ramjee Prasad., “OFDM for Multimedia Communications”, ArtechHouse Publication, 2001.
4. SuvraSekhar Das, Ramjee Prasad, “OTFS : Orthogonal Time Frequency Space Modulation – A Waveform for 6G”, River Publishers, 2021.
5. Theodore S. Rappaport., “Wireless Communications‘”, Pearson Education, Second Edition, 2002.
6. Sergio Verdu, “Multiuser Detection”, Cambridge University Press, 1998.
7. Andrea Goldsmith , “Wireless Communication”, Cambridge Univ. Press, 2006.
8. Heinrich Meyer, Mare Moeneclacy, Stefan A.Fechtel, “ Digital communication receivers “, Vol I &Vol II, John Wiley, New York, 1997.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	3	2	2	2	-	-
CO3	3	2	2	2	1	1
CO4	3	2	2	2	1	1
CO5	3	2	2	2	1	1
Avg.	**3**	**2**	**1.8**	**2**	**1**	**1**

CU3103 ADVANCED WIRELESS COMMUNICATION **L T P C**
2 0 2 3

UNITI WIRELESSCHANNELPROPAGATIONAND MODEL 6

Propagation of EM signals in wireless channel–Reflection, diffraction and Scattering- free space, two ray. Small scale fading- channel classification- channel models — COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Composite Fading–shadowing Distributions, Link power budget Analysis.

UNITII CAPACITYOFWIRELESS CHANNELS 6

Capacity in AWGN, capacity of flat fading channel, capacity of frequency selective fading channels.

UNITIII DIVERSITY 6

Realization of independent fading paths, Receiver Diversity: Selection combining, Threshold

Combining, Maximum-ratio Combining, Equal Gain Combining. Transmitter Diversity: Channel known at transmitter, Channel unknown at the transmitter.

UNITIV MIMOCOMMUNICATIONS 6

Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO channel capacity,MIMO Diversity Gain: Beam forming, Diversity-Multiplexing trade-offs, Space time Modulation and coding: STBC, STTC, Spatial Multiplexing and BLAST Architectures.

UNITV MULTIUSER SYSTEMS 6

Review of Multiple Access Techniques, Scheduling, power control, Uplink and Downlink channel capacity, multi user diversity, MIMO-MU systems.

LIST OF LABORATORY EXPERIMENTS :

(Using DSP / MATLAB / SIMULINK / System View / BWSIM / 5G Tool Kit or Equivalent)

1. Simulation and evaluation of large scale fading channel
2. Simulation and evaluation of small scale fading channel
3. Simulation and Evaluation of modulation schemes under various wireless channel
4. Simulation and Evaluation of various diversity combining techniques
5. Simulation and Evaluation of STBC techniques
6. Simulation and analysis of Beamforming techniques
7. Simulation and analysis of water filling power allocation techniques

LABORATORY : 30 PERIODS

TOTAL : 60 PERIODS

COURSE OUTCOMES:

COURSEOUTCOME:

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

CO1 Analyze the wireless channel characteristics and identify appropriate channel models

CO2 Understand the mathematics behind the capacity calculation under different channel conditions

CO3 Understand the implication of diversity combining methods and the knowledge of channel

CO4 Understand the concepts in MIMO Communications

CO5 Understand multiple access techniques and their use in different multi-user scenarios.

REFERENCES

1. Andrea Goldsmith, Wireless Communications, Cambridge University Press,2007.
2. Harry R. Anderson, “Fixed Broadband Wireless System Design”, John Wiley, India,2003.
3. Andreas.F.Molisch,“WirelessCommunications”,JohnWiley,India,2006.
4. Simon Haykin& Michael Moher, “Modern Wireless Communications”, Pearson Education, 2007.
5. Rappaport.T.S., “Wireless communications”, Pearson Education, 2003.
6. Gordon L.Stuber, “Principles of Mobile Communication”, Springer International Ltd., 2001.
7. UpenaDalal, “Wireless Communication”, Oxford Higher Education, 2009.

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CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	1
CO2	3	2	2	2	2	1
CO3	3	2	2	2	2	1
CO4	3	2	2	3	2	1
CO5	3	2	3	3	2	1
Avg.	**3**	**2**	**2**	**2.4**	**2**	**1**

CU3104 ADVANCED RADIATION SYSTEMS L T P C

3 0 0 3

UNIT I RADIATION FUNDAMENTALS AND WIRE ANTENNAS 9

Review of electromagnetics – Types of Antennas- Fundamental parameters of antennas - Linear wire antennas - Infinitesimal dipole, Finite length dipole - radiated fields-power density and radiation resistance - Field regions.

UNIT II ANTENNA ARRAYS 9

Linear array –uniform array-Two element and N element array-Broadside and Endfire – Binomial Chebyshev, Taylor series - Planar arrays– Design considerations - Mutual coupling –Feed networks.

UNIT III APERTURE ANTENNAS 9

Field equivalence principle, Babinets principle; Horn antenna; Reflector antenna, design consideration, and Excitation techniques, Microstrip Antennas-Design and analysis-simulation using EM software.

UNIT IV BROADBAND ANTENNAS 9

Rumsey's principle, Helical Antenna, Normal mode and axial mode –sleeve antenna--Yagi Uda array of linear elements – Biconical-Spiral antennas-Log periodic dipole array- Design considerations-simulation using EM software

UNIT V MODERN ANTENNAS AND ANTENNA MEASUREMENTS 9

Higher generation antennas-Antennas for near field communication-wearable antennas Micromachining; Measurements: Vector Network Analyzer, Measurement ranges, Gain measurement, Radiation pattern measurement- Polarization measurement

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the student should be able to:

CO1 Explain the various antenna parameters
CO2 Analyze and design simple antennas to complex antennas
CO3 Demonstrate the understanding of antenna radiation mechanism

CO4 Identify and classify antennas based on their applications
CO5 Exhibit an understanding of antenna fabrication and measurements

REFERENCES:

1. C.A. Balanis, “Antenna Theory: Analysis and Design”, 4th ed., Wiley (India), 2021.
2. W. L. Stutzman and G.A. Thiele, "Antenna theory and design," 2nd ed., Wiley-India, 1998.
3. J. D. Kraus, R. J. Marhefka, and A. S. Khan, "Antennas and wave propagation," Tata McGraw-Hill Education, 2006.
4. R.S. Ell R.S. Elliot, “Antenna theory and design” (Revised edition), John Wiley & Sons, 2005.
5. S. Drabowitch, A. Papiernik, H. D. Griffiths, J. Encinas, B. L. Smith, “Modern Antennas”, 2nd Ed., Springer (New York), 2005.
6. Journal articles to be suggested by the instructor

CO-PO MAPPING:

Cos	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1					
CO2	3					
CO3	3					
CO4	2		2			3
CO5	3					2
Avg.	**2.4**		**2**			**2.5**

CU3105 ANALOG AND DIGITAL ELECTRONIC SYSTEM DESIGN **L T P C**
3 0 2 4

UNIT I MOS TRANSISTOR PRINCIPLES AND LOGIC GATES **9**
MOS(FET) Transistor Characteristic under Static and Dynamic Conditions, MOS Transistor Secondary Effects, CMOS Inverter-Static Characteristic, Dynamic Characteristic, Power, Energy, and Energy Delay parameters, CMOS Logic gates design.

UNIT II SINGLE STAGE AMPLIFIERS **9**
MOS device models and equivalent circuits, CS, CG and CD amplifiers - Analysis of gain, impedances and noise, Amplifiers designed with cascode transistor, Current mirror.

UNIT III DIFFERENTIAL AMPLIFIERS **9**
Design of differential amplifiers – Analysis of gain, common mode range, bandwidth, slew rate and power dissipation, voltage swing, frequency response and stability. Structures of high gain amplifier and principles of operational amplifier design.

UNIT IV DIGITAL CIRCUIT DESIGN **9**
FPGA Architecture, data path circuit design, Analysis of clocked synchronous sequential circuits and modelling- Design of synchronous sequential circuits design of iterative circuits-ASM chart and realization using ASM

UNIT V SYSTEM DESIGN USING HDL 9

Logic System, Data Types and Operators for Modelling in HDL - Behavioral Descriptions in HDL – HDL Based Synthesis – Synthesis of Finite State Machines – structural modelling – Realization of combinational and sequential circuits using HDL

LIST OF EXPERIMENTS: 30 PERIODS

Simulations using Cadence Sprectre/Mentor Graphics/SPICE/Equivalent tools

1. DC Characteristics of NMOS and PMOS Devices
2. Logic gates design and simulation (NOT, NAND, NOR, AND, OR)
3. CS amplifiers design and performance analysis (Z_{IN}, Z_{OUT}, Gain, bandwidth, transient)
4. Design a differential amplifier with resistive load (low-frequency voltage gain, unity gain bandwidth, Power dissipation, CMRR, Transient analysis)

FPGA based Experiments

5. Implementation of combinational circuits
6. Implementation of simple state machine and timing analysis
7. FPGA realization and real time output analysis

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: Ability to realize the impact of MOS devices and their impact in logic gate designs
CO2: Ability to design and analyze the performance of amplifiers
CO3: Ability to design and analyze differential amplifiers and op amps
CO4: Ability to analyze and design synchronous sequential circuits
CO5: Ability to design and use programming tools for implementing digital circuits

REFERENCES:

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw Hill, 2nd Edition, 2016.
2. Willey M.C. Sansen, "Analog Design Essentials", Springer, March 2007.
3. Grebene, "Bipolar and MOS Analog Integrated circuit design", John Wiley & sons, Inc.,2003.
4. Charles H. Roth Jr, "Fundamentals of Logic Design" Thomson Learning 5th Edition, October 2005.
5. Nripendra N Biswas "Logic Design Theory" Prentice Hall of India,2001
6. S. Palnitkar, Verilog HDL – A Guide to Digital Design and Synthesis, Pearson, 2003.

Articulation Matrix:

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

Attested

CU3111 **SEMINAR** **L T P C**
0 0 2 1

COURSE OUTCOMES:

CO1 The students would be able to develop independent and collaborative learning ability
CO2 The students would be able to distinguish and integrate different forms of academic knowledge
CO3 The students would be capable of applying the principles of ethics and respect in interaction with others
CO4 The students would be able to apply multidisciplinary strategy to address current, real-world issues.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3				
CO2	3	3				
CO3	3					
CO4	3	3	3	3	3	3
Avg.	**3**	**3**	**3**	**3**	**3**	**3**

CU3201 **WIRELESS COMMUNICATION TECHNIQUES FOR 5G AND BEYOND** **L T P C**
2 0 2 3

UNITI INTRODUCTION TO 5G AND BEYOND **6**
5G characteristics and requirements, Applications, Case studies, 5G channel models: METIS channel models, Map-based model, stochastic model, Comparison of Models

UNITII 5G ARCHITECTURE **6**
Introduction, NFV and SDN, Basics about RAN architecture, High –level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional Split Alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfill 5G requirements, Enhanced Multi-RAT Coordination features, Physical architecture and 5G deployment.

UNITIII MULTI-CARRIERWAVEFORMSFOR5G **6**
Filter-bank based multi-carrier (FBMC)- Principles, Transceiver block diagram, Frame structure, Resource structure, allocation, mapping.Universal filtered multi carrier (UFMC)- Principles, Transceiver structure, Frame and Resource structure, allocation, mapping. Generalized frequency division multicarrier (GFDM) —Principles, Transceiver Block diagram, Frame structure, Resource structure, allocation, mapping, MIMO-GFDM

UNITIV MULTIPLEACCESSTECHNIQUESIN5G **6**
Challenges in OFDM- NOMA — Principle- Superposition Coding, Successive Interference Cancellation, Power Domain NOMA, Sparse Code NOMA - types, Power Domain Sparse

Code NOMA, Cooperative NOMA – Benefits and Challenges.

UNITV COOPERATIVECOMMUNICATION 6

Machine Type Communication (MTC), Device to Device Communication (D2D), 5G Narrowband IoT, Cloud Computing architecture and Protocols**, Relaying:** Cooperative NOMA- Benefits and Challenges, Half duplex relaying, Full duplex relaying, Amplify and forward relaying, Decode and forward relaying, Decode and forward relaying with PLNC, BER Analysis, Capacity Analysis.

TOTAL:30 PERIODS

LIST OF EXPERIMENTS:

1. Design and Implementation of FBMC using MATLAB
2. Design and Implementation of GFDM using MATLAB
3. Design and Implementation of UFMC using MATLAB
4. Implementation of NOMA transceiver system
5. Cooperative relaying in NOMA and comparison of amplify and forward, Decode and forward systems
6. Project on Massive MIMO System Implementation with Perfect CSI
7. Cellular Network modeling of 5G systems

LABORATORY :30 PERIODS

TOTAL:60PERIODS

COURSEOUTCOMES:

At the end of the course, the student should be able to:

CO1: Able to analyze the performance of different channel models adopted in 5G wireless systems

CO2: Able to design a transceiver for Multicarrier waveforms.

CO3: Able to analyze multiple access techniques in 5G networks

CO4: Able to design a pilot, estimate channels and analyze capacity for single cell and multi cell Massive MIMO.

CO5: Able to analyze different types of cooperative communications.

REFERENCES

1. AfifOsseiran, Jose.F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
2. Robert W. Heath Jr., Nuria González-Prelcic, SundeepRangan, WonilRohand Akbar M. Sayeed, "An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems", IEEE Journal of Selected Topics in Signal Processing, Vol. 10, No. 3, April 2016.
3. Min ChulJu and Il-Min Kim, "Error Performance Analysis of BPSK Modulation in Physical-Layer Network-Coded Bidirectional Relay Networks", IEEE Transactions on Communications,Vol. 58, No. 10, October 2010.
4. Shengli Zhang, Soung-Chang Liew, Patrick P.Lam, "Physical Layer Network Coding", Mobicom ‗06, Proceeding of the 12th International Conference on Mobile Computing and Networking, pp.358-365, Los Angeles, CA, USA, Sep.23-29,2006.
5. ThomasL.Marzetta, ErikG.Larsson,HongYang, HienQuocNgo,"Fundamentals of Massive MIMO", Cambridge University Press, 1stEdition, 2016.
6. AfifOsseiran, Jose F. Monserrat, Patrick Marsch, " 5G Mobile and Wireless Communications Technology", Cambridge University Press, 2nd edition, 2011
7. Erik Dahlman, Stefan Parkvall, Johan Sköld, "5G NR: The Next Generation Wireless Access Technology", Elsevier, 1stEdition, 2016.

8. Jonathan Rodriguez.” Fundamentals of 5G Mobile Networks”, Wiley, 1st Edition, 2010.

COs	PROGRAMMEOUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	2		1
CO2	1		2	2		1
CO3	1		1	1		1
CO4	1		3	3		1
CO5	1		1	1	1	1
Avg.	**1**		**1.8**	**1.8**	**1**	**1**

CU3202 RADIO FREQUENCY TRANSCEIVER DESIGN **L T P C**
3 0 0 3

UNIT I BASICS OF RADIO FREQUENCYSYSTEMDESIGN 9

System Parameter definitions: Gain, noise figure, SNR, Characteristic impedance, S-parameters, Impedance matching and Decibels, Average value, RMS value, Crest factor, sensitivity, selectivity, dynamic range and, adjacent and alternate channel power leakages.

Elements of digital base band signaling: complex envelope of band pass signals, Sampling, jitter, ISI, pulse shaping, IQ imbalance, EVM, BER.

UNIT II AMPLIFIER MODELINGANDANALYSIS 9

Noise: Noise equivalent model for Radio frequency device, amplifier noise model, cascade performance, minimum detectable signal, performance of noisy systems in cascade.

Non-Linearity: Amplifier power transfer curve, gain compression, AM-AM, AM-PM, polynomial approximations, Saleh model, Wiener model and Hammerstein model, intermodulation, Single and two tone analyses, second and third order distortions and measurements, SOI and TOI points, cascade performance of nonlinear systems.

UNIT III MIXER AND OSCILLATOR MODELINGANDANALYSIS 9

Mixers: Frequency translation mechanisms, frequency inversion, image frequencies, spurious calculations, principles of mixer realizations.

Oscillators: phase noise and its effects, effects of oscillator spurious components, frequency accuracy, oscillator realizations: Frequency synthesizers, NCO.

UNIT IV RADIO ARCHITECTURES AND DESIGNCONSIDERATIONS 9

Superheterodyne architecture, direct conversion architecture, Low IF architecture, band-pass sampling radio architecture

UNIT V CASE STUDY: APPLICATIONS OF SYSTEMS DESIGN 9

Multimode and multiband Superheterodyne transceiver: selection of frequency plan, receiver system and transmitter system design – Direct conversion transceiver: receiver system and transmitter system design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course,

CO1 Students will be able understand the specifications of transceiver modules

CO2 Students will understand pros and cons of transceiver architectures and their associated design considerations

CO3 Students will understand the impact of noise and amplifier non-linearity of amplification modules and also will learn the resultant effect during cascade connections

CO4 Students will be get exposure to learn about spurs and generation principles during signal generation and frequency translations

CO5 The case study will reinforce the understanding of transceiver systems and aid to select specification parameters selections

REFERENCES:

1. QizhengGu, "RF System Design of Transceivers for Wireless Communications", Springer, 2005.
2. Kevin Mc Claning, "Wireless Receiver Design for Digital Communications,". 2/3, Yes Dee Publications, 2012.
3. M C Jeruchim, P Balapan and K S Shanmugam, "Simulation of Communication systems: Modeling, Methodology and Techniques", Kluwer Academic/Plenum Publishers, 2nd Edition,2000.

CO-PO MAPPING:

COs	PROGRAME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		1	1	1	
CO2	1		1	1	1	
CO3	1		3	1	1	
CO4	1		3	1	1	
CO5	1	3	2	2	1	
Avg.	**1**	**3**	**2**	**1.2**	**1**	

CU3203 MICROWAVE INTEGRATED CIRCUITS

L	T	P	C
2	0	2	3

UNIT I PLANAR TRANSMISSION LINES AND COMPONENTS 6

Review of Transmission line theory– Types of transmission lines: Strip line, Slot line, Microstrip lines – Coupled lines: Even mode and odd mode analysis – Filters – Couplers – Power dividers.

UNIT II IMPEDANCE MATCHING NETWORKS 6

Circuit Representation of two port RF/Microwave Networks: High Frequency Parameters, Transmission Matrix, ZY Smith Chart, Design of Matching Circuits using Lumped Elements, Matching Network Design using Distributed Elements.

Attested

UNIT III MICROWAVE AMPLIFIER DESIGN 6

Introduction – Power Gain Equations- Stability considerations- Constant gain circles- Noise in two port networks- constant noise figure circles - Power amplifier design - Low noise amplifiers.

UNIT IV MICROWAVEOSCILLATORSDESIGN 6

Introduction – Design principles – CAD techniques for large-signal oscillator design – Phase noise in oscillators – MMIC Voltage controlled oscillator design – MMIC Injection locked oscillator design.

UNIT V MICROWAVE IC DESIGN AND MEASUREMENT TECHNIQUES 6

Microwave Integrated Circuits – MIC Materials- Hybrid versus Monolithic MICs – Multichip Module.

Technology – Fabrication Techniques, Miniaturization techniques, Introduction to Test fixture measurements, probe station measurements, thermal and cryogenic measurements.

THEORY: 30 PERIODS

LIST OF LABORATORY EXPERIMENTS:

1. Study of transmission line parameters – Impedance analysis
2. Design of impedance matching networks
3. Design of low pass and high pass filter
4. Design of band pass and band stop filters
5. Design of branch line couplers
6. Design of phase shifters
7. Design of Power dividers

PRACTICAL: 30 PERIODS

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, the student should be able to:

CO1 Demonstrate the construction and operation of various transmission lines
CO2 Analyze and design microwave passive components such as filters, power dividers, couplers.
CO3 Design and analyze stability of amplifiers and oscillators
CO4 Exhibit an understanding on MMIC fabrication and measurements.
CO5 Perform the simulation of microwave components using electromagnetic software module.

REFERENCES:

1. David M. Pozar, "Microwave Engineering", II Edition, John Wiley & Sons, 1998.
2. Jia Sheng Hong, M. J. Lancaster, "Microstrip Filters for RF/Microwave Applications", John Wiley& Sons, 2001
3. Guillermo Gonzalez, "Microwave Transistor Amplifiers – Analysis and Design", II Edition, Prentice Hall, New Jersy.
4. Thomas H.Lee, "Planar Microwave Engineering", Cambridge University Press, 2004.
5. ArjunaMarzuki, Ahmad Ismat Bin Abdul Rahim, MouradLoulou, "Advances in Monolithic Microwave Integrated Circuits for Wireless Systems: Modeling and Design Technologies" Engineering Science Reference, 2012.

6. Matthew M. Radmanesh, "Radio Frequency and Microwave Electronics", Pearson Education, II Edition 2002.
7. RavenderGoyal, "Monolithic MIC; Technology & Design", Artech House, 1989.
8. Gupta K.C. and Amarjit Singh, "Microwave Integrated Circuits", John Wiley, New York, 1975.
9. Hoffman R.K. "Handbook of Microwave Integrated Circuits", Artech House, Boston, 1987.

CO-PO MAPPING:

COs	PROGRAMEE OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2		2	2
CO2	3		2			2
CO3	3		2		2	2
CO4	3		2		2	2
CO5	3	3				3
Avg.	**3**	**3**	**2**		**2**	**2**

CU3204 ADVANCED OPTICAL COMMUNICATION AND NETWORKS **L T P C**
2 0 2 3

UNIT I OCN COMPONENTS 6

Coupler, isolator, circulators, switches, Modulators, Optical amplifiers: SOA, EDFA, Raman amplifiers. Photonic switching-optical cross connect, wavelength convertors, multiplexer, demultiplexer - filters-tunable filters.

UNIT II PHOTONIC IC's 6

ICs-Introduction, evolution, materials, integrated optical inter connects, integrated photonic devices-couplers, modulators, gratings.

UNIT III OCN ARCHITECTURES 6

SONET / SDH Network, Second Generation (WDM) Optical Networks, Need for Multilayered Architecture.

UNIT IV OCN SURVIVABILITY 6

Protection and Restoration, Objectives, Fault Protection and Restoration Techniques in the Logical Layer, SONET Self-Healing Rings.

UNIT V OPTICAL ACCESS NETWORKS 6

Classification proposed architectures and issues of fiber to home (FTH) Passive optical networks (PON), Classifications of PON network. Introduction to Radio over fiber (ROF) technology, Visible Light Communication (VLC),Free Space Optics (FSO).

THEORY: 30 PERIODS

LIST OF LABORATORY EXPERIMENTS:

1. To design and simulate a fiber optic analog and digital link
2. Study and measurement of losses in optical fiber.

Attested

3. Link Budget and Rise Time Analysis of Optical Link.
4. Study and perform time division multiplexing (digital).
5. Characterization of Fiber Bragg Grating Filter (Reflectivity, Insertion loss &Crosstalk) and measure isolation and insertion loss of a three port Circulators/Isolator.
6. Signal transmission and reception using WDM and spectral characterization.
7. Analysis of optical switching technologies using Optical Simulation tool.
8. Implementation of a simple All Optical Network.
9. Implementation of a Free Space Optics Link.
10. Photonic IC design- Components

LABORATORY: 30 PERIODS
TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course,

CO1 Students have a good knowledge on operation of couplers, isolators, circulators, multiplexers and filters and optical amplifiers.

CO2 Students will be able to design Photonic IC's.

CO3 Students will have a good knowledge of SONET/SDH.

CO4 Students will be able to resolve link issues and have good knowledge of fault restoring techniques.

CO5 Students will have a good knowledge of the various access networks.

REFERENCES:

1. Optical networks – A practical perspective – Rajiv Ramaswami N Sivarajan, (Morgan Kaufmann, 3rd Ed 2010)
2. Integrated Optics – Theory and technology –R G Hunsperger (Springer series in optical sciences", 5th edition 2002)
3. Optical Communication System – John Gowar, (PHI , 2nd Ed 1996)
4. Optical Fiber Communications Principles and practice – John M Senior (3rd Edn, 2010)
5. Optical Networks – Third generation transport systems - Uyless Black,1st edition, Pearson, 2002.
6. Principles of Photonic Integrated Circuits- Materials, Device Physics, Guided Wave Design; Richard Osgood jr.,Xiang Meng; Edition 1, Springer Cham.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	1	1
CO2	3	3	3	2	1	1
CO3	3	3	3	2	1	1
CO4	3	3	3	2	1	1
CO5	3	3	3	2	1	1
Avg.	**3**	**3**	**3**	**2**	**1**	**1**

CU3211 **RF PCB FABRICATION AND EMI/EMC TESTING** **L T P C**
1 0 4 3

UNIT I BASICS OF PCB DESIGN, TOOLS & INDUSTRY STANDARDS 3+12

PCB fabrication process photolithography and chemical etching, Mechanical Layer registration. Function of the Layout in the PCB Design Process. Classes and Types of PCBs, Introduction to Standard Fabrication Allowances, PCB Dimensions and Tolerances, Copper Trace and Etching Tolerances, Standard Hole Dimensions, Solder mask Tolerance.

1. PCB design using traditional method.
2. PCB design using LASER technology.
3. PCB component Assembly and Testing.

UNIT II PCB DESIGN FLOW USING CAD TOOL 3+12

Electronic Design Automation Tools (EDA) - Schematic capture - Component Selection - Annotation - Foot print assignment - Wiring - Design Rule Check - Netlist generation -Convert to PCB - Component Placement - Manual Routing - Auto Routing - Gerber file generation.

4. To fabricate PCB using additive technology and testing of electronics circuit on PCB.
5. To perform Assembly Processes -Manual assembly processes.
6. To perform automated assembly processes (pick and place).

UNIT III RF PCB DESIGN 3+12

Radiation from surface current and line current distribution, Basic Antenna parameters, Feeding structure-Patch Antenna, Micro strip arrays, Antenna System for Mobile Radio-Antenna Measurements and Instrumentation.

7. Design and Fabrication of single ISM band microstrip antenna
8. Design and Fabrication of dual band microstrip antenna
9. Design and Fabrication of UWB antenna

UNIT IV EMI/EMC CONCEPTS 3+12

EMI/EMC Concepts, EMI-EMC definitions and Units of parameters, Sources and victim of EMI Conducted and Radiated EMI Emission, Susceptibility, Transient EMI, ESD, Radiation Hazards.

10. Design of microstrip patch antenna for 4G/5G applications
11. Fabrication of microstrip patch antenna using LPKF Promat
12. SMA Connector Identification for microstrip antenna and its soldering.
13. Antenna measurement and validation using EMI/EMC facility

UNITV EMI/EMC TESTING 3+12

EMI Coupling Principles - Conducted, radiated and transient coupling; Common ground impedance coupling; Common mode and ground loop coupling; Differential mode coupling; Near field cable to cable coupling, cross talk; Field to cable coupling; Power mains and Power supply coupling. Simulation of Electromagnetic interference.

14. Design of RF transmitter and receiver module using EDA tool
15. Fabricate a PCB Layout for transmitter and receiver using LPKF Promat
16. Populate components in an automated assembly processes
17. EMI/EMC Pre-compliance testing of transmitter and receiver module

TOTAL : 75 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1 Ability to use EDA tools and PCB terminologies

CO2 Ability to fabricate a PCB from board diagram and skilfully perform assembling and soldering of components

CO3 Ability to design microstrip antenna and make appropriate trade-offs to achieve the most cost effective design that meets all requirements.

CO4 Familiar with the concepts related to Electromagnetic interference and Compatibility issues in PCBs

CO5 Familiar with the principles of EMI coupling and control techniques and able to propose solutions for minimizing EMI in PCBs

REFERENCES:

1. Kraig Mitzner, "Complete PCB Design Using OrCad Capture and Layout", Newness, 1stEdition, 2009.
2. Simon Monk,"Make You rOwn PCBs with EAGLE: From Schematic Designs to Finished Boards", McGraw-Hill Education TAB; 2ndEdition,2017.
3. Douglas Brooks, "Signal Integrity Issues and Printed CircuitBoardDesign",PrenticeHallPTR,2003.
4. Lee W. Ritchey, John Zasio, Kella J. Knack, "Right the First Time: a Practical Handbook on High Speed PCB and SystemDesign",SpeedingEdge,2003.
5. V.P.Kodali, "Engineering EMC Principles, Measurements and Technologies", IEEE Press, Newyork, 1996.
6. Henry W.Ott., "Noise Reduction Techniques in Electronic Systems", A Wiley Inter Science Publications, John Wiley and Sons, Newyork, 1988.
7. Bemhard Keiser, "Principles of Electromagnetic Compatibility", Artech house, Norwood, 3rd Edition, 1986.
8. C.R.Paul, "Introduction to Electromagnetic Compatibility", John Wiley and Sons, Inc, 1992. 5. Don R.J.White, "Consultant Incorporate, —Handbook of EMI/EMC", Vol I-V, 1988.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1		3	2	3
CO2	2	1	1	2	2	2
CO3	2	1		1	2	1
CO4	1	1	2		2	1
CO5	3	2		2	2	2
Avg.	**2**	**1.2**	**1.5**	**2**	**2**	**1.8**

Attested

CU3311 **PROJECT WORK I** **L T P C**
0 0 12 6

COURSE OUTCOMES:

At the end of the course, the student would be

CO1 Able to demonstrate sound technical knowledge in the area of communication techniques
CO2 Able to undertake problem identification, formulation and design
CO3 Able to conduct complex experiments and present the results with valid methodologies
CO4 Able to communicate with society at large in written an oral forms

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		
CO2	3		3	3		
CO3	3		3	3	3	3
CO4	3	3	3	3		
Avg.	3	3	3	3	3	3

CU3411 **PROJECT WORK II** **L T P C**
0 0 24 12

COURSE OUTCOMES:

At the end of the course, the student would be

CO1 Able to demonstrate sound technical knowledge in the area of communication techniques
CO2 Able to undertake problem identification, formulation and design
CO3 Able to conduct complex experiments and present the results with valid methodologies
CO4 Able to communicate with society at large in written an oral forms

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		
CO2	3		3	3		
CO3	3		3	3	3	3
CO4	3	3	3	3		
Avg.	3	3	3	3	3	

CU3001 TELECOMMUNICATION SYSTEM MODELING AND SIMULATION **L T P C**
3 0 0 3

UNITI SIMULATIONMETHODOLOGY 8

Introduction, Aspects of methodology, Performance Estimation, Simulation sampling frequency, Low pass equivalent simulation models for bandpass signals, Multicarrier signals, Non-linear and time-varying systems, Post processing – Basic graphical techniques and estimations.

UNITII RANDOM SIGNAL GENERATION&VALIDATION 8

Uniform random number generation, Mapping uniform random variables to an arbitrary pdf, Correlated and Uncorrelated Gaussian random number generation, PN sequence generation, Random signal processing, Testing of random number generators.

UNITIII MONTE CARLOSIMULATION 9

Fundamental concepts, Application to communication systems, Monte Carlo integration, Semi analytic techniques, Case study: Performance estimation of a wireless system.

UNITIV ADVANCED MODELS &SIMULATIONTECHNIQUES 10

Modeling and simulation of non-linearities: Types, Memory less non-linearities, Non-linearities with memory, Modeling and simulation of Time varying systems: Random process models, Tapped delay line model, Modeling and simulation of waveform channels, Discrete memory less channel models, Markov model for discrete channels with memory.

UNITV CASE STUDY: PERFORMANCE EVALUATION OF WIRELESS COMMUNICATION SYSTEMS 10

Case study: Simulation of a wireless communication System: AWGN Channel, Fading channel - analytic and semi analytic approaches

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be able to

CO1: Understand the different signal generation and processing methods
CO2: Mathematically model a physical phenomena
CO3: Simulate a phenomena so as to depict the characteristics that may be observed in a real experiment.
CO4: Apply knowledge of the different simulation techniques for designing a communication system or channel
CO5: Ability to validate a simulated system performance so as to match a realistic scenario.

REFERENCES

1. William.H.Tranter, K. Sam Shanmugam, Theodore. S. Rappaport, Kurt L. Kosbar, "Principles of Communication Systems Simulation", Pearson Education (Singapore) Pvt. Ltd,2004.
2. M.C. Jeruchim, P.Balaban and K. Sam Shanmugam, "Simulation of Communication Systems: Modeling, Methodology and Techniques", Plenum Press, New York,2001.
3. Averill.M.Law and W. David Kelton, "Simulation Modeling and Analysis", McGraw Hill Inc., 2000.

4. Geoffrey Gorden, “System Simulation”, Prentice Hall of India, 2nd Edition,1992.
5. Jerry Banks and John S. Carson, “Discrete Event System Simulation”, Prentice Hall ofIndia, 1984.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	1	1	
CO2	1		2	1	1	
CO3	1		2	3	1	
CO4	1		2	3	1	
CO5	2	2	2	3	1	2
Avg.	**1.2**	**2**	**2**	**2.2**	**1**	**2**

CU3002 RADAR SIGNAL PROCESSING **L T P C**
3 0 0 3

UNIT I RANGE EQUATION AND TYPES OF RADAR 9

Basic Radar, Radar equation, Radar parameters, Block diagram, Radar frequencies. Types of Radar: CW, Doppler, MTI, FMCW, Pulsed, Tracking Radar. DSP in Radar (MTD1), Radar measurements.

UNIT II RADAR SYSTEM CONCEPTS 9

Scattering and RCS, RCS models, propagation, antennas, receivers, Different type of Noise, Noise figure, False alarm & Missed detection, Radar cross section, Transmit/Receive and AntiTransmit/Receive Switches

UNIT III SIGNAL PROCESSING – I 9

Radar Signal Processing Fundamentals –Detection and likelihood ratio, binary detection, matched filtering, radar ambiguity functions, pulse compression and radar waveforms, radar resolution, Detection of radar signals in Noise and clutter, detection of non-fluctuating target in noise, Matched filter response to delayed Doppler shifted signals,

UNIT IV SIGNAL PROCESSING – II 9

Doppler Processing, Linear FM Pulse Compression, Waveform diversity, Passive System: Digital compression, SAW pulse compression. Signal processing in Antenna arrays.

UNIT V APPLICATIONS OF RADAR SIGNAL PROCESSING 9

Pulse-Doppler radar, CFAR detection, synthetic aperture radar (SAR), inverse synthetic aperture radar (ISAR), moving target indication (MTI), displaced-phase-center-antenna technique (DPCA), adaptive radar, super resolution (MUSIC), space-time adaptive processing (STAP).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the basic principles of radar operation and the types

CO2: Able to appreciate the impact of the different performance measures in a radar system.

CO3: Able to identify and apply different signal processing tools in the design of radar systems

CO4: Able to design radar systems to meet user specified operational goals.

CO5: Able to model radar returns in various operational environments and analyze performance.

REFERENCES

1. M.I.Skolnik , "Introduction to Radar Systems", Tata McGraw Hill 2006.
2. Mark A. Richards, "Fundamentals of Radar Signal Processing", McGraw-Hill, 2005.
3. Peyton Z. Peebles, Jr., "Radar Principles", Wiley India Pvt Ltd, 2007.
4. NadavLevanon , "Radar Principles", Wiley – Technology and Engineering Publication, 1988.
5. Nathansan, "Radar design principles-Signal processing and environment", PHI, 2 nd Edition, 2007.
6. Roger J.Sullivan, "Radar foundations for Imaging and advanced concepts", PHI,2004.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1		2			
CO2	2		2			
CO3	2		3	3		
CO4	1		3	3	1	
CO5	2		2	1		1
Avg.	**1.6**		**2.4**	**2.3**	**1**	**1**

CU3003 MASSIVE MIMO AND mm WAVE SYSTEMS

L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Massive MIMO: characteristics, principles, applications and implementation challenges, Transmission/detection techniques; Channel hardening in large dimensions,- Channel Models – Effect of spatial correlation – Channel Estimation – Pilot contamination.

UNIT II PRECODING IN LARGE MIMO SYSTEMS 9

SVD precoding, Precoding in a multiuser MIMO downlink – Linear precoding & Non-linear

Attested

precoding, Precoding in large multiuser MISO systems, Precoder based on norm descent search (NDS), Multicell precoding.

UNIT III mmWAVE CHANNEL CHARECTIRISTICS 9

Millimeter wave characteristics, applications and challenges, Radio wave propagation for mm wave: Large scale propagation channel effects, small scale channel effects, channel estimation: OMP and SOMP, mmwave link budget.

UNIT IV mmWAVE ARCHITECTURE 9

Millimeter wave design considerations, Partially connected and Fully-connected mmwave architectures, Transceiver architecture, Transceive without mixer, Receiver without Oscillator, millimeter wave calibration, production and manufacture.

UNIT V mmWAVE MIMO SYSTEMS 9

Massive MIMO Communications, Spatial diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise coupling in MIMO system, Spatial, Temporal and Frequency diversity, Dynamicspatial, frequency and modulation allocation, Beamforming for MmWave communications: Analog, digital and hybrid Beamforming.

TOTAL: 45 PERIODS

COURSEOUTCOMES:

CO1: Ability to understand Massive MIMO characteristics and implementation challenges
CO2: Ability to design precoding techniques for massive MIMO system and analyze their impacts
CO3: Ability to characterize propagation issues at Millimeter wave frequencies and analyze mmWave link budget
CO4: Ability to design mmWave transceivers
CO5: Ability to design mmWave beamforming techniques

REFERENCES:

1. Chockalingam and B.SundarRajan, “Large MIMO Systems“, Cambridge University Press, 2014.
2. EzioBiglieri, Robert Calder bank, Anthony Constantinides, Andrea Goldsmith, ArogyaswamiPaulraj, Vincent Poor, “MIMO Wireless Communications”, Cambridge University Press, 2006.
3. I.Robertson, N.Somjit and M.Chongcheawchamnan, “Microwave and Millimetre-Wave Design for Wireless Communications”, 2016.
4. T.S.Rappaport, R.W.Heath Jr., R.C.Daniels and J.N.Murdock, “Millimeter Wave Wireless Communications: Systems and Circuits”,2015.
5. K.C.Huang,Z.Wang, “Millimeter Wave Communication Systems”, Wiley-IEEE Press, 2011.
6. Robert W.Heath, Robert C.Daniel, James N.TheodoreS.Rappaport, Murdock, ”Millimeter Wave Wireless Communication”, Prentice Hall, 2014.
7. Xiang, W; Zheng, K; Shen, X.S; “5G Mobile Communications”, Springer,2016

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		
CO2	3		3	3		
CO3	3		3	3		

Attested

CO4	3		3	3		
CO5	3		3	3		
Avg.	**3**		**3**	**3**		

CU3004 MACHINE LEARNING IN COMMUNICATION NETWORKS **L T P C**
3 0 0 3

UNIT I MACHINE LEARNING BASICS 9

Supervised and Unsupervised learning, Capacity, Over fitting and Under fitting, Cross Validation, Linear regression, Logistic Regression, Regularization, Naive Bayes, Principle Component Analysis, Support Vector Machines (SVM), Decision tree, Random forest, K-Means Clustering, k nearest neighbor.

UNIT II NEURAL NETWORKS 9

Feed forwardNetworks,Back propagation, Convolutional Neural Networks-LeNet, AlexNet, ZFNet, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Back propagation, Recurrent Neural Network (RNN).

UNIT III DISTRIBUTED ML AND REINFORCEMENT LEARNING 9

Distributed optimization in resource-constrained systems, Communication-Efficient Distributed Edge Learning, Federated learning, Decentralized learning, Low-latency and on-device AI; Reinforcement Learning-Markov decision processes, Q-learning and Policy Optimization methods, Deep Reinforcement Learning (DRL), Multi-agent systems.

UNIT IV ML IN WIRELESS PHYSICAL LAYER SYSTEM DESIGN 9

Machine Learning in Channel Estimation, Feedback, and Signal Detection-Compressive sensing and pilot Estimation. Physical layer communications-Use of auto encoders for data transmission, Modulation, Channel coding, Modulation / Signal and Constellation classification, Localization, Spectrum Sensing using Deep Learning.

UNIT V ML IN WIRELESS SYSTEMS AND SECURITY 9

LOS and NLOS channel classification, Water-filling power allocation for 5G systems, Optimization for OFDM and MIMO-OFDM systems. Optimization in beamformer design – Robust receive beamforming, Transmit downlink beamforming. IoT Application: MCU-Net, Radar for target detection, Array Processing, MUSIC, ML in Side channel analysis.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Familiar with the different machine learning techniques and their use cases.
CO2: In a position to formulate Neural Network based problems corresponding to different applications.
CO3: In a position to formulate reinforcement learning concepts based problems corresponding to wireless applications.

Attested

CO4: Able to evaluate machine learning techniques that are useful to solve wireless physical layer problems.

CO5: In a position to read current research papers, understand the issues and implement the machine learning based real time solution approaches.

REFERENCES

1. Ian Good fellow, YoshuaBengio, and Aaron Courville, "Deep learning", Cambridge, MA", MIT Press, 2017.
2. Tom M. Mitchell, "Machine Learning", McGraw Hill, 1997.
3. EthemAlpaydın, "Introduction to machine learning", MIT Press, 3rd Edition, 2014.
4. Richard S. Sutton, Andrew G. Barto, "Reinforcement Learning, An Introduction", · 2018
5. Xu Wang , Sen Wang, Xingxing Liang , Dawei Zhao, Jincai Huang, XinXu , Bin Dai , and Qiguang Miao , "Deep Reinforcement Learning: A Survey", IEEE Transactions On Neural Networks And Learning Systems, 2017.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	-	-
CO2	3	2	2	2	-	-
CO3	3	2	2	2	1	1
CO4	3	2	2	2	1	1
CO5	3	2	2	2	1	1
Avg.	**3**	**2**	**1.8**	**2**	**1**	**1**

CU3005 MULTIMEDIA COMMUNICATION TECHNIQUES **L T P C**
3 0 0 3

UNITI INFORMATION THEORY BASICS 9

Information, Entropy, Uniquely decodable codes, prefix codes, Kraft-McMillan inequality, Shannon-Fano Code, static Huffman coding, - conditional entropy, Mutual Information, differential entropy, Rate-distortion theory,

UNITII DATA COMPRESSION 9

Minimum variance Huffman coding, Extended Huffman coding, arithmetic coding, Dictionary based coding – Lempel-Ziv-Welsh Compression

UNITIII AUDIO COMPRESSION 9

Audio – PCM, CD quality audio, synthesized audio, Audio compression–DPCM, Adaptive PCM, linear Predictive coding, code excited LPC, perpetual coding, MPEG audio coder and Dolby audio coders

UNITIV IMAGE COMPRESSION 9

Image formats – GIF, TIFF, Compression principles- lossless compression-digitized documents - run length encoding, facsimile encoding and lossy compression-JPEG, Embedded zero tree coder, JPEG2000.

UNITV VIDEO COMPRESSION 9

Video digitization formats, Compression principles- H.261-H.263-MPEG 1, 2, 4 formats

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1:Understanding the concepts of lossless and lossy compression techniques and their constraints
CO2: Able to demonstrate an understanding of the data compression
CO3: Able to demonstrate an understanding of the audio compression.
CO4: Able to demonstrate an understanding of the image compression
CO5: Able to demonstrate an understanding of the video compression.

REFERENCES:

1. Khalid Sayood, "Introduction To Data Compression", 5th edition, Morgan Kaufmann Publishers, (Elsevier), 2017
2. Fred Halshall, "Multimedia communication – applications, networks, protocols and standards", Pearson education,2007.
3. R. Rao,Z S Bojkovic, D A Milovanovic, "Multimedia Communication Systems: Techniques, Standards, and Networks", Pearson Education,2007.
4. R. Steimnetz, K. Nahrstedt, "Multimedia Computing, Communications and Applicationsǁ, Pearson Education", 1st Edition,1995.
5. Ranjan Parekh, "Principles of Multimedia", TMH,2006.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2	2		
CO2	2		2	2		
CO3	2		2	2		
CO4	2		2	2		
CO5	2		2	2		
Avg.	**2**		**2**	**2**		

CU3006 WIRELESS SENSOR NETWOKS AND WBAN L T P C
3 0 0 3

UNITI OVERVIEW OF WIRELESS SENSOR NETWORKS 9

Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks- case study, Enabling Technologies for Wireless Sensor Networks

UNIT II MAC AND ROUTING 9

Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts. Physical Layer and Transceiver Design Considerations

UNIT III ARCHITECTURES 9

MAC Protocols for Wireless Sensor Networks, IEEE 802.15.4, ZigBee, Low Duty Cycle Protocols and Wakeup Concepts - S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy Efficient Routing, Geographic Routing.

UNIT IV INFRASTRUCTURE ESTABLISHMENT AND DATA MANAGEMENT 9

Topology Control, Clustering, Time Synchronization, Localization and Positioning-Data management in WSN, Storage and indexing in sensor networks, Query processing in sensor, Data aggregation.

UNIT V WIRELESS BODY AREA NETWORK 9

Introduction to WBAN Standard-Architecture-WBAN layers- Network and MAC Protocol Design for WBAN-Energy Management in WBAN-Performance Analysis of WBAN- Miniaturized Antennas Implanted Antennas- PHY layer for UWB WBAN. Case study using Simulation Tools.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of the course the student would be

CO1: Ability to demonstrate an understanding of the different components of WSN and WBAN
CO2: Ability to demonstrate an understanding of the different implementation challenges and the solution approaches
CO3: Ability to design and implement protocols suitable to sensor communication scenario using design tools and characterize them
CO4: Ability to appreciate the need for designing energy efficient sensor nodes and protocols for prolonging network lifetime.
CO5: Ability to understand the practical design issues and find out different implementation tools for improving the overall performance of body area network.

REFERENCES

1. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks",JohnWiley, 2005.
2. Ian F. Akyildiz, Mehmet Can Vuran, "Wireless Sensor Networks" John Wiley, 2010
3. Yingshu Li, My T. Thai, Weili Wu, "Wireless Sensor Networks and Applications" Springer, 2008.
4. Huan-Bang Li, KamyaYekehYazdandoost Bin-Zhen, "Wireless Body Area Networks", RiverPublishers, 2010.
5. KasunMaduranga Silva Thotahewa(Author), Jean-Michel Redoute (Author), Mehmet RasitYuce, "Ultra Wideband Wireless Body Area Networks", Springer, 2016.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1	2		
CO2			2	2		
CO3	1		3	3	1	1
CO4	1		2	2		
CO5	1		2	3	1	1
Avg.	**1**		**2**	**2.4**	**1**	**1**

CU3007 SECURITY FOR WIRELESS COMMUNICATION NETWORKS **L T P C**
2 0 2 3

UNITI INTRODUCTION ON SECURITY 12

Security Goals, Cryptographic attacks, Security services and mechanisms, Techniques: Cryptography and Steganography, Traditional Symmetric key ciphers, Mathematics of Cryptography.

- Implementation of Extended Euclidean algorithm
- Implementation of Substitution Cipher, Hill Cipher and Transposition Cipher

UNITII SYMMETRIC & ASYMMETRIC KEY ALGORITHMS 12

Introduction to Block and Stream Ciphers, Advanced Encryption Standard (AES), RC4, Principle of Asymmetric key algorithms.

- Implementation of AES & RC4 algorithms
- Implementation of RSA, Rabin and El Gamal algorithms

UNITIII INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT 12

Message Integrity, Hash functions, Digital signatures: Digital signature standards. Authentication: Entity authentication: Biometrics, Key management techniques.

- Implementation of SHA-512 and WHIRLPOOL
- Implementation of Diffie Hellman algorithm

UNITIV SECURITY PROTOCOLS 12

IP security, E-mail Security :PGP, S/MIME, Web Security: SSL, TLS and SET.

- Application example: Implementation of web protocols

UNITV WIRELESS NETWORK SECURITY 12

Security for Broadband networks: Security challenges in 4G and 5G deployments, Introduction to side channel attacks and their counter measures.

- Application example: Implementation of WLAN protocol: WEP, WPA1 and WPA2

TOTAL : **60 PERIODS**

COURSE OUTCOMES:

At the end of the course, the student should be able to:

CO1:Ability to gain knowledge about the importance of security for networks, use of number theory and Galois field concepts.
CO2: Ability to design new symmetric and Asymmetric key crypto system
CO3: Ability to develop new authentication and key management techniques
CO4: Ability to develop a new network security protocols
CO5: Ability to develop a wireless network security protocols

REFERENCES:

1. Behrouz A. Forouzan ,"Cryptography and Network security", McGraw- Hill, 2011
2. William Stallings, "Cryptography and Network security: principles and practice", Prentice Hall of India, New Delhi, 2nd Edition, 2002
3. AtulKahate , "Cryptography and Network security", Tata McGraw-Hill, 2 nd Edition, 2008.
4. R.K.Nichols and P.C. Lekkas , "Wireless Security: Models , threats and Solutions", McGraw- Hill, 2001.
5. H. Yang et al., "Security in Mobile Ad Hoc Networks: Challenges and Solution", IEEE Wireless Communications, Feb. 2004.
6. "Securing Ad Hoc Networks", IEEE Network Magazine, vol. 13, no. 6, pp. 24-30, December 1999. 7. "Security of Wireless Ad Hoc Networks," http://www.cs.umd.edu/~aram/wireless/ survey.pdf
7. David Boel et.al, "Securing Wireless Sensor Networks – Security Architecture", Journal of networks , Vol.3. No. 1. pp. 65 -76, Jan 2008.
8. Perrig, A., Stankovic, J., Wagner, D., "Security in Wireless Sensor Networks", Communications of the ACM, 47(6), 53-57, 2004.
9. Introduction to side channel attacks – http://gauss.ececs.uc.edu/Courses/c653/lectures/SideC/intro.pdf

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2	3	1	
CO2	3		2	3	1	
CO3	3		2	3	1	
CO4	3		2	3	1	
CO5	3		2	3	1	
Avg.	**3**		**2**	**3**	**1**	

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CU3008 **COGNITIVE RADIO COMMUNICATIONS** **L T P C 3 0 0 3**

UNIT I SOFTWARE DEFINED RADIO AND ITS ARCHITECTURE 9

Definitions and potential benefits, software radio architecture evolution, technology tradeoffs and architecture implications. Essential functions of the software radio, SDR, hardware architecture, software architecture, top level component interfaces, interface topologies among plug and play modules.

UNIT II COGNITIVE RADIOS AND ITS ARCHITECTURE 9

Marking radio self-aware, cognitive techniques – position awareness, environment awareness in cognitive radios, optimization of radio resources, Cognitive Radio – functions, components and design rules, Cognition cycle – orient, plan, decide and act phases, Inference Hierarchy, Architecture maps, Building the Cognitive Radio Architecture on Software defined Radio Architecture

UNIT III SPECTRUM SENSING AND IDENTIFICATION 9

Primary Signal Detection: Energy Detector, Cyclostationary Feature Detector, Matched Filter, Cooperative Sensing , Definition and Implications of Spectrum Opportunity, Spectrum Opportunity Detection , Fundamental Trade-offs: Sensing Accuracy versus Sensing Overhead.

UNIT IV INFORMATION THEORETICAL LIMITS ON CR NETWORKS 9

Types of Cognitive Behavior, Interference-Avoiding Behavior: Spectrum Interweave, Interference-Controlled Behavior: Spectrum Underlay, Underlay in Small Networks: Achievable Rates, Underlay in Large Networks: Scaling Laws, Interference-Mitigating Behavior: Spectrum Overlay, Opportunistic Interference Cancellation.

UNIT V USER COOPERATIVE COMMUNICATIONS 9

User Cooperation and Cognitive Systems, Relay Channels: General Three-Node Relay Channel, Wireless Relay Channel, User Cooperation in Wireless Networks: Two-User Cooperative Network, Cooperative Wireless Network ,Multihop Relay Channel

TOTAL :45 PERIODS

COURSE OUTCOMES:

CO1: Ability to understand the basics of SDR and cognitive radio
CO2: Ability understand the architecture of cognitive radio and SDR
CO3: Ability to identify the role of spectrum sensing and dynamic spectrum access
C04: Ability to apply the concept of cognitive radio in different applications like IOT
CO5: Ability to design the MAC and network layers for cognitive radio

REFERENCES:

1. Alexander M. Wyglinski, MaziarNekovee, And Y. Thomas Hou, “Cognitive Radio Communications and Networks - Principles And Practice”, Elsevier Inc. , 2010
2. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks”, John Wiley & Sons, Ltd, 2009.

Attested

3. Khattab, Ahmed, Perkins, Dmitri, Bayoumi, Magdy, “Cognitive Radio Networks - From Theory to Practice”, Springer Series, Analog Circuits and Signal Processing, 2009.
4. J. Mitola, “Cognitive Radio: An Integrated Agent Architecture for software defined radio”, Doctor of Technology thesis, Royal Inst. Technology, Sweden 2000.
5. Simon Haykin, “Cognitive Radio: Brain –empowered wireless communications”, IEEE Journal on selected areas in communications, Feb 2005.
6. Ian F. Akyildiz, Won – Yeol Lee, Mehmet C. Vuran, ShantidevMohanty, “Next generation / dynamic spectrum access / cognitive radio wireless networks: A Survey Elsevier Computer Networks”, May 2006.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		1	1	2	2
CO2	1		1	1	2	2
CO3	1		2	2	3	2
CO4	1		2	2	3	2
CO5	1		1	1	2	2
Avg.	**1**		**1.4**	**1.4**	**2.4**	**2**

CU3009 SATELLITE COMMUNICATIONS AND NAVIGATION SYSTEMS **L T P C**
3 0 0 3

UNITI ELEMENTS OFSATELLITE COMMUNICATION 9

Satellite Systems, Orbital description and Orbital mechanics of LEO, MEO and GSO, Placement ofa Satellite in a GSO, Antennas and earth coverage, Altitude and eclipses, Satellite drift and station keeping, Satellite—description of different Communication subsystems, Bandwidth allocation.

UNITII SATELLITESPACESEGMENT ANDACCESS 9

Introduction; attitude and orbit control system; telemetry, tracking and command; power systems, communication subsystems, antenna subsystem, equipment reliability and space qualification, Multiple Access: Demand assigned FDMA - spade system - TDMA - satellite switched TDMA — CDMA.

UNITIII SATELLITELINKDESIGN 9

Basic link analysis, Interference analysis, Rain induced attenuation and interference, Ionospheric characteristics, Link Design: System noise temperature and G/T ratio, Downlink and uplink design, C/N, Link Design with and without frequency reuse, link margins, Error control for digital satellite link.

UNITIV SATELLITE BASED BROADBAND COMMUNICATION 9

VSAT Network for Voice and Data — TDM/TDMA, SCPC/DAMA, Elements of VSAT Network, Mobile and Personal Communication Services, Satellite based Internet Systems, Multimedia Broadband Satellite Systems, UAVs

Attested

UNITV SATELLITENAVIGATIONAND GLOBALPOSITIONINGSYSTEM 9

Radio and Satellite Navigation, GPS Position Location Principles of GPS Receivers and Codes, Satellite Signal Acquisition, GPS Receiver Operation and Differential GPS, INS, Indian Remote Sensing and ISRO GPS Systems.

TOTAL:45 PERIODS

COURSEOUTCOMES:

At the end of the course the student would be

CO1:Able to demonstrate an understanding of the basic principles of satellite based communication the essential elements involved and the transmission methodologies.

CO2:Familiar with satellite orbits, placement and control, satellite link design and the communication system components.

CO3:Able to demonstrate an understanding of the different interferences and attenuation mechanisms affecting the satellite link design.

CO4:The student would be able to demonstrate an understanding of the different communication, sensing and navigational applications of satellite.

CO5: Familiar with the implementation aspects of existing satellite based systems.

REFERENCES:

1. Wilbur L. Pritchard, Hendri G. Suyderhoud and Robert A. Nelson, "Satellite Communication Systems Engineering", Prentice Hall/Pearson,2007.
2. TimothyPrattandCharlesW.Bostain,"Satellite Communications",JohnWileyandSons,2nd Edition,2012.
3. D.Roddy,"SatelliteCommunication",McGrawHill,4th Edition(Reprint),2009.
4. TriTHa,"Digital Satellite Communication", McGraw Hill, 2nd Edition,1990.
5. B.N.Agarwal, "Design of Geo synchronous Spacecraft", Prentice Hall,1993.
6. Brian Ackroyd, "World Satellite Communication and Earth Station Design", BSP Professional Books,1990.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1			
CO2	1		3	2		
CO3	1		2	2		
CO4			2			
CO5			2	2	1	1
Avg.	1		2	2	1	1

AP3057 SIGNAL INTEGRITY FOR HIGH SPEED DESIGN

L T P C
3 0 0 3

UNIT I SIGNAL PROPAGATION ONTRANSMISSIONLINES 9

Transmission line equations, wave solution, wave *vs*. circuits, initial wave, delay time, Characteristic impedance , wave propagation, reflection, and bounce diagrams Reactive terminations – L, C , static field maps of micro strip and strip line cross-sections, per unit length parameters, PCB layer stackups and layer/Cu thicknesses, cross-sectional analysis tools, Zo and Td equations for microstrip and stripline Reflection and terminations for logic gates, fan-out, logic switching , input impedance into a transmission-line section, reflection coefficient, skin-effect, dispersion.

UNIT II MULTI-CONDUCTOR TRANSMISSION LINESAND CROSS-TALK 9

Multi-conductor transmission-lines, coupling physics, per unit length parameters ,Near and far-end cross-talk, minimizing cross-talk (stripline and microstrip) Differential signaling, termination, balanced circuits ,S-parameters, Lossy and Lossless models.

UNIT III NON-IDEAL EFFECTS 9

Non-ideal signal return paths – gaps, BGA fields, via transitions , Parasitic inductance and capacitance , Transmission line losses – Rs, tanδ , routing parasitic, Common-mode current, differential-mode current , Connectors.

UNIT IV POWER CONSIDERATIONS ANDSYSTEM DESIGN 9

SSN/SSO, DC power bus design, layer stack up, SMT decoupling, Logic families, power consumption and system power delivery, Logic families and speed Package types and parasitic,SPICE, IBIS models,Bit streams, PRBS and filtering functions of link-path components , Eye diagrams, jitter, inter-symbol interference Bit-error rate,Timing analysis.

UNIT V CLOCK DISTRIBUTION AND CLOCKOSCILLATORS 9

Timing margin, Clock slew, low impedance drivers, terminations, Delay Adjustments, canceling parasitic capacitance, Clock jitter.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to identify sources affecting the speed of digital circuits.
CO2: Ability to identify methods to improve the signal transmission characteristics
CO3: Ability to analyze non-ideal effects
CO4: Ability to analyze system power dissipation
CO5: Ability to analyze clocking strategies.

REFERENCES

1. H. W. Johnson and M. Graham, “High-Speed Digital Design: A Handbook of Black Magic”, Prentice Hall,1993.
2. Douglas Brooks, “Signal Integrity Issues and Printed Circuit Board Design”, Prentice Hall PTR , 1st Edition 2012.
3. S. Hall, G. Hall, and J. McCall, “High-Speed Digital System Design: A Handbook of Interconnect Theory and Design Practices”, Wiley-Interscience,2000.
4. Eric Bogatin , “Signal Integrity – Simplified”, Prentice Hall PTR,2003.

TOOLS REQUIRED

1. SPICE, source -http://www-cad.eecs.berkeley.edu/Software/software.html
2. HSPICE from synopsis, www.synopsys.com/products/mixedsignal/hspice/hspice.html
3. SPECCTRAQUEST from Cadence,http://www.specctraquest.com

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2		3			1
CO2	2		3		1	
CO3	2		3		1	
CO4	2		3		1	
CO5	2		3		1	
Avg.	**2**		**3**		**1**	**1**

CU3010 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY IN SYSTEM DESIGN

L T P C
3 0 0 3

UNIT I EMI/EMC CONCEPTS 9

EMI-EMC definitions and Units of parameters; Sources and victim of EMI; Conducted and Radiated EMI Emission and Susceptibility; Transient EMI, ESD; Radiation Hazards.

UNIT II EMI COUPLING PRINCIPLES 9

Conducted, radiated and transient coupling; Common ground impedance coupling ; Common mode and ground loop coupling ; Differential mode coupling ; Near field cable to cable coupling, cross talk ; Field to cable coupling ; Power mains and Power supply coupling.

UNIT III EMI CONTROL TECHNIQUES 9

Shielding, Filtering, Grounding, Bonding, Isolation transformer, Transient suppressors, Cable routing, Signal control.

UNIT IV EMC DESIGN OF PCBS 9

Component selection and mounting; PCB trace impedance; Routing; Cross talk control; Power distribution decoupling; Zoning; Grounding; VIAs connection; Terminations.

UNIT V EMI MEASUREMENTS AND STANDARDS 9

Open area test site; TEM cell; EMI test shielded chamber and shielded ferrite lined anechoic chamber; Tx /Rx Antennas, Sensors, Injectors / Couplers, and coupling factors; EMI Rx and spectrum analyzer; Civilian standards-CISPR, FCC, IEC, EN; Military standards-MIL461E/462.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Familiar with the concepts related to Electromagnetic interference and Compatibility issues in PCBs
CO2: Familiar with the principles of EMI coupling and control techniques
CO3: Able to analyze Electromagnetic interference effects in the design of PCBs

CO4: Able to propose solutions for minimizing EMI in PCBs
CO5: Able to analyze Electromagnetic environment and carryout measurements as per standards

REFERENCES:

1. V.P.Kodali, "Engineering EMC Principles, Measurements and Technologies", IEEE Press, New York, 1996.
2. Henry W.Ott., "Noise Reduction Techniques in Electronic Systems", A Wiley Inter Science Publications, John Wiley and Sons, New York, 1988.
3. Bemhard Keiser, "Principles of Electromagnetic Compatibility", Artech house, Norwood, 3rdEdition, 1986.
4. C.R.Paul, "Introduction to Electromagnetic Compatibility", John Wiley and Sons, Inc, 1992.
5. Don R.J.White, "Consultant Incorporate - Handbook of EMI/EMC", Vol. I-V, 1988.
6. David A.Weston, "Electromagnetic Compatibility-Principles and Applications", CRC Press,2017.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2		1	
CO2			2	2		
CO3			3	3		
CO4	1		2	2		
CO5			2	1		1
Avg.	1		2.2	2	1	1

CU3011 MICRO ELECTRO MECHANICAL SYSTEMS L T P C

3 0 0 3

UNITI INTRODUCTION TO MEMS AND NEMS 9

MEMS and Microsystems, Miniaturization, Typical products, Micro sensors, Micro actuation, MEMS with micro actuators, Micro accelerometers and Micro fluidics, Introduction to NEMS, Nano scaling, classification of nano-structured materials, Applications of nano-materials. Synthesis routes – Bottom up and Top down approaches.

Materials for MEMS: Silicon, silicon compounds, polymers, metals.

UNIT II MECHANICS FOR MEMS DESIGN 9

Elasticity, Stress, strain and material properties, Bending of thin plates, Spring configurations, torsional deflection, Mechanical vibration, Resonance, Thermo mechanics – actuators, force and response time, Fracture and thin film mechanics.

UNIT III MATERIALS AND FABRICATION OF MEMS 9

Atomic Structures and Quantum Mechanics, Molecular and Nanostructure Dynamics Photolithography, Ion Implantation, Diffusion, Oxidation, Dry and wet etching, Bulk Micromachining, Surface Micromachining, LIGA.

UNIT IV DESIGN OF MEMS SENSORS AND ACTUATORS 9

Acoustic sensor – Quartz crystal microbalance, Surface acoustic wave, Flexural plate wave, shear horizontal; Vibratory gyroscope, Pressure sensors, Electrostatic actuators, piezoelectric actuators, Thermal actuators, Actuators using shape memory alloys, Micro grippers, Micro motors, Micro valves, Micro pumps,Packaging.

UNIT V INTRODUCTION TO OPTICAL AND RF MEMS 9

Optical MEMS, - System design basics — Gaussian optics, matrix operations, resolution. Casestudies, MEMS scanners and retinal scanning display, Digital Micro mirror devices. RF MEMS–design, RF MEMS switch, performance issues. Packaging.

TOTAL: 45 PERIODS

COURSE OUTCOME:

CO1: Recognize the basics of materials and fabrication of micro electromechanical systems.
CO2: Devise the fabrication techniques of nano-electromechanical systems
CO3: Analyze the key performance aspects of micro electromechanical sensors and transducers.
CO4: Analyze various aspects of nano-materials and sensors.
CO5: Identify the potential applications of MEMS in the RF and optical domain

REFERENCES

1. Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata McGraw Hill, 2002.
2. Murty B.S, Shankar P, Raj B, Rath, B.B, Murday J, Textbook of Nanoscience and Nanotechnology, Springer publishing, 2013.
3. Sergey Edward Lyshevski, "MEMS and NEMS: Systems, Devices, and Structures", CRC Press, 2002
4. Chang Liu, "Foundations of MEMS", Pearson education India limited, 2006
5. Vinod Kumar Khanna Nanosensors: Physical, Chemical, and Biological, CRC press, 2012.
6. Mahalik N P, MEMS, Tata McGraw Hill, 2007.
7. Manouchehr E Motamedi, MOEMS: Micro-Opto-Electro-Mechanical Systems, SPIE press, First Edition, 2005.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2		3	
CO2	3		2		3	
CO3	3		2		3	
CO4	3		2		3	
CO5	3		2		3	
Avg.	**3**		**2**		**3**	

CU3012 HIGH SPEED SWITCHING AND NETWORKING

L T P C
3 0 0 3

UNITI LAN SWITCHINGTECHNOLOGY 9

Switching Concepts, LAN Switching, switch forwarding techniques - cut through and store and forward, Layer switching, Loop Resolution, Switch Flow control, virtual LANs.

UNITII QUEUES IN HIGHSPEED SWITCHES 9

Internal Queuing -Input, output and shared queuing, multiple queuing networks – combined Input, output and shared queueing-performance analysis of Queued switches.

UNITIII PACKETS WITCHING ARCHITECTURES 9

Architectures of Internet Switches and Routers- Bufferless and buffered Crossbar switches, Multi-stager switching, Optical Packet switching; Switching fabriconachip; Internally buffered Crossbars

UNITIV OPTICAL SWITCHING ARCHITECTURES 9

Need for Multilayered Architecture-, Layers and Sub-layers, Spectrum partitioning, Optical Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays, Connection Management and Control

UNITV IP SWITCHING 9

Addressing model, IP Switching types - flow driven and topology driven solutions, IP over ATM address and nexthopresolution, multicasting, IPv6overATM.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the student should be able to:

CO1: Familiar with the basics of switching technologies and the its implementation in LANs, ATM, IP and Optical networks
CO2: Familiar with the different switching architectures and queuing strategies
CO3: Able to analyze switching networks based on their blocking performances and implementation complexities.
CO4: Able to identify suitable switch architectures for a specified networking scenario.
CO5: In a position to apply his knowledge of switching technologies, architectures and buffering strategies for designing high speed communication networks and analyse their performance.

REFERENCES:

1. AchillePattavina, "Switching Theory: Architectures and Performance in Broadband ATM networks ",John Wiley & Sons Ltd, New York. 1998
2. Thomas E.Stern, Georgios Ellinas, Krishna Bala, "Multi wavelength Optical Networks —Architecture, Design and control", Cambridge University Press, 2ndEdition, 2009.
3. Rich Siefert, Jim Edwards,"The All New Switch Book—The Complete Guide to LAN Switching Technology", Wiley Publishing, Inc., 2nd Edition, 2008.
4. Elhanany M. Hamdi, "High Performance Packet Switching Architectures, Springer Publications, 2007.
5. Christopher Y Metz, "Switching Protocols & Architectures", McGraw-Hill Professional Publishing, New York,1998.
6. Rainer Handel, Manfred N Huber, Stefan Schroder," ATM Networks-Concepts Protocols, Applications", Addison Wesley, New York, 3rd Edition,1999.

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CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	2		1
CO2			2	2		
CO3	1		2	2		1
CO4			2	2		
CO5	1		3	3		2
Avg.	**1**		**2.2**	**2.2**		**1.3**

CU3013 COMMUNICATION NETWORK DESIGN L T P C
3 0 0 3

UNITI INTRODUCTION 9

Importance of Quantitative Modeling in Engineering of Telecommunication Networks, The Functional Elements of Networking, Evolution of Networking in the Wired and Wireless Domain.

UNITII MULTIPLEXING 9

Performance Measures and Engineering Issues Network performance and source characterization, Circuit multiplexed Networks, packet Multiplexing over wireless networks, Eventsand processes in packet multiplexer models, Deterministic traffic Models and network calculus, stochastic traffic models, LRD traffic, Link Scheduling and network capacity in wireless networks.

UNITIII SWITCHING 9

Performance Measures of packet switches and circuit switches, queuing in packet switches, delay Analysis in Output Queued Switch, Input Queued Switch and CIOQ Switch with Parallelism, Blocking in Switching Networks, Closed Networks.

UNITIV ROUTING 9

Algorithms for Shortest Path Routing - Dijkstra‘s Algorithm, Bellman Ford Algorithm, Generalized Dijkstra‘s Algorithm, Optimal Routing, Routing Protocols-Distance Vector, Link State and Exterior gateway protocols, Formulations of the Routing Problem-minimum interference Routing, MPLS, QoS Routing, Non-additive and Additive metrics

UNITV CASE STUDIES 9

Design of a wireless network and a wired network, prototype implementation to be simulated in a network simulator.

TOTAL:45PERIODS

COURSEOUTCOMES:

At the end of the course the studentwouldbe

CO1:Familiar with the functional elements and evolution of communication networking

CO2:Familiar with the multiplexing, switching and routing related issues, solutions and performance metrics

CO3: Able to understand the wired and wireless network design process.

CO4: Analyse the various aspects of a protocol and implement it using a network simulation tool.

CO5:Able to break up the communication network design problem into a number of sub-problems, identify suitable protocol solutions, implement using any simulator tool and carryout performance characterization.

REFERENCES:

1. Anurag Kumar, D.Manjunath and Joy, "Communication Networking", Morgan Kaufan Publishers, 2005.
2. A.LeanGarica and IndraWidjaja," Communications Networks", Tata McGraw Hill, 2004.
3. Thomas G. Robertazzi, "Computer Networks and Systems", Springer,3rdEdition, 2006.
4. Keshav.S., "An Engineering Approach to Computer Networking", Addison–Wesley,1999.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1			2			
CO2			2	2		
CO3			2	2		
CO4			2	2		
CO5	1		3	3		
Avg.	**1**		**2.2**	**2.25**		

CU3014 CONVEX OPTIMIZATION **L T P C**
3 0 0 3

UNITI INTRODUCTION TO OPTIMIZATION 8

Introduction to properties of Vectors, Norms, Positive Semi-Definite matrices, Gaussian Random Vectors. Extrema of functions — local and global. Optimization problem — categories, objective unction, constraints, feasible region. Introduction to Convex Optimization— Convex sets, Hyper planes/ Half-spaces, Convex/ Concave Functions.

UNITII CONVEX PROGRAMMING 8

Uniform random, Geometric programming(GP). Linear programming (LP). Quadradic programming(QP) Quadratically constraint QP(QCQP). Second order cone programming(SOCP). Semi-definite programming(SDP).

UNITIII DUALITY 9

Fundamental concepts, Lagrange dual function and conjugate function. Lagrange dual problem. Strongduality. Karush-Kuhn-Trcker(KKT) conditions. Lagrange dual optimization. Duality of problems with generalized inequalities.

UNITIV MULTI ANTENNATECHNIQUIES 10

Water-filling power allocation, Optimization for MIMO Systems, OFDM Systems and MIMO-OFDM systems. Optimization in beam former design - Robust receive beam forming, Transmit downlink beam forming. Application: Radar for target detection, Array Processing, MUSIC, MIMO-Radar Schemes for Enhanced Target Detection.

UNITV COOPERATIVE COMMUNICATIONS 10

Optimal Power Allocation for cooperative Communication. Cooperative communications in OFDM and MIMO cellular relay – System mode –Radio resource allocation (RRA) in OFDMA relay systems, Dynamic RRA in OFDMA, RRA in MIMO multi-hop networks. Power allocation in Multi-cell cooperative OFDM systems. Radio resource optimization in cooperative cellular wireless networks – Network with single source – destination pair, multiuser cooperation, Relay selection.

TOTAL:45 PERIODS

COURSEOUTCOMES:

At the end of the course the student would be

CO1: Familiar with the basic mathematics associated with Optimization
CO2: Able to understand the Convex programming approaches and the application of duality conditions
CO3: Familiar with the application methodology for real time communication applications
CO4: Able to mathematically model optimization problems and propose solution approaches
CO5: In a position to apply his knowledge of the different convex optimization techniques to solve different problems in communication system.

REFERENCES

1. Chia-Hsiang Lin, Chong-Yung Chi, and Wei-Chiang Li (Eds.), “Convex Optimization for Signal Processing and Communications: From Fundamentals to Applications”, CRC press,2017.
2. Hossain, E., Kim, D., & Bhargava, V. (Eds.),“Cooperative Cellular Wireless Networks”. Cambridge: Cambridge University Press, 2011.
3. https://nptel.ac.in/courses/108104112/
4. Stephen Boyd and LievenVandenberghe, “Convex Optimization”, Cambridge University Press.
5. http://www.stanford.edu/~boyd/cvxbook/

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1		2			
CO2			3	1		
CO3			3			
CO4			2	2		
CO5			2	2		
Avg.	1		2.4	1.66		

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CU3015 SIGNAL DETECTION AND ESTIMATION L T P C
3 0 0 3

UNITI STATISTICALDECISIONTHEORY 9

Review of Gaussian variables and processes; problem formulation and objective of signal detection and signal parameter estimation in discrete-time domain, Hypothesis testing- Bayes' detection, Maximum APosteriori detection, Maximum likelihood criterion, Minimum probability of error criterion, Min-Max criterion, Neyman-Pearson criterion- Multiple hypotheses. Composite hypothesis. Non-parametric detection. Wilcoxon detector, sequential detection.

UNITII DETECTION OF DETERMINISTIC AND RANDOM SIGNALS 9

M-ary detection- correlation receiver and matched filter receiver. General binary detection with unwanted parameters. Binary detection in colored noise- Karhunen-Lowve expansion approach, whitening approach and detection performance. Detection and estimation in white Gaussian noise. Detection and estimation in non-white Gaussian noise.

UNITIII ESTIMATION OF SIGNALPARAMETERS 9

Bayesian linear model. Bayesian estimation for deterministic parameters. General Bayesian estimators- Minimum variance unbiased estimation, minimum mean square error estimators, maximum a posteriori estimations. Cramer-Rao bound, Linear Bayesian estimations. Best linear unbiased estimations.

UNITIV SIGNAL ESTIMATIONINDISCRETE-TIME 9

Linear transformation and orthogonality principle. Wiener filters. Discrete wiener filters. Kalman filters- dynamical signal models, Kalman-Bucy filtering, Wiener-Kolmogorov filtering.

UNITV RECENT TECHNIQUES FOR DETECTION ANDESTIMATIONPROBLEMS 9

Applications to detection, parameter estimation and classification- the periodogram and the spectrogram, correlation, Wigner-Ville distribution, spectral correlation and ambiguity function. Cyclo-stationary processing. Higher order moments and poly spectra. Coherence processing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of this course, the students will be able to

CO1: Understand the qualitative problems of Signal Detection and Estimation in the framework of statistical inference.
CO2: Understand different hypotheses in Signal Detection and Estimation problems
CO3: Write down hypothesis tests and estimation schemes for typical problems of interest.
CO4: Gain an understanding of Signal Detection and Estimation of signals in white and non-white Gaussian noise
CO5: Understand the detection of random signals

REFERENCES:

1. MouradBarkat, "Signal detection and estimation", Artech house, Inc., 2nd Edition,2005.

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2. Ralph D. Hippenstiel, “Detection theory applications and digital signal processing”,CRC press,2002
3. Steven M. Kay, “Fundamentals of statistical signal processing: Estimation theory”, Prentice-Hall PTR,1993.
4. H.Vincent Poor, “An introduction to signal detection and estimation”, Springer-Verlag,
5. 2nd Edition,1994.
6. Harry L. Van trees, “Detection, estimation and modulation theory:Part 1”, John Wiley& sons, Inc.,2001.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2			
CO2			2			
CO3	1		1	1		
CO4	1		3			
CO5	1		3	2		
Avg.	**1**		**2.2**	**1.5**		

CU3016 SPEECH PROCESSING

L T P C
3 0 0 3

UNITI BASIC CONCEPTS 9

Speech Fundamentals: Articulatory Phonetics – Production and Classification of Speech Sounds; Acoustic Phonetics – Acoustics of speech production; discrete time model of speech, Short-Time Fourier Transform. Basics of Linear prediction, autocorrelation method, Levinson Durbin algorithm. Pitch estimation using linear prediction analysis.

UNITII FEATURE EXTRACTION 9

Fundamentals of pattern recognition and significance of feature selection. Homomorphic filtering - Cepstrum. Feature Extraction - MFCC, LPCC and PLP. Speech distortion measures– mathematical and perceptual – Log–Spectral Distance, Cepstral Distances, Weighted Cepstral Distances, Likelihood Distortions. Time alignment and normalization - dynamic time warping, multiple time alignment paths.

UNITI III SPEECH MODELING 9

Statistical modeling of speech - Gaussian mixture modeling, Hidden Markov models - Markov processes, HMMVs - Probability Evaluation, optimal state sequence - Viterbi search, Baum-Welch parameter re-estimation

UNITIV RECOGNITION ENGINES 9

Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – n-gram statistics, context dependent sub-word units. Speaker recognition - Text dependent and Text independent speaker recognition systems

UNIT V SPEECH SYNTHESIS 9

Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, hidden Markov model-based TTS, context dependent sub-word units for TTS, Prosodic modification of speech, voice conversion

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to model speech production system and describe the fundamentals of speech
CO2: Ability to Extract and compare different speech features
CO3 : Ability to select an appropriate statistical speech model for a given application
CO4 : Ability to design and implement a speech and speaker recognition system

CO5: Ability to Build speech synthesis systems

REFERENCES:

1. Lawrence Rabiner and Biing-Hwang Juang, “Fundamentals of Speech Recognition”, Pearson Education, 2003.
2. Thomas F Quatieri, “Discrete-Time Speech Signal Processing – Principles and Practice”, Pearson 2012
3. John Makhoul, “Linear prediction: a tutorial review” –Proceedings of the IEEE, Vol. 63, No. 4, Apr. 1975, pp. 561 – 580
4. L. R. Rabiner and Schaffer, “Digital Processing of Speech signals Pearson Education”, 2004.
5. Ben Gold and Nelson Morgan, “Speech and Audio Signal Processing, Processing and Perception of Speech and Music”, Wiley- India Edition, 2006.
6. Heiga Zen, Keiichi Tokuda, Alan W. Black, "Statistical Parametric Speech Synthesis", Speech Communication, Vol. 51, Issue 11, Nov. 2009, pp. 1039 - 1064.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2			
CO2	1		3			
CO3	1		1			
CO4	1		2	2		
CO5	1		3	3		
Avg.	1		2.2	2.5		

CU3017 CO-OPERATIVE COMMUNICATION L T P C
3 0 0 3

UNITI COOPERATIVECOMMUNICATIONSANDGREENCONCEPTS 9

Network architectures and research issues in cooperative cellular wireless networks; Cooperative communications in OFDM and MIMO cellular relay networks : issues and approaches; Fundamental trade-offs on the design of green radio networks, Green modulation and coding schemes.

UNITII COOPERATIVE TECHNIQUES 9

Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbobasestations; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying and Coordinated multi-point transmission in LTE-Advanced.

UNITIII RELAY-BASED COOPERATIVE CELLULAR NETWORKS 9

Distributed space-time block codes ; Collaborative relaying in downlink cellular systems ; Radio resource optimization; Adaptive resource allocation; Cross-layer scheduling design for cooperative wireless two-way relay networks; Network coding in relay-based networks, Co-operative relaying in NOMA, Coordinated Multipoint transmission in NOMA.

UNITIV GREEN RADIO NETWORKS 9

Base Station Power-Management Techniques- Opportunistic spectrum and load management, Energy-saving techniques in cellular wireless base stations , Power-management for base stations in smart grid environment , Cooperative multicell processing techniques for energy-efficient cellular wireless communications.

UNITV ACCESS TECHNIQUES FOR GREEN RADIO NETWORKS 9

Cross-layer design of adaptive packet scheduling for green radio networks; Energy- efficient relaying for cooperative cellular wireless networks; Energy performance in TDD-CDMA multi hop cellular networks; Resource allocation for green communication in relay-based cellular networks; Green Radio Test-Beds and Standardization Activities.

TOTAL: 45PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1:Able to appreciate the necessity and the design aspects of cooperative and green wireless communication.

CO2:Familiar with different techniques used in cooperative cellular networks

CO3:Familiar with different techniques used in green radio networks

CO4:Able to evolve new techniques and demonstrate their feasibility using mathematical validations and simulation tools.

CO5:Able to demonstrate the impact of the green engineering solutions in a global, economic, environmental and societal context.

REFERENCES:

1. Ekram Hossain, DongInKim, Vijay K.Bhargava, “Cooperative Cellular Wireless Networks”, Cambridge University Press,2011.
2. Ekram Hossain, Vijay K. Bhargava (Editor), Gerhard P.Fettweis(Editor), “Green Radio Communication Networks”, Cambridge University Press, 2012.
3. F.Richard Yu, Yu, Zhang and Victor C.M.Leung, “Green Communications and Networking”, CRC press, 2012.
4. Mazin Al Noor, “Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access”, GRIN Verlag, 2012.
5. Mohammad S.Obaidat, AlaganAnpalagan and Isaac Woungang, “Handbook of Green Information and Communication Systems”, Academic Press, 2012.
6. Ramjee Prasad and Shingo Ohmori, Dina Simunic, “Towards Green ICT”, River Publishers, 2010.

7. Jinsong Wu, SundeepRangan and Honggang Zhang, “Green Communications: Theoretical Fundamentals, Algorithms and Applications”,CRC Press, 2012.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		2	1	1	
CO2	1		2	1	1	
CO3	1		2	1	1	
CO4	1		2	2	1	
CO5	1		3	1	1	1
Avg.	**1**		**2.2**	**1.2**	**1**	**1**

CU3018 OPTICAL SENSORS AND APPLICATIONS **L T P C**
3 0 0 3

UNIT I OVERVIEW OF OPTICAL FIBER AND SENSING 9

Basic characteristics of optical fiber, Classification, dispersion, attenuation, nonlinear optical effects - SRS, SBS, SPM. Modal birefringence and polarization maintaining fibers.
Fiber optic Sensor – Basic elements of a fiber optic sensor, Categories, Distributed fiber optic system

UNIT II INTENSITY AND PHASE MODULATED OPTICAL SENSORS 9

Intensity modulation sensors – Extrinsic and intrinsic type – Transmissive, Reflective, Micro-bending and other Optic Effects sensor. Phase modulation sensors – Michelson Interferometers, Fabry – Perot Interferometer, Mach – Zender Interferometer and Sagnac Interferometer

UNIT III WAVELENGTH, SCATTERING AND POLARIZATION OPTICAL SENSOR 9

Wavelength modulation sensors - Bragg grating sensors, Distributed Sensing, Wavelength detection schemes. Scattering based sensors – Losses in fiber, OTDR, Distributed fiber sensing and scattering effects. Polarization based sensors – Birefringent optical systems, Birefringent effect in Bragg gratings

UNIT IV OPTICAL SENSING TECHNIQUES 9

Bragg grating based sensors - Temperature, Strain and Displacement Measurement, Interferometric Sensors for Strain and Temperature measurement, Fabry-Perot Optical Sensors for Pressure Measurement, Sensor Packaging.

UNIT V APPLICATIONS OF OPTICAL SENSORS 9

Flow Measurement - Laser Doppler velocimetry, Chemical sensors – Fluorescence, RI change, Distributed fiber optic chemical sensors, fiber-optic enabled spectroscopy, Optical gyroscopes, Application and recent trends on biophotonic sensors, Fiber Optic Smart Sensors – Atomic Force Microscope

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the student should be able to:

CO1: Ability to understand optical principles underlying various optical sensing methods
CO2: Ability to comprehend the various modes of modulation of optical signals for sensing
CO3: Ability to choose an optical sensing technique for a particular application
CO4: Ability to understand apply optical sensing mechanisms for various applications
CO5: Ability to apply optical sensing mechanisms for various applications

REFERENCES:

1. David A. Krohn, Trevor W. MacDougall and Alexis Mendez, "Fiber optic Sensors: Fundamental and Applications", SPIE, Fourth Edition, 2015
2. Eric Uddand William B. Spillman, Jr., "Fiber optics sensors: An introduction for Engineers and scientists", John Wiley & Sons, Second Edition, 2011
3. Gerd Keiser, "Optical Fiber Communications", Tata McGraw Hill, Fifth Edition, 2013.
4. José Miguel López-Higuera, "Handbook of Optical Fibre Sensing Technology", John Wiley & Sons Ltd., 2002
5. Zujie Fang, Ken Chin, Ronghui Qu, HaiwenCai, Kai Chang, "Fundamentals of Optical Fiber Sensors", John Wiley &Sons Inc, 2012

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1			2
CO2	3	2	1			2
CO3	3	2	1			2
CO4	3	2	1			2
CO5	3	2	1			2
Avg.	**3**	**2**	**1**			**2**

CU3019 ARTIFICIAL INTELLIGENCE AND INTERNET OF THINGS **L T P C**
3 0 0 3

UNIT I ARTIFICIAL INTELLIGENCE 9

Introduction to AI, agent, environment and its Applications; Principles of search, uninformed ("blind") search, informed ("heuristic") search, constraint satisfaction problems, adversarial search and games; AI Models: Knowledge representation and reasoning: rule based representations, declarative or logical formalisms, Logic Programming and logic network; Reasoning in uncertain environments: Genetic algorithms, fuzzy logic, soft computing.

UNIT II AI LEARNING MODELS 9

Supervised learning, unsupervised learning, reinforcement learning. Generative discriminative models; Probabilistic models: Bayesian models, probabilistic discriminative models; Optimization methods: gradient descent, multi-objective optimization. Practical cases: natural language processing, computer vision, bioinformatics, etc.

UNIT III INTRODUCTION TO IOT 9

Challenges, IoT network architecture & design: oneM2M, IoTWF, Core functional stack, Data management stack. 'Things' in IoT: Sensors, Actuators, Smart objects, Basics of Sensor Networks.

UNIT IV COMMUNICATING SMART OBJECTS 9

Communication criteria, IoT access technologies- IEEE 802.15.4, IEEE 802.15.4e, IEEE 802.11ah, IEEE 1901.2a, NB-IoT. IoT Network Layer: IP as IoT network layer, 6LoWPAN, 6Lo, 6TiSCH, RPL.

UNIT V IOT APPLICATION LAYER 9

IoT application transport methods, CoAP, MQTT. Data and Analytics for IoT: IoT Middleware, Data analytics for IoT, Big Data analytics tools and technology. IoT application case study: Smart City, Smart Grid, Smart Transportation, Smart Manufacturing, Smart Healthcare.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the student should be able to:

CO1:Ability of the student to understand the basics of Artificial intelligence.
CO2:Understand and analyze the AI learning models
CO3:Ability of the student to understand the basics of Internet of things.
CO4:Ability to understand the communication of smart objects and their underlying protocols
CO5:Ability to understand the application layer and to work on real time applications

REFERENCES:

1. Russell, Norvig, Artificial Intelligence: A MODERN APPROACH, 4th edition , 2022
2. Perry Lea, IoT and Edge Computing for Architects: Implementing edge and IoT systems from sensors to clouds with communication systems, analytics, and security, 2nd Edition, 2020.
3. SudipMisra, Anandarup Mukherjee, Arijit Roy, Introduction to IoT, Cambridge press, 2022
4. Zach Shelby,Carsten Bormann,“—6LoWPAN:TheWireless Embedded Internet”, John Wiley& Sons, 2009.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2	1	1	
CO2	2		3	2		
CO3	2		3	2		1
CO4	2		3	2		2
CO5	2		2	2		2
Avg.	**2**		**2.6**	**1.8**	**1**	**1.66**

CU3020 IMAGE PROCESSING AND PATTERN RECOGNITION **L T P C**
3 0 0 3

UNITI IMAGING PRELIMINARIES 9

Image Acquisition, Sensors, Image formation, Image transformations: 2D-DFT, DCT, DST, Hadamard, Walsh, Hotelling transformation, 2D-Wavelet transformation, Wavelet packets.

UNIT II IMAGE ENHANCEMENT AND RESTORATION 9

Gray-level mapping, non-liner gray-level mapping, image histogram, histogram stretching, histogram equalization. Spatial filters- Smoothing and Sharpening- Frequency domain filters. Image Degradation/Restoration Model- Noise Model- Linear Position Invariant Degradations- Wiener Filtering.

UNIT III IMAGE SEGMENTATION 9

Point, Line, and Edge segmentation. Edge linking and Boundary detection. Segmentation using thresholding, Region-based segmentation. Segmentation by morphological watersheds. Use of motion in segmentation.

UNIT IV IMAGE COMPRESSION AND WATER MARKING 9

Error free compression: Variable length coding, LZW, Bit-plane coding Lossy compression: Lossy predictive coding, transform coding, wavelet coding. Image compression standards (CCITT, JPEG, JPEG 2000) and Video compression standards. Digital Image Watermarking.

UNIT V FEATURE EXTRACTION 9

Boundary Representation - Chain codes, Boundary segments. Boundary Descriptors- Simple, Fourier Descriptors- Regional Descriptors- Simple, Texture. Corner Detection, Scale-invariant Feature Transform (SIFT), Speed-up Robust Features (SURF), Principal Component Analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, the student should be able to:

CO1: To apply a variety of introductory digital image processing techniques
CO2: To apply the combinations of enhancement/restoration methods in cases where a single approach is insufficient
CO3: To identify the suitable image segmentation techniques for image analysis
CO4: To familiar with the understanding of various lossless and lossy image compression techniques
CO5: To apply the understanding of extracted image features for further analysis

REFERENCES:

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing"‘, Pearson, Education, Inc., 4th Edition, 2018.
2. Anil K. Jain, "Fundamentals of Digital Image Processing"‘, Pearson Education, Inc., 2002.
3. William K. Pratt, "Digital Image Processing", John Wiley, New York, 2002.
4. Kenneth R. Castleman, "Digital Image Processing", Pearson, 2006.
5. D.E. Dudgeon and RM. Mersereau, "Multidimensional Digital Signal Processing", Prentice Hall Professional Technical Reference, 1990.

6. Milan Sonkaetal, "Image Processing, Analysis and Machine Vision", Brookes/Cole, Vikas Publishing House, 2nd Edition, 1999.
7. Alan C. Bovik, "Handbook of image and Video Processing ", Elsevier Academic press, 2005.
8. S.Sridhar, "Digital Image Processing" Oxford University press, Edition 2011.

CO-PO MAPPING:

COs	PROGRAMME OUTCOMES					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1					
CO2	1		2	2		
CO3	1		2	2		
CO4	1			1	3	
CO5	1		2	2		3
Avg.	**1**		**2**	**1.75**	**3**	**3**

AP3054 NONLINEAR SIGNAL PROCESSING **L T P C 3 0 0 3**

UNIT I INTRODUCTION TO NONLINEAR FILTERS AND STATISTICAL PRELIMINARIES 9

Nonlinear filters – measure of robustness – M estimators – L estimators – R estimators – order statistics – median filter and their characteristics – impulsive noise filtering by median filters – Recursive and weighted median filters – stock filters.

UNIT II NON LINEAR DIGITAL SIGNAL PROCESSING BASED ON ORDER STATISTICS 9

Time ordered nonlinear filters – rank ordered nonlinear filters – max/median filtering – median hybrid filters — characteristics of ranked order filters — L filters — M filters — R filters — comparison.

UNIT III ADAPTIVE NONLINEAR AND POLYNOMIAL FILTERS 9

Definition of polynomial filters – Wiener filters – robust estimation of scale – Adaptive filter based on local statistics – Decision directed filters – Adaptive L filters – Comparison of adaptive nonlinear filters – Neural networks for nonlinear filter

UNIT IV ALGORITHMS AND ARCHITECTURES 9

Sorting and selection algorithm – running median algorithm – fast structures for median and order statistics filtering – systolic array implementation – Wave front array implementation – quadratic digital filters implementation

UNIT V APPLICATIONS OF NONLINEAR FILTERS 9

Power spectrum analysis – Morphological image processing – nonlinear edge detection impulse noise rejection in image and bio signals – two component image filtering – speech processing

Attested

TOTAL: 45 PERIODS

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

COURSE OUTCOMES

CO1: Ability to evaluate the characteristics of nonlinear filters

CO2: Ability to design and implement rank order filters.

CO3: Ability to develop polynomial filters.

CO4: Ability to design architectures for nonlinear filters.

CO5: Ability to implement nonlinear filters for different types of signals.

REFERENCES:

1. Ioannis Pitas, Anastarios. N.Venetsanopoulos, “Nonlinear Digital filters — Principles andApplications”, Kluwer Academic Publishers, 1990.
2. Jaakko Astola, P Kuosmanen, “Fundamentals of Nonlinear Digital Filtering”, CRC PressLLC, 1st Edition 2020.
3. Gonzalo R. Arce, “Nonlinear Signal Processing – A Statistical Approach”, Wiley Publishers,2005
4. Wing Kuen Ling, “Nonlinear Digital Filters: Analysis and Applications”, Elsevier Science &Tech. 2007.

CO-PO MAPPING:

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

AP3055 RF INTEGRATED CIRCUIT DESIGN

L T P C
3 0 0 3

UNIT I CMOS PHYSICS, TRANSCEIVER SPECIFICATIONS AND ARCHITECTURES 9

Introduction to MOSFET Physics, Noise: Thermal, shot, flicker, popcorn noise, Two port Noise theory, Noise Figure, THD, IP2, IP3, Sensitivity, SFDR, Phase noise - Specification distribution over a communication link, Homodyne Receiver, Heterodyne Receiver, Image reject, Low IF Receiver Architectures Direct up conversion Transmitter, Two step up conversion Transmitter.

UNIT II IMPEDANCE MATCHING AND AMPLIFIERS 9

S-parameters with Smith chart, Passive IC components, Impedance matching networks, Common Gate, Common Source Amplifiers, OC Time constants in bandwidth estimation and enhancement, High frequency amplifier design, Power match and Noise match, Single ended and Differential LNAs, Terminated with Resistors and Source Degeneration LNAs.

UNIT III FEEDBACK SYSTEMS AND POWER AMPLIFIERS 9

Stability of feedback systems: Gain and phase margin, Root-locus techniques, Time and Frequency domain considerations, Compensation, General model — Class A, AB, B, C, D, E and F amplifiers, Power amplifier Linearization Techniques, Efficiency boosting techniques, ACPR metric, Design considerations

UNIT IV MIXERS AND OSCILLATORS 9

Mixer characteristics, Non-linear based mixers, Quadratic mixers, Multiplier based mixers, Single balanced and double balanced mixers, subsampling mixers, Oscillators describing Functions, Colpitts oscillators Resonators, Tuned Oscillators, Negative resistance oscillators, Phase noise.

UNIT V PLL AND FREQUENCY SYNTHESIZERS 9

Linearized Model, Noise properties, Phase detectors, Loop filters and Charge pumps, Integer-N frequency synthesizers, Direct Digital Frequency synthesizers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to explore user specifications for RF systems

CO2: Ability to analyze and design RF low noise amplifiers.

CO3: Ability to analyze and design RF power amplifiers.

CO4: Ability to analyze and design RF mixers and oscillators

CO5: Ability to design PLL for RF applications.

REFERENCE BOOKS:

1. T.Lee, "Design of CMOS RF Integrated Circuits", Cambridge, 2004.
2. B.Razavi, "RF Microelectronics", Pearson Education, 2nd Edition, January 2013.
3. Jan Crols, Michiel Steyaert, "CMOS Wireless Transceiver Design", Kluwer Academic Publishers, 1997.
4. B.Razavi, "Design of Analog CMOS Integrated Circuits", McGraw Hill, 2nd Edition, 2017.
5. Recorded lectures and notes available at http://www.ee.iitm.ac.in/~ani/ee6240/

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

VL3151 DIGITAL CMOS VLSI DESIGN

L T P C
3 0 0 3

UNIT I MOS TRANSISTOR PRINCIPLES AND CMOS INVERTER 12

MOS(FET) Transistor Characteristic under Static and Dynamic Conditions, MOS Transistor Secondary Effects, CMOS Inverter-Static Characteristic, Dynamic Characteristic, Power, Energy, and Energy Delay parameters, Stick diagram and Layout diagrams.

UNIT II COMBINATIONAL LOGIC CIRCUITS 9

Static CMOS design, Different styles of logic circuits, Logical effort of complex gates, Static and Dynamic properties of complex gates, Interconnect Delay, Dynamic Logic Gates.

UNIT III SEQUENTIAL LOGIC CIRCUITS 9

Static Latches and Registers, Dynamic Latches and Registers, Timing Issues, Pipelines, Nonbistable Sequential Circuits.

UNIT IV ARITHMETIC BUILDING BLOCKS 9

Data path circuits, Architectures for Adders, Accumulators, Multipliers, Barrel Shifters, Speed and Area Tradeoffs

UNIT V MEMORY ARCHITECTURES 6

Memory Architectures and Memory control circuits : Read-Only Memories, ROM cells, Read- write memories (RAM), dynamic memory design, 6 transistor SRAM cell, Sense amplifiers.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: To be able to use mathematical methods and circuit analysis models in analysis of CMOS digital circuits

CO2:To be able to create models of moderately sized static CMOS combinational circuits that realize specified digital functions and to optimize combinational circuit delay using RC delay models and logical effort

CO3:To be able to design sequential logic at the transistor level and Compare the tradeoffs of sequencing elements including flip-flops, transparent latches

CO4:To be able to learn design methodology of arithmetic building blocks

CO5:To be able to design functional units including ROM and SRAM

REFERENCES:

1. Jan Rabaey, Anantha Chandrakasan, B Nikolic, "Digital Integrated Circuits: A Design Perspective", Prentice Hall of India, 2nd Edition, May 2016,
2. N.Weste, K. Eshraghian, " Principles of CMOS VLSI Design", Addison Wesley, 2nd Edition, 1993
3. M J Smith, "Application Specific Integrated Circuits", Addison Wesley, January 2002.
4. Sung-Mo Kang & Yusuf Leblebici, "CMOS Digital Integrated Circuits Analysis and Design", McGraw-Hill, December 2002.

CO-PO MAPPING:

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

VL3012 SIGNAL PROCESSING IN VLSI DESIGN L T P C
3 0 0 3

UNIT I INTRODUCTION TO DSP SYSTEMS, PIPELINING AND PARALLEL PROCESSING OF FIR FILTERS 9

Introduction to DSP systems – Typical DSP algorithms, Data flow and Dependence graphs - critical path, Loop bound, iteration bound, Longest path matrix algorithm, Pipelining and Parallel processing of FIR filters, Pipelining and Parallel processing for low power.

UNIT II RETIMING, ALGORITHMIC STRENGTH REDUCTION 9

Retiming – definitions and properties, Unfolding – an algorithm for unfolding, propertiesof unfolding, sample period reduction and parallel processing application, Algorithmic strength reduction in filters and transforms – 2-parallel FIR filter, 2-parallel fast FIR filter, DCT architecture, rank-order filters, Odd-Even merge-sort architecture, parallel rank- order filters.

UNIT III FAST CONVOLUTION, PIPELINING AND PARALLEL PROCESSING OF IIR FILTERS 9

Fast convolution – Cook-Toom algorithm, modified Cook-Toom algorithm, Pipelined and parallel recursive filters – Look-Ahead pipelining in first-order IIR filters, Look-Ahead pipelining with power- of-2 decomposition, Clustered look-ahead pipelining, Parallel processing of IIR filters, combined pipelining and parallel processing of IIR filters.

UNIT IV BIT-LEVEL ARITHMETIC ARCHITECTURES 9

Bit-level arithmetic architectures – parallel multipliers with sign extension, parallel carry ripple and carry-save multipliers, Design of Lyon‟s bit-serial multipliers using Horner‟s rule, bit-serial FIR filter, CSD representation, CSD multiplication using Horner‟s rule for precision improvement, Distributed Arithmetic fundamentals and FIR filters.

UNIT V NUMERICAL STRENGTH REDUCTION, SYNCHRONOUS, WAVE AND ASYNCHRONOUS PIPELINING 9

Numerical strength reduction – sub expression elimination, multiple constant multiplication, iterative matching, synchronous pipelining and clocking styles, clock skew in edge-triggered single phase clocking, two-phase clocking, wave pipelining. Asynchronous pipelining bundled data versus dual rail protocol.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Ability to determine the parameters influencing the efficiency of DSP architectures andapply pipelining and parallel processing techniques to alter FIR structures for efficiency

CO2: Ability to analyse and modify the design equations leading to efficient DSP architectures for transforms

CO3: Ability to speed up convolution process and develop fast and area efficient IIR structures

CO4: Ability to develop fast and area efficient multiplier architectures

CO5: Ability to reduce multiplications and build fast hardware for synchronous digital systems

REFERENCES

1. Keshab K. Parhi, " VLSI Digital Signal Processing Systems, Design andimplementation ", Wiley, Interscience, 2007.
2. U. Meyer – Baese, " Digital Signal Processing with Field Programmable Gate Arrays", Springer, 4th Edition, June 2014.

CO-PO MAPPING:

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

CO4	2		2	1	1	
CO5	2		2	1	1	
Avg.	2		2	1	1	