RAJALAKSHMI ENGINEERING COLLEGE

(An Autonomous Institution Affiliated to Anna University, Chennai)

DEPARTMENT OF ELECTRONCS AND COMMUNICATION ENGINEERING

CURRICULUM AND SYLLABUS – REGULATIONS - 2023

M.E (COMMUNICATION SYSTEMS)

VISION

To produce globally competent Electronics and Communication Engineers with a commitment to serve the society.

MISSION

M1 To impart training with the best of teaching expertise supported by excellent laboratory infrastructure and exposure to recent trends in the industry.

M2 To ensure that the students are molded into competent Electronics and Communication engineers with the knowledge of computer applications and worthy citizens of the country.

PROGRAM OUTCOMES (POs)

Engineering Graduates will have:

PO1: Ability to apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude in the field of communication.

PO2: Ability to identify, formulate, solve engineering problems and to explore recent developments in the areas like RF& Microwave, Signal Processing, Modern communication systems and Networks.

PO3: Ability to understand and use of different recent hardware and software tools for Analysis and verification in the domain of communication and networking.

PO4: Ability to design and conduct experiments, analyze and interpret data, imbibe programming skills for development of simulation experiments.

PO5: Ability to impart knowledge to enthusiastic young minds for developing products for scientific and business applications with state of art technologies.

PO6: Ability to function as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.

CURRICULUM

SEMESTER I

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MH23112	Applied Mathematics for Communication Engineers	FC	4	3	1	0	4
2	CU23111	Advanced Radiation Systems	PC	4	3	1	0	4
3	CU23112	Optical Networks	PC	3	3	0	0	3
4	CU23113	Advanced Digital Communication Techniques	PC	3	3	0	0	3
5	CU23131	Advanced Digital Signal Processing	PC	5	3	0	2	4
6	PG23111	Research Methodology and IPR	MC	3	3	0	0	3
7	AC23111	English for Research Paper Writing (Audit Course)	HS	3	3	0	0	0
PRACTICALS								
8	CU23121	Communication Systems Laboratory	PC	4	0	0	4	2
			TOTAL	**29**	**21**	**2**	**6**	**23**

SEMESTER II

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	CU23211	Wireless Communication Networks	PC	3	3	0	0	3
2	CU23212	MIC and RF System Design	PC	4	3	1	0	4
3	CU23213	Communication System Modeling and Simulation	PC	3	3	0	0	3
4		Professional Elective- I	PE	3	3	0	0	3
5		Professional Elective- II	PE	3	3	0	0	3
6		Professional Elective- III	PE	3	3	0	0	3
7	AC23211	Constitution of India (Audit Course)	MC	3	3	0	0	0
PRACTICALS								
8	CU23221	RF System Design Laboratory	PC	4	0	0	4	2
			TOTAL	**26**	**20**	**1**	**4**	**21**

SEMESTER III								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY								
1	CU23311	Wireless Ad Hoc and Sensor Networks	PC	3	3	0	0	3
2		Professional Elective -IV	PE	3	3	0	0	3
3		Open Elective	OE	3	3	0	0	3
PRACTICALS								
4	CU23321	Project Work (Phase I)	EEC	12	0	0	12	6
		TOTAL		**21**	**9**	**0**	**12**	**15**
SEMESTER IV								
S.NO	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY								
1	CU23421	Project Work (Phase II)	EEC	24	0	0	24	12
		TOTAL		**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS: 71

LIST OF PROFESSIONAL ELECTIVES

PROFESSIONAL ELECTIVE- I

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	CU23A11	Advanced Satellite Communication	PE	3	3	0	0	3
2	CU23A12	Real Time Embedded Systems	PE	3	3	0	0	3
3	CU23A13	MEMS and NEMS	PE	3	3	0	0	3
4	CU23A14	Multimedia Compression Techniques	PE	3	3	0	0	3
5	CU23A15	High Performance Networks	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE-II

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	CU23B11	RF MEMS	PE	3	3	0	0	3
2	CU23B12	Digital Communication Receivers	PE	3	3	0	0	3
3	CU23B13	Cognitive Radio	PE	3	3	0	0	3
4	CU23B14	VLSI for Wireless Communication	PE	3	3	0	0	3
5	CU23B15	Digital Communication over Fading Channels	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE-III

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	CU23C11	Speech and Audio Signal Processing	PE	3	3	0	0	3
2	CU23C12	Digital Image and Video processing	PE	3	3	0	0	3
3	CU23C13	Radar Signal Processing	PE	3	3	0	0	3
4	CU23C14	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
5	CU23C15	Soft Computing	PE	3	3	0	0	3

PROFESSIONAL ELECTIVE-IV

S.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	CU23D11	Detection and Estimation Theory	PE	3	3	0	0	3
2	CU23D12	Internetworking Multimedia	PE	3	3	0	0	3
3	CU23D13	Millimeter Wave Communication	PE	3	3	0	0	3
4	CU23D14	Communication Network Security	PE	3	3	0	0	3
5	CU23D15	5G Communication Technology	PE	3	3	0	0	3

AUDIT COURSES -I & II

SEMESTER I							
S.No	**COURSE CODE**	**COURSE TITLE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY							
1	AC23111	English for Research Paper Writing	3	3	0	0	0
SEMESTER II							
S.No	**COURSE CODE**	**COURSE TITLE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
1	AC23211	Constitution of India	3	3	0	0	0

OPEN ELECTIVES

S.No	COURSE CODE	COURSE TITLE	CONTACT PERIODS	L	T	P	C
THEORY							
1	CP23O11	Business Analytics	3	2	1	0	3
2	ED23O11	Industrial Safety	3	3	0	0	3
3	ED23O12	Operations Research	3	2	1	0	3
4	PG23O11	Cost Management of Engineering Projects	3	2	1	0	3
5	ED23O13	Composite Materials	3	3	0	0	3
6	PG23O12	Waste to Energy	3	2	1	0	3

SEMESTER WISE CREDIT DISTRIBUTION

CATEGORY	I	II	III	IV	Total
FC	4				4
PC	16	12	3		31
PE		9	3		12
EEC			6	12	18
MC	3				3
OE			3		3
Total	**23**	**21**	**15**	**12**	**71**

SYLLABUS

SEMESTER I

Subject Code	Subject Name	Category	L	T	P	C
MH23112	APPLIED MATHEMATICS FOR COMMUNICATION ENGINEERS	FC	3	1	0	4

Objectives:	
•	To become computational proficiency involving procedures in Matrix theory.
•	To formulate and obtain the optimal solution for Linear Programming problems.
•	To get familiarized with the numerical methods which are necessary to solve numerically the ordinary differential equations that arise in engineering.
•	To explain data, and synthesis of the information to provide valid conclusions using design of experiments.
•	To develop the modelling and mathematical skills in queuing theory literature.

UNIT-I	MATRIX THEORY	12
LU Factorization-The Cholesky Decomposition – generalized eigenvectors – Canonical forms – pseudo inverse – least square approximations -Toeplitz matrices and some applications- Stochastic matrices and Markov Chains-Tridiagonal matrices.		
UNIT-II	**LINEAR PROGRAMMING**	**12**
Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models		
UNIT-III	**ORDINARY DIFFERENTIAL EQUATIONS**	**12**
Runge-Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.		
UNIT-IV	**LINEAR STATISTICAL MODELS**	**12**
Scatter diagram, Linear regression and correlation. Least squares method. Rank correlation. Multiple regression and multiple correlation, Analysis of variance (one way, two way with as well as without interaction).		
UNIT-V	**QUEUEING MODELS**	**12**
Poisson Process – Markovian queues – Single and Multi-server Models – Little's formula - Machine Interference Model – Steady State analysis – Self Service queue.		
	Total Contact Hours : 60	

Course Outcomes: On completion of the course, students will be able to	
□	Analyze and solve system of equations using the techniques of matrix decomposition and least square sense.
□	Collect decisions using solutions of Linear programming problems.
□	Use various numerical techniques in solving the differential equations arising in the relevant branch of engineering.
□	Interpret data, and synthesis of the information to provide valid conclusions using design of experiments.
□	Categorize the queuing models and formulate the solutions reaching substantiated conclusions.

SUGGESTED ACTIVITIES

Problem solving sessions

Activity Based Learning

SUGGESTED EVALUATION METHODS

Tutorial problems

Assignment problems

Quizzes

Class Presentation/Discussion

Reference Books(s) / Web links:	
1	Veerarajan T, Probability, statistics and random process with queueing theory and queueing networks, 4th edition, McGraw - Hill Publishing Company Limited.
2	Richard Bronson, "Matrix Operation", Schaum's outline series, 2nd Edition, McGraw Hill, 2011.
3	Taha H.A., "Operations Research: An introduction", Pearson Education Asia, New Delhi, Ninth Edition, 2012.
4	Richard Bronson, Gabriel B.Costa, "Linear Algebra", Academic Press, Second Edition, 2007.
5	Richard Johnson, Miller & Freund, "Probability and Statistics for Engineers", 7th Edition, Prentice – Hall of India, Private Ltd., New Delhi (2007).
6	Donald Gross and Carl M. Harris, "Fundamentals of Queueing Theory", 2nd Edition, John Wiley and Sons, New York.
7	Moon, T.K., Sterling, W.C., Mathematical methods and algorithms for signal processing, Pearson Education,2000

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
MH23112.1	2	1	-	-	1	1
MH23112.2	2	1	-	-	1	1
MH23112.3	1	1	-	-	1	2
MH23112.4	1	1	-	-	1	1
MH23112.5	1	1	-	-	1	1
Average	1.4	1	-	-	1	1.2

Subject Code	Subject Name	Category	L	T	P	C
CU23111	**ADVANCED RADIATION SYSTEMS**	**PC**	**3**	**1**	**0**	**4**

Objectives:	
	To understand the fundamental parameters of antennas and radiations from apertures
	To be able to learn the antenna array and design considerations of smart antennas
	To explore microstrip antenna and various techniques for polarization and miniaturization
	To impart knowledge on the antenna for wearable devices
	To understand the reconfigurable antenna and antenna measurements

UNIT-I	**RADIATION FROM APERTURES**	**12**
Review of antenna fundamental parameters, Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna; Reflector antenna, aperture blockage, and design consideration.		
UNIT-II	**ARRAYS AND SMART ANTENNAS**	**12**
Antenna array- Array factor, Uniform N-element linear array, Planar arrays, Circular array, Non-uniform array – Binomial array, Dolph–Chebyshev method. Smart antennas - Beam-forming basics, Analog beamforming, Digital beamforming, Smart antenna method, Smart antenna algorithms – Adaptive beamforming, Direction finding methods, Smart antenna advantages, Smart antenna implementation and system issues, MIMO systems.		
UNIT-III	**MICRO STRIP ANTENNA**	**12**
Technical background, Analysis and design - Analysis techniques - Transmission-line circuit model, Multimode cavity model, Moment method, FDTD method, FEM. Design methodology - Patch element design, Array configuration design. Feed/excitation methods, Dual-polarization and Circular-polarization techniques, Broadband and Dual-band techniques, Antenna miniaturization techniques.		
UNIT-IV	**ANTENENA FOR WEARABLE DEVICES**	**12**

Wireless body area networks, Antenna design requirements for wireless BAN/PAN, Modelling and characterization of wearable antennas, WBAN radio channel characterization and effect of wearable antennas. Case study – A compact wearable antenna for healthcare sensors.		
UNIT-V	**RECONFIGURABLE ANTENNAS AND ANTENNA MEASUREMENTS**	**12**
Design consideration and recent development, Frequency reconfigurable antennas - Frequency reconfigurable slot loaded microstrip patch antenna, Frequency reconfigurable E shaped patch antenna. Pattern reconfigurable antennas - Pattern reconfigurable fractal patch antenna, Pattern reconfigurable leaky-wave antenna. Multi-reconfigurable antenna. Antenna measurement - Antenna ranges, Microwave absorbing material, Instrumentation, Impedance measurements, current measurements, Polarization measurements.		
	Total Contact Hours : 60	

Course Outcomes: On completion of the course, students will be able to	
□	To apply the knowledge of fundamental parameters and analyse the radiations from apertures
□	To develop antenna array and design smart antennas
□	To design the microstrip patch antennas
□	To analyse and design various wearable antennas
□	To explain the various antenna reconfigurations and the measure various antenna parameter
Reference Books(s) / Web links:	
1	Zhijun Zhang" Antenna Design for Mobile Devices" 1st Edition, John Wiley & Sons (Asia) Ltd, Newyork,2011.
2	Balanis.A, "Antenna Theory Analysis and Design", John Wiley and Sons, New York, 1982.
3	Krauss.J.D, "Antennas", II edition, John Wiley and sons, New York, 1997.
4	W.L.Stutzman and G.A.Thiele,"Antenna Theory and Design", 2nd Edition, John Wiley& Sons Inc., 1998.
5	S.DrabowitchEt.al,"Modern Antennas", 2nd Edition Springer science business Media, Inc.2005.
6	ZhiNing Chen, "Antennas for portable devices", John Wiley& Sons Inc., 2007.
7	Eng Hock Lim, "Compact multifunctional antennas for wireless systems", John Wiley& Sons Inc., 2012.
8	Constantine A. Balanis, "Modern antenna handbook" John Wiley & Sons, Inc., Publication, 2008.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom
- Survey on various antennas and its applications
- Activity based learning
- Implementation of small module

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23111.1	3	3	2	2	2	2
CU23111.2	3	3	2	2	2	2
CU23111.3	3	3	2	2	2	2
CU23111.4	3	3	2	2	2	2
CU23111.5	3	3	2	2	2	2
Average	**3**	**3**	**2**	**2**	**2**	**2**

Subject Code	Subject Name	Category	L	T	P	C
CU23112	OPTICAL NETWORKS	PC	3	0	0	3

Objectives:	
	To have deep learning about the different optical system components and network architecture
	To enrich the knowledge about the different topologies, protocols related to optical network
	To explore the different system models, control and management of optical networks
	To deal with the issues related to fault and safety managements

UNIT-I	OPTICAL NETWORK ARCHITECTURES	9
Introduction to Optical Networks; SONET / SDH standards, Layered Architecture; Broadcast and Select Networks– Topologies for Broadcast Networks, Media Access Control Protocols, Wavelength Routing Architecture.		
UNIT-II	**WAVELENGTH ROUTING NETWORKS**	**9**
The optical layer, Node Designs, Optical layer cost tradeoff, Routing and wavelength Assignment, Virtual topology design, Architectural variations.		
UNIT-III	**PACKET SWITCHING AND ACCESS NETWORKS**	**9**
Photonic Packet Switching – OTDM, Multiplexing and Demultiplexing, Synchronisation, Broadcast OTDM networks, Switch-based networks; Access Networks – Network Architecture overview, OTDM networks; Optical Access Network Architectures.		
UNIT-IV	**NETWORK DESIGN AND MANAGEMENT**	**9**
Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers, crosstalk, dispersion; Wavelength stabilization; Overall design considerations. Control and Management – Network management functions, Configuration management, Fault management.		
UNIT-V	**NETWORK PERFORMANCE AND FUTURE TRENDS**	**9**
Performance Impairments in an Optical Network Environment, Performance Evaluation: Methodology and Case Studies, Passive Optical Networks, Metropolitan Area Networks, Long-Haul and Ultra Long-Haul Networks.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Identify the transmission of data in different optical network architectures
	Design the virtual topology and various routing assignments
	Discuss the various routing topologies in packet switching and access networks
	Analyse and address the issues related to faults and safety management in the optical networks
	Evaluate the methods for network performance.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom – (Unit-2)
- Implementation of models using MATLAB

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems

Reference Books(s) / Web links:	
1	Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks: A Practical Perspective", Harcourt Asia Pte Ltd., Second Edition 2004.
2	C. Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks: Concept, Design and Algorithms", Prentice Hall of India, Ist Edition, 2002.
3	Biswanath Mukherjee, "Optical Communication Networks", Mc-GrawHill ©1997, First Edition
4	P.E. Green, Jr., "Fiber Optic Networks", Prentice Hall, NJ, 1993.
5	Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks: A Practical Perspective", Harcourt Asia Pte Ltd., First Edition 2006.
6	Thomas E. Stern, Georgios Ellinas, Krishna Bala, ―Multiwavelength Optical Networks – Architecture, Design and control ―, Cambridge University Press, 2nd Edition, 2009.

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6
CU23112.1	3	3	3	1	1	1
CU23112.2	3	3	3	2	1	1
CU23112.3	3	3	3	1	1	1
CU23112.4	3	3	3	1	1	2
CU23112.5	3	3	2	1	1	1
Average	**3**	**3**	**2.8**	**1.2**	**1**	**1.2**

Subject Code	Subject Name	Category	L	T	P	C
CU23113	ADVANCED DIGITAL COMMUNICATION TECHNIQUES	PC	3	0	0	3

Objectives:

- To understand the basics of signal-space analysis and coherent & non-coherent receivers and its impact on
- different channel characteristics
- To understand the different Equalizers.
- To understand the different block coded digital communication systems
- To understand the convolutional coded digital communication systems.

UNIT-I	**COHERENT AND NON-COHERENT COMMUNICATION**	**9**

Coherent receivers – Optimum receivers in WGN- Coherent receivers – QPSK; QAM– Rayleigh and Rician channels –Partially coherent receivers –DPSK; M-PSK-BER Performance Analysis, Carrier Synchronization- Bit synchronization, Non-coherent FSK Receiver, Spectral characteristics of digital modulation.

UNIT-II	**EQUALIZATION TECHNIQUES**	**9**

ISI – Nyquist Criterion- Controlled ISI-Partial Response signals-Equalization algorithms– Linear equalizer – Decision feedback equalization – Adaptive Equalization algorithms, Eye pattern..

UNIT-III	**BLOCK CODED DIGITAL COMMUNICATION**	**9**

Shannon's channel coding theorem; Channel capacity; Matched filter; Concepts of Spread spectrum communication –Linear block codes; Hamming; Golay; Cyclic; BCH; Reed – Solomon codes - Space time block codes.

UNIT-IV	**CONVOLUTIONAL CODED DIGITAL COMMUNICATION**	**9**

Representation of codes using Polynomial, State diagram, Tree diagram, and Trellis diagram – Decoding techniques using Maximum likelihood, Viterbi algorithm, Sequential and Threshold methods – Error probability performance for BPSK and Viterbi algorithm, Turbo Coding, Turbo Coding for Rayleigh Channels.

UNIT-V	**MULTICARRIER SYTEMS**	**9**

OFDM- Generation of sub-carriers using the IFFT; Guard Time and Cyclic Extension; Windowing; Peak to Average Power reduction schemes; Overview of GFDM, FBMC, UFMC, Multicarrier CDMA.

Total Contact Hours	**:**	**45**

Course Outcomes:

On completion of the course, students will be able to

- Describe the concepts of signal space analysis in coherent and non-coherent receivers.
- Describe different Equalization techniques and fading channel
- Apply the different block codes.
- Apply the convolutional codes and turbo codes.
- Design the multi-carrier modulation schemes

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom – Equalization Techniques (Unit-2)
- Implementation of coding techniques using MATLAB

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems

Reference Books(s) / Web links:

1. M.K.Simon, S.M.Hinedi and W.C.Lindsey, Digital communication techniques; Signalling and detection, Prentice Hall India, New Delhi. 1995
2. Simon Haykin, Digital communications, John Wiley and sons, 1998
3. Bernard Sklar., 'Digital Communications', second edition, Pearson Education, 2001.

4	John G. Proakis., "Digital Communication", Mc Graw Hill Publication, 4 th Edition, 2001
5	Stephen G. Wilson., 'Digital Modulation and Coding', First Indian Reprint, Pearson Education, 2003.
6	Richard Van Nee & Ramjee Prasad., 'OFDM for Multimedia Communications' Artech House Publication, 2001.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23113.1	3	3	2	2	2	3
CU23113.2	3	3	2	2	2	2
CU23113.3	3	3	2	2	2	3
CU23113.4	3	3	2	2	2	3
CU23113.5	3	3	2	2	2	3
Average	**3.00**	**3.00**	**2.0**	**2.0**	**2.0**	**2.8**

Subject Code	Subject Name	Category	L	T	P	C
CU23131	**ADVANCED DIGITAL SIGNAL PROCESSING**	**PC**	**3**	**0**	**2**	**4**

Objectives: The student should be made	
•	To provide in-depth treatment on methods and techniques in discrete-time signal transforms, digital filter design, optimal filtering
•	To understand the methods and techniques in power spectrum estimation and signal modeling
•	To know the concepts of adaptive filters and algorithms.

UNIT-I	**DISCRETE RANDOM PROCESS**	**9**
Introduction to Estimation of probability theory-Mathematical preliminaries- Weiner Khitchine relation – Power spectral density – filtering random process, Spectral Factorization Theorem, special types of random process-Model based approach – AR, MA, ARMA Signal modelling – Parameter estimation using Yule-Walker method		
UNIT-II	**SPECTRUM ESTIMATION**	**9**
Non-Parametric methods – Correlation method – Co-variance estimator – Performance analysis of estimators – Unbiased consistent estimators – Periodogram estimator – Barlett spectrum estimation – Welch estimation		
UNIT-III	**LINEAR ESTIMATION AND PREDICTION**	9
.Efficiency of estimator – Least mean squared error criterion – Wiener filter – Discrete Wiener Hoff equations – Recursive estimators – Kalman filter – Linear prediction, Prediction error – Whitening filter, Inverse filter – Levinson recursion, Levinson recursion algorithm for solving Toeplitz system of equations.		
UNIT-IV	**ADAPTIVE FILTERS**	**9**
FIR Adaptive filters – Newton's steepest descent method – Adaptive filters based on steepest descent method – Widrow Hopf LMS Adaptive algorithm - RLS Adaptive filters – Exponentially weighted RLS – Sliding window RLS – Simplified IIR LMS Adaptive filter.		
UNIT-V	**MULTIRESOLUTION ANALYSIS**	**9**
Short-time Fourier transform - Heisenberg uncertainty principle. Principles of multi-resolution analysis - sub-band coding, the continuous and discrete wavelet transform - properties. Applications of wavelet transform - noise reduction, image compression.		
Total Contact Hours: 45		

List of Experiments	
1	Real time signal and image representation (Audio signal, speech signal, biosignal, satellite image)
2	Auto and Cross Correlation

3	Sampling FFT Of Input Sequence			
4	Butterworth Low pass And High pass Filter Design			
5	Estimation Of PSD			
6	Cascade Digital IIR Filter Realization			
7	Signal decomposition using wavelet			
		Contact Hours	**:**	**30**
		Total Contact Hours	**:**	**75**

Course Outcomes: On completion of the course, students will be able to	
	Characterize and Design models for processing random signal
	Identify the appropriate method for spectrum estimation
	Estimate and predict the error present in different types of filters
	Apply adaptive filters for various applications
	Analyze random signals using multiresolution techniques.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom – Spectrum Estimation (Unit-2)
- Implementation of models using MATLAB

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems

Reference Books(s) / Web links:	
1	Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley and Sons Inc., New York, 2006.
2	Simon Haykin, "Adaptive Filter Theory", Prentice Hall, Englehood Cliffs, NJ1986.
3	S. Kay," Modern spectrum Estimation theory and application", Prentice Hall, Englehood Cliffs, NJ1988.
4	John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing", Prentice Hall of India, New Delhi, 2005
5	Sophoncles J. Orfanidis, "Optimum Signal Processing ", McGraw-Hill, 2000
6	P. Vaidyanathan, "Multirate systems and filter banks", Prentice Hall Inc. 1993

Lab equipment required:

S. No	Name of the Equipment	Quantity Required	Remarks
1	MATLAB-Signal processing, mathematics tool	30 users	

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	-	1	-	1
CO2	3	3	3	1	1	2
CO3	1	1	2	2	3	2
CO4	-	-	1	1	1	3
CO5	-	-	-	1	3	3
Average	**2.3**	**2.3**	**2**	**1.2**	**2**	**2.2**

Subject Code	Subject Name	Category	L	T	P	C
PG23111	**RESEARCH METHODOLOGY AND IPR** *(USE OF STATISTICAL TABLES TO BE PERMITTED)*	MC	3	0	0	3

Objectives:	
	At the end of this course the students will be able to understand the research problem formulation and analyse the research related information by following research ethics.
	Inculcating the understanding of today's computer, information technology and also understand tomorrows world of ideas and creativity.
	Emphasizing the role of IPR in individual and nations growth.

UNIT-I	**INTRODUCTION TO RESEARCH METHODOLOGY**	**9**

Objectives and Motivation of Research - Types of Research - Defining and Formulating the Research Problem - Errors in selecting a research problem - Features of research design, Different Research Designs- Criteria of good research - Problems encountered by researchers in India - Benefits to the society in general.

UNIT-II	**DATA ANALYSIS AND HYPOTHESIS TESTING**	**9**

Data collection: Primary data - Secondary data - Data organization - Sample design - Estimation of population - Parametric vs. non parametric methods - Measures of central tendency and dispersion.

ANOVA; Principles of least squares-Regression and correlation; Normal Distribution Properties of Normal Distribution; Testing of Hypothesis – Hypothesis Testing Procedure, Types of errors, t-Distribution - Chi-Square Test as a Test of Goodness of Fit - Use of statistical softwares.

UNIT-III	**LITERATURE REVIEW AND RESEARCH REPORT WRITING**	**9**

Effective literature studies approaches- Importance of literature survey - Sources of information– analysis – Plagiarism - Research ethics.

Interpretation and Report Writing - Techniques and Precautions; Report Writing – Significance - Different Steps – Layout - Types of reports, Mechanics of Writing a Research Report - Precautions in Writing Reports; Format of the research report

UNIT-IV	**INTRODUCTION TO INTELLECTUAL PROPERTY , TRADE MARKS ,GRAPHICAL INDICATION AND INDUSTRIAL DESIGN**	**9**

Importance of intellectual property rights; types of intellectual property-international organizations; Purpose and function of trademarks - acquisition of trade mark rights - protectable matter - selecting and evaluating trade mark - trade mark registration processes.

Industrial designs and IC Layout design - Registrations of designs-Semiconductor Integrated circuits and layout design Act - Geographical indications-potential benefits of Geographical Indications.

UNIT-V	**LAW OF COPYRIGHTS & PATENTS**	**9**

Fundamental of copy right law - originality of material - rights of reproduction - rights to perform the work publicly - copy right ownership issues - copy right registration -notice of copy right, international copy right law.

Law of patents: Foundation of patent law, patent searching process - ownership rights and transfer New Developments in IPR: Administration of Patent System.

	Total Contact Hours	**:**	**45**

Course Outcomes:

On completion of the course, students will be able to

	Understand the research problem and research process
	To formulate the hypothesis, data collection and processing, analyzing the data using statistical methods
	Interpret the observations and communicating the novel findings through a research report.
	Apply the conceptual knowledge of intellectual property rights for filing patents and trade mark registration process.
	Understand the adequate knowledge on copyright and patent law and rights.

Reference Books(s) / Web links:

1. C.R. Kothari, Research Methodology: Methods and Techniques, 2nd revised edition, New Age International Publishers, New Delhi, 2004.
2. Deborah, E. Bouchoux, Intellectual property right, 5th edition, Cengage learning, 2017.
3. R. Panneerselvam, Research Methodology, PHI learning Pvt. Ltd., 2009.
4. Prabuddha Ganguli, Intellectual property right - Unleashing the knowledge economy, Tata McGraw Hill Publishing Company Ltd, 2001.
5. Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000
6. Uma Sekaran, Research Methods for Business, John Wiley and Sons Inc., New York, 2000.
7. Ranjit Kumar, Research Methodology, Sage Publications, London, New Delhi, 1999.
8. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

POs / COs	a	b	c	d	e	f	g	h	i
PG23111.1	√	√		√		√		√	√
PG23111.2	√	√	√		√		√	√	√
PG23111.3		√	√	√		√	√	√	√
PG23111.4	√	√	√	√	√			√	
PG23111.5	√	√		√		√	√	√	√

Subject Code	Subject Name	Category	L	T	P	C
AC23111	ENGLISH FOR RESEARCH PAPER WRITING (Common to all branches of M.E. /M.Tech / MBA – I Semester)	HS	3	0	0	0

Objectives:	
	To facilitate the students to express technical ideas in writing
	To train the students in using language structures appropriately
	To enable students to plan and organize the research paper
	To assist the students in understanding the structure and familiarize the mechanics of organized writing
	To equip the students to improvise academic English and acquire research writing skills.

UNIT-I	INTRODUCTION TO RESEARCH WRITING	9
Research – Types of Research - Selecting the Primary resources - Categorizing secondary sources - Discovering a researchable area and topic – Need Analysis - Research Question- Focussing on the Research Problem- Developing Research Design – Framing the Hypothesis – Identifying the Scope of the Research - Writing – General and Academic Writing		
UNIT-II	**LANGUAGE OF WRITING**	**9**
Active reading – text mining – use of academic words – jargons – ambiguities – use of expression – use of tense - proper voices – third person narration – phraseology – use of foreign words – use of quotes – interpreting quotes.		
UNIT-III	**THE FORMAT OF WRITING**	**9**
Types of Journals - different formats and styles - IEEE format - Structure – Margins – Text Formatting - Heading and Title - Running Head with Page Numbers - Tables and illustrations - Paper and Printing - Paragraphs - Highlighting – Quotation – Footnotes		
UNIT-IV	**ORGANISING A RESEARCH PAPER**	**9**
Title- Abstract – Introduction – Literature review - Methodology - Results –Discussion –Conclusion - Appendices - Summarising - Citation and Bibliography		
UNIT-V	**PUBLISHING PAPER**	**9**
Finding the Prospective publication or Journal - analysing the credits - Reviewing – Revising – Plagiarism Check - Proof reading - Preparing the Manuscript- Submitting - Resubmitting - Follow up - Publishing		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Understand the basic structure of research work
	Apply proper use of language in writing paper
	Comprehend different formats of journal paper
	Follow the process of writing a research paper and write one
	Emulate the process of publishing journal paper and publish papers

SUGGESTED ACTIVITIES

- Group Discussions
- Writing review of literature
- Presentations
- Case study
- Writing a paper

SUGGESTED EVALUATION METHODS

- Assignment topics
- Quizzes
- Class Presentation / Discussion
- Continuous Assessment Tests

Reference Books(s) / Web links:

1. Adrian Wallwork: "English for Writing Research Papers", Springer Science Business Media, Second Edition, LLC 2011
2. Stephen Howe and Kristina Henrikssion: "Phrasebook for Writing Papers and Research in English", The Whole World Company Press, Cambridge, Fourth edition 2007
3. The Modern Language Association of America: "MLA Handbook for Writers of Research Papers" 8th Edition, The Modern Language Association of America, 2016
4. Rowena Murray: The Handbook of Academic Writing: A Fresh Approach, Sarah Moore Open University Press, 2006
5. Stephen Bailey: Academic Writing: A Practical Guide for Students Routledge Falmer: 2003
6. Joseph M. Moxley: Publish, Don't Perish: The Scholar's Guide to Academic Writing and Publishing, Praeger Publishers, 1992

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
AC23111.1	-	-	-	2	2	3
AC23111.2	-	-	-	2	2	3
AC23111.3	-	-	-	2	2	2
AC23111.4	-	-	-	2	2	2
AC23111.5	-	-	-	2	2	3
Average	-	-	-	**2**	**2**	**2.6**

Subject Code	Subject Name	Category	L	T	P	C
CU23121	**COMMUNICATION SYSTEMS LABORATORY**	**PC**	**0**	**0**	**4**	**2**

Objectives:	
	To facilitate the knowledge about different modulation techniques and error control codes
	To explore the trends in microwave devices and transmission lines
	To enrich the ideas in simulation tools for antenna radiation pattern measurement
	To learn the design procedures of OFDM
	To familiar in vector network analyser for S-parameter estimation.

List of Experiments				
1	Channel equalizer design (LMS, RLS)			
2	Performance Evaluation of digital modulation schemes			
3	OFDM transceiver design			
4	Performance evaluation of simulated CDMA System.			
5	Error control codes			
6	Simulation of Microstrip Antennas			
7	Antenna Radiation Pattern measurement.			
8	BER performance of MC-CDMA system			
9	Channel estimation using Machine Learning			
10	Spectrum sensing using Deep Learning			
	Total Contact Hours	**:**	**60**	

Course Outcomes: On completion of the course, students will be able to	
	To evaluate the performance of digital modulation techniques and error control codes.
	To measure the parameters of microwave devices and transmission lines.
	To measure the antenna radiation pattern.
	To evaluate the performance of CDMA, OFDM and MC-CDMA systems.
	To measure the S-parameters of microwave devices using vector network analyser.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23121.1	3	3	3	2	1	2
CU23121.2	3	3	3	3	2	2
CU23121.3	3	3	3	3	3	2
CU23121.4	3	3	3	2	2	2
CU23121.5	3	3	3	3	3	2
Average	**3**	**3**	**3**	**2.6**	**2.2**	**2**

SEMESTER II

Subject Code	Subject Name	Category	L	T	P	C
CU23211	WIRELESS COMMUNICATION NETWORKS	PC	3	0	0	3

Objectives:	
	To make the students to know about the various propagation methods and channel models.
	To understand the concepts of transmit and receive diversity.
	To introduce the various multiple access schemes for multi user systems. .
	To know the concepts of MIMO techniques.
	To enhance the understanding of 4G and 5G networks.

UNIT-I	WIRELESS CHANNEL PROPAGATION AND MODEL	9
Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-Small scale fading-channel classification- channel models – COST -231, Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Link power budget Analysis.		
UNIT-II	**DIVERSITY**	**9**
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.		
UNIT-III	**MULTI USER SYSTEMS**	**9**
Multiple Access: FDMA, TDMA, CDMA, SDMA, Hybrid techniques, Random Access: ALOHA, SALOHA, CSMA, Scheduling, power control, multiuser diversity.		
UNIT-IV	**MIMO COMMUNICATIONS**	**9**
Narrowband MIMO model, Parallel decomposition of MIMO channel, MIMO channel capacity, MIMO Diversity Gain: Beamforming, Diversity-Multiplexing trade-offs, Space time Modulation and coding: STBC, STTC, Spatial Multiplexing and BLAST Architectures.		
UNIT-V	**WIRELESS NETWORKS**	**9**
4G features and challenges, Introduction to LTE- LTE radio access-Basic principle- Channel dependent scheduling and rate adaptation- Carrier Aggregation- Overall system architecture-Core network- RAN-5G system concept- 5G RAN-Non-orthogonal multiple access (NOMA).		
	Total Contact Hours : 45	

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23211.1	3	3	2	2	1	-
CU23211.2	3	3	3	2	1	-
CU23211.3	3	2	2	2	1	-
CU23211.4	3	3	3	2	2	2
CU23211.5	3	3	2	1	2	2
Average	**3**	**2.8**	**2.4**	**1.8**	**1.4**	**2**

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Flipped classroom – SDMA
- Seminar
- Problem solving sessions.
- MATLAB simulation

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- CAT

- Class Presentation/Discussion

Course Outcomes: At the end of the course, the student should be	
	Analyse the characteristics of wireless propagation channel.
	Infer the various diversity techniques
	Outline the various multiple access techniques suitable for multi-user environment.
	Analyse the channel and various techniques of MIMO communication.
	Summarise the concepts of 4G & 5G Wireless networks.
Reference Books(s) / Web links:	
1	Andreas Goldsmith, Wireless Communications, Cambridge University Press, 2007.
2	Andreas.F. Molisch, "Wireless Communications", John Wiley – India, 2006.
3	Erik Dahlman, Stefan Parkvall, and Johan Sköld, "4G LTE/LTE-Advanced for Mobile Broadband", Academic Press is an imprint of Elsevier,2011.
4	Afif Osseiran, Jose F. Monserrat, Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2 nd Edition, 2011.

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU23212	**MIC AND RF SYSTEM DESIGN**	**PC**	**3**	**1**	**0**	**4**

Objectives:	
	To understand the fundamentals of RF radio system design.
	To understand the various components that constitutes an RF radio system for wireless Communications.
	To know the basic analysis techniques needed for evaluating the performance of an RF radio system for Wireless applications.

UNIT-I	**CMOS PHYSICS, TRANSCEIVER SPECIFICATIONS AND ARCHITECTURES**	**12**
CMOS: Introduction to MOSFET Physics – Noise: Thermal, shot, flicker, popcorn noise transceiver Specifications: Two port Noise theory, Noise Figure, THD, IP2, IP3, Sensitivity, SFDR, Phase noise - Specification distribution over a communication link Transceiver Architectures: Receiver: Homodyne, Heterodyne, Image reject, Low IF Architectures – Transmitter: Direct up conversion, two step up conversion		
UNIT-II	**IMPEDANCE MATCHING AND AMPLIFIERS**	**12**
S-parameters with Smith chart – Passive IC components - Impedance matching networks Amplifiers: Common Gate, Common Source Amplifiers – OC Time constants in bandwidth estimation and enhancement – High frequency amplifier design Low Noise Amplifiers: Power match and Noise match – Single ended and Differential LNAs – Terminated with Resistors and Source Degeneration LNAs.		
UNIT-III	**FEEDBACK SYSTEMS AND POWER AMPLIFIERS**	**12**
Feedback Systems: Stability of feedback systems: Gain and phase margin, Root-locus techniques – Time and Frequency domain considerations – Compensation Power Amplifiers: General model – Class A, AB, B, C, D, E and F amplifiers –Linearization Techniques – Efficiency boosting techniques – ACPR metric – Design considerations.		
UNIT-IV	**RF FILTER DESIGN, OSILLATOR, MIXER**	**12**
Overview-basic resonator and filter configuration-special filter realizations-filter implementation. Basic oscillator model-high frequency oscillator configuration- basic characteristics of mixers-phase locked loops-RF directional couplers hybrid couplers-detector and demodulator circuits.		
UNIT-V	**MIC COMPONENTS, ANTENNAS AND MEASUREMENT TECHNIQUES**	**12**
Introduction to MICs-Fabrication Technology, Advantages and applications, MIC components-Micro strip components, Coplanar circuits, Integrated antennas, photonic band gap antennas, Measurement techniques-test fixture measurements, probe station measurements, thermal and cryogenic measurements, experimental field probing techniques.		
	Total Contact Hours : 60	

Course Outcomes: On completion of the course, students will be able to	
	To understand the specification and architectures of transceivers
	To analyze time and frequency domain of various power amplifiers
	To able to design RF circuits
	To able to analyze the performance of RF circuits
	To explain the radiation mechanism and the antenna factor measurements

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom – CMOS circuits.
- Seminar

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Class Presentation/Discussion

Reference Books(s) / Web links:	
1	T. Lee,"Design of CMOS RF Integrated Circuits", Cambridge, 2004.
2	B.Razavi, "RF Microelectronics", Pearson Education, 1997.
3	Jan Crols, MichielSteyaert,"CMOS Wireless Transceiver Design", Kluwer Academic Publications, 1997.
4	B. Razavi, Design of analog CMOS Integrated Circuits", McGraw Hill, 2001
5	I.D. Robertson &S. Lucyszyn, "RFIC and MMIC Design and Technology", IEE Circuits, Devices and Systems series 13, London, UK, 2001.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CU23212.1	3	3	2	2	1	1
CU23212.2	3	3	3	2	1	1
CU23212.3	3	3	3	2	2	1
CU23212.4	3	3	3	2	2	1
CU23212.5	3	3	2	1	2	1
Average	**3**	**3**	**2.6**	**1.8**	**1.6**	**1**

Subject Code	Subject Name	Category	L	T	P	C
CU23213	COMMUNICATION SYSTEM MODELING AND SIMULATION	PC	3	0	0	3

Objectives:	
	To understand the aspect of simulation and modeling.
	To acquire the knowledge on random signals and process.
	To get exposed to simulation methods for wireless systems.
	To know modeling procedures for various channels.
	To understand the efficient techniques in simulating wireless communication technologies.

UNIT-I	INTRODUCTION	9
Role of Simulation-Fundamental Concepts and Techniques: Sampling - quantizing - reconstruction and interpolation - simulation sampling frequency - low pass simulation models for band pass – low pass complex envelope for band pass signals - linear band pass systems - multicarrier signals - nonlinear and time - varying systems.		
UNIT-II	**RANDOM SIGNAL GENERATION AND PROCESSING**	**9**
Uniform random number generators - mapping uniform random variables to an arbitrary PDF - Correlated and Uncorrelated Gaussian random number generation- PN sequence generators, Random signal processing, Testing of random number generators.		
UNIT-III	**METHODOLOGY FOR SIMULATING A WIRELESS SYSTEM**	**9**
Monte Carlo Simulation Fundamental Concepts: Applications and integration - two Monte Carlo examples; Semi Analytic Techniques System: Level simplifications and sampling rate considerations - overall methodology; Modeling and Simulation of Nonlinearities: Introduction - modeling and simulation of memory less nonlinearities – modeling and simulation of nonlinearities with memory.		
UNIT-IV	**MODELING AND SIMULATION OF TIME-VARYING SYSTEMS**	**9**
Modeling and simulation of Time varying systems: Random process models, Tapped delay line model, Modelling and simulation of waveform channels, Discrete memoryless channel models, Markov model for discrete channels with memory - estimation of Markov model parameters.		
UNIT-V	**EFFICIENT SIMULATION TECHNIQUES**	**9**
Tail Extrapolation: PDF estimators- importance sampling; Case study of a cellular radio system; Cellular radio system - simulation methodology - A code-division multiple access system - FDM system with a nonlinear satellite transponder.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Design various models for wireless communication
	Generate and process various random signals
	Identify various methodology to simulate a wireless system
	Apply knowledge of the different simulation techniques for designing a communication channel
	Apply various efficient techniques in simulating wireless communication technologies

Reference Books(s) / Web links:

1	William H. Tranter, K. Sam Shanmugan, Theodore S. Rappaport and Kurt L. Kosbar “Principles of Communication Systems Simulation with Wireless Applications”, Prentice Hall, Upper Saddle River, 2003.
2	M. C. Jeruchim, Philip Balaban and K.Samshanmugam. “Simulation of Communication Systems”, Plenum Press, 2007
3	M. Law and W. David Kelton, “Simulation Modelling and Analysis”, McGraw Hill, 2008.
4	K. Hayes, “Modelling and Analysis of Computer Communication Networks”, Plenum Press, 1984.
5	Banks, J. S. Carson, Nelson and D. M. Nicol, “Discrete Event System Simulation”, 4th Edition, Prentice Hall of India, 2005.
6	Geoffrey Gorden, System Simulation, Prentice Hall of India, 2 nd Edition, 1992.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic
- Problem solving sessions
- Flipped classroom – Random signal and process.
- Seminar
- MATLAB simulation

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic
- Tutorial problems
- Assignment problems
- CAT
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23213.1	3	3	2	2	1	-
CU23213.2	3	3	2	2	1	2
CU23213.3	3	3	3	3	1	-
CU23213.4	3	3	3	3	2	2
CU23213.5	3	3	3	3	2	2
Average	3	3	2.6	2.6	1.4	2

Subject Code	Subject Name	Category	L	T	P	C
AC23211	**CONSTITUTION OF INDIA**	**MC**	**3**	**0**	**0**	**0**

Objectives:	
	To inculcate the values enshrined in the Indian constitution.
	To create a sense of responsible and active citizenship.
	To make the students aware of the Constitutional and the Non- Constitutional bodies
	To help the students understand the relationships exist between union and states
	To make the students understand the sacrifices made by the freedom fighters.

UNIT-I	**INTRODUCTION**	**9**
Historical Background - Constituent Assembly of India - Philosophical foundations of the Indian Constitution - Features - Basic Structure – Preamble		
UNIT-II	**UNION GOVERNMENT**	**9**
Union and its territory - Citizenship - Fundamental Rights - Directive Principles of State Policy (DPSP) - Fundamental Duties. President - Vice President - Prime Minister - Central Council of Ministers - Cabinet Committees - Parliament: Committees, Forums and Groups - Supreme Court.		
UNIT-III	**STATE GOVERNMENT & UNION TERRITORIES: STATE GOVERNMENT : EXECUTIVE, LEGISLATURE AND JUDICIARY**	**9**
Governor - Chief Minister - State Council of Ministers - State Legislature - High Court - Subordinate Courts -Panchayati Raj – Municipalities-Union Territories - Scheduled and Tribal Areas.		
UNIT-IV	**RELATIONS BETWEEN UNION AND STATES**	**9**
Relations between Union and States - Services under Union and States. Cooperative Societies - Scheduled and Tribal Areas - Finance, Property, Contracts and Suits - Trade and Commerce within Indian Territory – Tribunals.		

UNIT-V	CONSTITUTIONAL BODIES AND AMENDMENTS	9
Introduction to Constitutional & Non-Constitutional Bodies-Elections - Special Provisions relating to certain classes - Languages - Emergency Provisions - Miscellaneous - Amendment of the Constitution - Temporary, Transitional and Special Provisions - Short title, date of commencement, Authoritative text in Hindi and Repeals. Schedules of the Constitution of India - Appendices in the Constitution of India.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Appreciate the philosophical foundations of the Indian Constitution.
	Understand the functions of the Indian government.
	Apprehend and abide by the rules of the Indian constitution.
	Comprehend the functions of state Government and Local bodies.
	Gain Knowledge on constitution functions and role of constitutional bodies and amendments of constitution.

SUGGESTEDACTIVITIES

- OnlineQuizzes
- Posterpresentations
- Presentations
- GroupDiscussions
- Casestudy

SUGGESTED EVALUATION METHODS

- Assignmenttopics
- Quizzes
- ClassPresentation/Discussion
- ContinuousAssessmentTests

Text Book(s):	
1	M Lakshmikanth "Indian Polity", McGraw Hill Education, 5th edition 2017.
2	Durga Das Basu, "Introduction to the Constitution of India ", Lexis Nexis, New Delhi., 21st edition, 2013.
Reference Books(s) / Web links:	
1	Sharma, Brij Kishore, "Introduction to the Constitution of India", Prentice Hall of India, New Delhi, 7th edition, 2015.
2	Subhash Kashyap, "Our Constitution: An Introduction to India's Constitution and Constitutional Law", National Book Trust India, 1994.
3	Mahendra Prasad Singh and Himanshu Roy, "Indian Political System", Pearson India, 4th edition, 2017.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
AC23211.1	-	-	-	-	-	3
AC23211.2	-	-	--	-	-	2
AC23211.3	-	-	-	-	-	3
AC23211.4	-	-	-	-	-	2
AC23211.5	-	-	-	-	-	3
Average	-	-	-	-	-	**2.6**

Subject Code	Subject Name	Category	L	T	P	C
CU23221	RF SYSTEM DESIGN LABORATORY	PC	0	0	4	2

Objectives:	
	To enable the students to verify the basic principles and design aspects involved in high frequency communication systems components
	To expose the student to different high frequency components and conduct the experiments to analyze and interpret data to produce meaningful conclusion and match with theoretical concepts.
	To design and develop RF components using microstrip technology

List of Experiments				
1	Measurement of S parameters for a) Inductor b) Capacitor c) impedance matching circuits, filters using network analyzer			
2	Design of λ/2, λ/4 micro strip transmission line.			
3	Design of microstrip inductor and capacitor.			
4	Design of impedance matching network.			
5	Design of low pass, high pass, band pass and band stop filter at RF.			
6	Design and characterization of microstrip patch antenna array.			
7	Design and characterization of Mixer, VCO			
8	Measurement of transmission line parameters.			
9	S-parameter estimation of Microwave device using Network Analyser.			
		Total Contact Hours	**:**	**60**

Course Outcomes: On completion of the course, students will be able to	
	Apply knowledge to identify a suitable architecture and systematically design an RF system.
	Comprehensively record and report the measured data, and would be capable of analyzing, interpreting the experimentally measured data and produce the meaningful conclusions.
	Design and characterize microstrip patch antenna array.
	Design and develop filters.
	Characterize Mixer and VCO.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23221.1	3	2	2	2	2	1
CU23221.2	2	2	2	3	2	1
CU23221.3	2	3	3	2	3	2
CU23221.4	2	3	3	2	3	2
CU23221.5	2	2	2	2	2	1
Average	**2.2**	**2.4**	**2.4**	**2.2**	**2.4**	**1.4**

SEMESTER III

Subject Code	Subject Name	Category	L	T	P	C
CU23311	WIRELESS AD HOC AND SENSOR NETWORKS	PC	3	0	0	3

Objectives: Students will be able to	
	Learn the concepts of Ad hoc wireless networks
	Understand the basics of routing protocols
	Learn the security concepts
	Study the architecture and MAC protocols of sensor networks
	Know the concepts of various operating systems and routing protocols of sensor networks

UNIT-I	ADHOC NETWORKS – INTRODUCTION AND ROUTING PROTOCOLS	9
Elements of Ad hoc Wireless Networks, Issues in Ad hoc wireless networks, Example commercial applications of Ad hoc networking, Ad hoc wireless Internet, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols, Table Driven Routing Protocols – Destination Sequenced Distance Vector (DSDV), On–Demand Routing protocols –Ad hoc On–Demand Distance Vector Routing (AODV).		
UNIT-II	**MULTICAST ROUTING**	**9**
Issues in Designing a Multicast Routing Protocol – Operation of Multicast Routing Protocols – An Architecture Reference Model for Multicast Routing Protocols –Classifications of Multicast Routing Protocols – Tree–Based Multicast Routing Protocols– Mesh–Based Multicast Routing Protocols – Summary of Tree and Mesh based Protocols – Energy–Efficient Multicasting – Multicasting with Quality of Service Guarantees .		
UNIT-III	**SENSOR NETWORKS – ARCHITECTURE**	**9**
Challenges for Wireless Sensor Networks, Enabling Technologies for Wireless Sensor Networks, WSN application examples, Single-Node Architecture – Hardware Components, Network architecture – Sensor network scenarios types of sources and sinks, physical layer and transceiver design consideration in wireless sensor networks, Energy Consumption of Sensor Nodes, Network Architecture – Sensor Network Scenarios, Transceiver Design Considerations, Optimization Goals and Figures of Merit.		
UNIT-IV	**WSN MAC PROTOCOLS**	**9**
MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols And Wakeup Concepts – S-MAC, The Mediation Device Protocol, Contention based protocols – PAMAS, Schedule based protocols – LEACH, IEEE 802.15.4 MAC protocol, Routing Protocols- Energy Efficient Routing		
UNIT-V	**SENSOR NETWORKS – ROUTING PROTOCOLS AND OPERATING SYSTEMS**	**9**
Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, mobile nodes, Data-centric routing – SPIN, Directed Diffusion, Energy aware routing, Gradient-based routing – COUGAR, ACQUIRE, Hierarchical Routing – LEACH, PEGASIS, Location Based Routing – GAF, GEAR, Data aggregation – Various aggregation techniques. Introduction to TinyOS – NesC, Programming in TinyOS using NesC, Emulator TOSSIM		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Acquire the knowledge of wireless Adhoc networks.
	Analyze various MAC protocols
	Acquire the knowledge on sensor node and its architectures
	Classify the WSN MAC protocols
	Illustrate the routing protocol and operating system

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Flipped classroom - Comparing routing protocols
- Survey on various MAC protocol
- Activity Based Learning
- Implementation of small wsn node module

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Reference Books(s) / Web links:	
1	C. Siva Ram Murthy and B. S. Manoj, "Ad Hoc Wireless Networks Architectures and Protocols", Prentice Hall, PTR, 2004.
2	Holger Karl, Andreas willig, "Protocol and Architecture for Wireless Sensor Networks", John Wiley publication, Jan 2006.
3	Feng Zhao, Leonidas Guibas, "Wireless Sensor Networks: an information processing approach", Elsevier publication, 2004.
4	K.Akkaya and M.Younis, "A Survey of routing protocols in wireless sensor networks", Elsevier Adhoc Network Journal, Vol.3, no.3, pp. 325-349, 2005.
5	Philip Levis, "TinyOS Programming", 2006 – www.tinyos.net.
6	I.F. Akyildiz, W. Su, Sankarasubramaniam, E. Cayirci, "Wireless sensor networks: a survey", computer networks, Elsevier, 2002, 394 - 422.
7	Jamal N. Al-karaki, Ahmed E. Kamal, "Routing Techniques in Wireless sensor networks: A survey", IEEE wireless communication, December 2004, 6 – 28

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CU23311.1	2	2	1	2	1	1
CU23311.2	3	3	2	3	3	2
CU23311.3	2	2	1	2	1	1
CU23311.4	3	3	2	3	3	2
CU23311.5	3	2	3	3	3	3
Average	**2.6**	**2.4**	**1.8**	**2.6**	**2.2**	**1.8**

PROFESSIONAL ELECTIVES

PROFESSIONAL ELECTIVE-I

Subject Code	Subject Name	Category	L	T	P	C
CU23A11	ADVANCED SATELLITE COMMUNICATION SYSTEMS	PE	3	0	0	3

Objectives:	
	To understand the basics of satellite orbits
	Learn M2M developments and satellite applications
	Understand Satellite Communication in IPv6 Environment
	To understand the basic concepts of remote sensing and navigation systems**.**
	To study the various broadcast and satellite networking systems

UNIT-I	**OVERVIEW OF COMMUNICATION**	**9**
Overview of satellite communication and orbital mechanics, coverage angle and slant range, eclipse, placement of satellite in geostationary orbit. Link budget Parameters, Link budget calculations, Auxiliary Equations, Performance Calculations.		
UNIT-II	**M2M DEVELOPMENTS AND SATELLITE APPLICATIONS**	**9**
Overview of the Internet of Things and M2M- M2M Applications Examples and Satellite Support-Satellite Roles Context and Applications- Antennas for Satellite M2M Applications- M2M Market Opportunities for Satellite Operators- Ultra HD Video/TV and Satellite Implications- High Throughput Satellites (HTS) and Ka/Ku Spot Beam Technologies- Aeronautical, Maritime and other Mobility Services.		
UNIT-III	**SATELLITE NETWORKING SYSTEM WITH IPV6**	**9**
Overview of IPv6 and its benefits- Migration and Coexistence- Implementation scenarios and support- Preparations for IPv6 in Satellite communication- Satellite specific Protocol issues in IPv6 – Impact of IPv6 on Satellite Network architecture and services-Detailed transitional plan- IPv6 demonstration over satellites		
UNIT-IV	**SATELLITE NAVIGATION AND GLOBAL POSITIONING SYSTEM**	**9**
Introduction - Commercial Imaging – Digital Globe – GeoEye - Meteorology – Meteosat - Land Observation – Landsat- Remote Sensing Data- Sensors- Overview - Optical Sensors: Cameras-Non-Optical Sensors- Image Processing - Image Interpretation- System Characteristics. Global Navigation Satellite Systems - Basic concepts of GPS. Space segment, Control segment, user segment, GPS constellation, GPS measurement characteristics, selective availability (AS), Anti spoofing (AS).Applications of Satellite and GPS for 3D position, Distress and Safety-Cospas-Sarsat.		
UNIT-V	**BROADCAST SYSTEMS**	**9**
Introduction - Satellite Radio Systems - XM Satellite Radio Inc. - Sirius Satellite Radio –world space - Direct Multimedia Broadcast- MBCO and TU Multimedia - European Initiatives - Direct-to-Home Television - Implementation Issues - DTH Services- Representative DTH Systems - Military Multimedia Broadcasts - US Global Broadcast Service (GBS)- Business TV(BTV), GRAMSAT, Specialized services – E –mail, Video conferencing, Internet.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Analyze the satellite orbits
	Prepare the budget plan for the uplink and downlink subsystems
	Understand GPS based navigation system.
	Analyze IPv6 in satellite system
	Outline various Broadcasting systems.

Reference Books(s) / Web links:	
1	Dennis Roddy, 'Satellite Communication', McGraw Hill International, 4th Edition, 2006.
2	Daniel Minoli 'Innovations in Satellite Communication and Satellite Technology' Wiley, 2015
3	Daniel Minoli, "Satellite Systems Engineering in an IPv6 Environment", CRC Press, First Edition, 2009.
4	Global Positioning Systems, Inertial Navigation, and Integration. Mohinder S. Grewal California State University at Fullerton, A John Wiley & Sons, Inc. Publication.

5	Satellite Systems Engineering in an IPv6 Environment, Daniel Minoli, CRC Press.
6	Satellite systems for personal Applications, Madhavendra Richharia, A John Wiley and Sons, Ltd.Publication.
7	Dennis Roddy, 'Satellite Communication', McGraw Hill International, 4th Edition, 2006.
8	Wilbur L. Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, 'Satellite Communication Systems Engineering', Prentice Hall/Pearson, 2007 (Books to be added)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23A11.1	3	2	2	2	1	3
CU23A11.2	3	3	2	3	3	2
CU23A11.3	3	3	3	3	3	3
CU23A11.4	3	3	3	2	2	3
CU23A11.5	2	3	3	3	2	2
Average	**2.8**	**2.8**	**2.6**	**2.6**	**2.2**	**2.6**

Subject Code	Subject Name	Category	L	T	P	C
CU23A12	**REAL TIME EMBEDDED SYSTEMS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
□	To understand the basics of embedded system and ARM architecture
□	To understand the RTOS concepts like scheduling and memory management related to the embedded system.
□	To learn about the programming aspects of RTOS
□	To learn the different protocols of embedded wireless application
□	To understand concepts involved in the design of hardware and software components for an embedded system

UNIT-I	**INTRODUCTION**	**9**
Real Time System – Embedded Systems – Architecture of Embedded System – Simple Programming for Embedded System – Process of Embedded System Development – Pervasive Computing – Information Access Devices – Smart Cards – Microcontrollers – ARM Processor -Real Time Microcontrollers.		
UNIT-II	**EMBEDDED/REAL TIME OPERATING SYSTEM**	**9**
Operating System Concepts: Processes, Threads, Interrupts, Events - Real Time Scheduling Algorithms - Memory Management – Overview of Operating Systems for Embedded, Real Time Handheld Devices – Target Image Creation – Programming In Linux, Rtlinux, Vxworks, Microcontroller Operating System Overview.		
UNIT-III	**CONNECTIVITY**	**9**
Wireless Connectivity - Bluetooth – Other Short Range Protocols – Wireless Application Environment – Service Discovery – Middleware.		
UNIT-IV	**REAL TIME UML**	**9**
The Rapid Object-Oriented Process for Embedded Systems (ROPES) Process. MDA and Platform Independent Models- Scheduling Model-Based Projects- Model Organization Principles- Working with Model-Based Projects - Object Orientation with UML 2.0-Structural Aspects-Object Orientation with UML 2.0-Dynamic Aspects-UML Profile for Schedulability, Performance, and Time. Requirements Analysis – Object Identification Strategies – Object Behaviour – Real Time Design Patterns..		
UNIT-V	**SOFTWARE DEVELOPMENT AND APPLICATION**	**9**
Concurrency – Exceptions – Tools – Debugging Techniques – Optimization –Interfacing Digital Camera With USB Port. Interfacing of Sensors and Actuators for a Real Time Industrial Application.		
	Total Contact Hours :	**45**

Course Outcomes: On completion of the course, students will be able to	
	Make a choice of suitable embedded processor for a given application
	Design the hardware and software for the embedded system
	Design and develop the real time kernel/operating system functions, task control block structure and analyze different task states
	Implement different types of inter task communication and synchronization techniques
	Know about the aspects embedded connectivity in real time systems

Reference Books(s) / Web links:	
1	R.J.a.Buhr, D.L.Bailey, "An Introduction To Real-Time Systems", Prentice-Hall International,1999
2	David E-Simon, "An Embedded Software Primer", Pearson Education, 2007
3	C.M.Krishna, Kang G.Shin, "Real Time Systems", Mc-Graw Hill, 2010
4	B.P.Douglass, "Real Time Uml - Advances In the UML for Real-Time Systems, 3rd Edition Addison-Wesley, 2004
5	K.V.K. Prasad, "Embedded/Real Time Systems: Concepts, Design And Programming", Dream Tech Press, Black Book, 2005
6	R.Barnett, L.O.Cull, S.Cox, "Embedded C Programming and the Microchip PIC ", Thomason Learning, 2004
7	Wayne Wolf, "Computers As Components - Principles of Embedded Computer System Design", Mergen Kaufmann Publisher, 2006.
8	Sriram V Iyer, Pankaj Gupta, "Embedded Real Time Systems Programming", Tata Mc-Graw Hill, 2004.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CU23A12.1	3	-	3	3	2	2
CU23A12.2	3	1	3	3	2	3
CU23A12.3	2	-	2	2	-	3
CU23A12.4	1	-	2	1	-	2
CU23A12.5	1	-	2	3	3	1
Average	**2**	**1**	**2.4**	**2.4**	**2.3**	**2.2**

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise)

- Programming contest
- Flipped class
- Seminar

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise)

- Mini projects
- MCQ

Subject Code	Subject Name	Category	L	T	P	C
CU23A13	MEMS AND NEMS	PE	3	0	0	3

Objectives:

- To introduce the concepts of micro electro mechanical devices.
- To know the fabrication process of microsystems.
- To know the design concepts of micro actuators and case study of actuators.
- To know the design concepts of micro sensors and micro actuators.
- To introduce the concepts of quantum mechanics and nano systems.

UNIT-I	OVERVIEW AND INTRODUCTION	9

New trends in Engineering and Science: Micro and Nano scale systems-Introduction to Design of MEMS and NEMS, Overview of Nano and Micro electro mechanical Systems, Applications of Micro and Nano electro mechanical systems, Micro electromechanical systems, devices and structures Definitions, Materials for MEMS: Silicon, silicon compounds, polymers, metals

UNIT-II	MEMS FABRICATION TECHNOLOGIES	9

Microsystem fabrication processes: clean room standards, Semiconductor wafer cleaning, Photolithography, Ion Implantation, Diffusion and Oxidation. Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-like) Technology; Packaging: Microsystems packaging, Essential packaging technologies, Selection of packaging materials.

UNIT-III	MICRO SENSORS	9

MEMS Sensors: Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Microsensors. Case study: Piezo-resistive pressure sensor, MEMS Gas sensors.

UNIT-IV	MICRO ACTUATORS	9

Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps. Case study: Micro Tweezers, Micro Accelerometers.

UNIT-V	NANOSYSTEMS AND QUANTUM MECHANICS	9

Atomic structures and Quantum mechanics, Molecular and Nanostructure Dynamics: Schrodinger equation and Wave function theory, Density functional theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular wires and Molecular circuits.

Total Contact Hours	:	45

Course Outcomes:

On completion of the course, students will be able to

- Students are enriched with the concepts of MEMS and NEMS.
- Students can design a system using MEMS components
- Students are able to design various MEMS sensors
- Students are able to design micro actuators
- Students can understand nanosystems theory.

Reference Books(s) / Web links:

1. Marc Madou, “Fundamentals of Microfabrication”, CRC press 1997.
2. Stephen D. Senturia,” Micro system Design”, Kluwer Academic Publishers,2001
3. Tai Ran Hsu,”MEMS and Microsystems Design and Manufacture” ,Tata Mcraw Hill, 2002.
4. Chang Liu, “Foundations of MEMS”, Pearson education India limited, 2006,
5. Sergey Edward Lyshevski, “MEMS and NEMS: Systems, Devices, and Structures” CRC Press, 2002

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions:
- Flipped classroom - Piezo-resistive pressure sensor, MEMS Gas sensor(Comparing SOA with Client-Server and Distributed architectures
- Survey on various storage technologies : : LPCVD, Microsystems packaging, (LIGA and LIGA-like
- Activity Based Learning : Simple actuator
- Implementation of small module: Arduino board based gas sensor

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23A13.1	2	2	2	3	2	2
CU23A13.2	2	2	2	2	2	2
CU23A13.3	2	2	1	3	2	3
CU23A13.4	3	2	2	3	2	3
CU23A13.5	3	2	3	3	2	3
Average	**2.4**	**2**	**2**	**2.8**	**2**	**2.6**

Subject Code	Subject Name	Category	L	T	P	C
CU23A14	**MULTIMEDIA COMPRESSION TECHNIQUES**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
□	To understand the various storage requirements and evaluation techniques for data compression
□	To learn the various Text Compression techniques
□	To know about the various speech compression methods
□	To understand the Image Compression techniques and standards
□	To gain knowledge on Video compression techniques and standards

UNIT-I	**INTRODUCTION**	**9**
Special features of Multimedia – Graphics and Image Data Representations -Fundamental Concepts in Video and Digital Audio – Storage requirements for multimedia applications -Need for Compression - Taxonomy of compression techniques – Overview of source coding, source models, scalar and vector quantization theory – Evaluation techniques – Error analysis and methodologies.		
UNIT-II	**TEXT COMPRESSION**	**9**
Compaction techniques – Huffman coding – Adaptive Huffman Coding – Arithmetic coding – Shannon-Fano coding – Dictionary techniques – LZW family algorithms.		
UNIT-III	**AUDIO COMPRESSION**	**9**
Audio compression techniques - μ- Law and A- Law companding. Speech compression- waveform codecs-source codecs- hybrid codecs-Shorten compressor, Frequency domain and filtering – Basic sub-band coding – Application to speech coding – G.722 –Application to audio coding – MPEG audio, progressive encoding for audio – Silence compression, speech compression techniques – Formant and CELP Vocoders.		
UNIT-IV	**IMAGE COMPRESSION**	**9**
Predictive techniques – DM, PCM, and DPCM: Optimal Predictors and Optimal Quantization– Contour based compression – Transform Coding – JPEG Standard – Sub-band coding algorithms: Design of Filter banks – Wavelet based compression: Implementation using filters – EZW, SPIHT coders – JPEG 2000 standards – JBIG, JBIG2 Standards.		

UNIT-V	VIDEO COMPRESSION		9
Video compression techniques and standards – MPEG Video Coding I: MPEG – 1 and 2 MPEG Video Coding II: MPEG – 4 and 7 – Motion estimation and compensation techniques – H.261 Standard – DVI technology – PLV performance – DVI real time compression – Packet Video.			
	Total Contact Hours	**:**	**45**

Course Outcomes:	
On completion of the course, students will be able to	
□	Explain Scalar quantization theory and evaluation techniques
□	Understand different coding techniques
□	Use the audio compression techniques
□	Describe Contour based compression and Motion estimation techniques
□	Explain the various video and real time compression methods

Reference Books(s) / Web links:	
1	Khalid Sayood: Introduction to Data Compression, Morgan Kauffman Harcourt India, 2nd Edition, 2000.
2	David Salomon: Data Compression – The Complete Reference, Springer Verlag New York Inc., 2nd Edition, 2001.
3	Yun Q.Shi, Huifang Sun: Image and Video Compression for Multimedia Engineering - Fundamentals, Algorithms & Standards, CRC press, 2003.
4	Peter Symes: Digital Video Compression, McGraw Hill Pub., 2004.
5	Mark Nelson: Data compression, BPB Publishers, New Delhi, 1998.
6	Mark S.Drew, Ze-Nian Li: Fundamentals of Multimedia, PHI, 1st Edition, 2003.
7	Watkinson,J : Compression in Video and Audio, Focal press,London.1995.
8	Jan Vozer : Video Compression for Multimedia, AP Profes, NewYork, 1995

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions:
- Flipped classroom
- Survey on various compression techniques
- Implementation of small module: any one video compression technique

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23A14.1	3	3	2	2	2	2
CU23A14.2	3	3	3	2	2	2
CU23A14.3	3	3	3	2	2	2
CU23A14.4	3	3	3	2	2	2
CU23A14.5	3	3	3	2	3	2
Average	**3**	**3**	**3**	**2**	**2.2**	**2**

Subject Code	Subject Name	Category	L	T	P	C
CU23A15	HIGH PERFORMANCE NETWORKS	PE	3	0	0	3

Objectives:

- To develop a comprehensive understanding of multimedia networking.
- To study the types of VPN and tunneling protocols for security.
- To learn about network security in many layers and network management.

UNIT-I	**INTRODUCTION**	**9**
Review of OSI, TCP/IP; Multiplexing, Modes of Communication, Switching, Routing. SONET – DWDM – ISDN – BISDN, Frame Relay, ATM.		
UNIT-II	**MULTIMEDIA NETWORKING APPLICATIONS**	**9**
Streaming stored Audio and Video – Best effort service – protocols for real time interactive applications – Beyond best effort – scheduling and policing mechanism – integrated services –RSVP- differentiated services.		
UNIT-III	**ADVANCED NETWORKS CONCEPTS**	**9**
VPN-Remote-Access VPN, site-to-site VPN, Tunneling to PPP, Security in VPN.MPLS-operation, Routing, Tunneling and use of FEC, Traffic Engineering, MPLS based VPN, overlay networks-P2P connections.		
UNIT-IV	**TRAFFIC MODELLING**	**8**
Little's theorem, Need for modeling, Poisson modeling and its failure, Non- poisson models, Network performance evaluation.		
UNIT-V	**NETWORK SECURITY AND MANAGEMENT**	**10**
Principles of cryptography – Authentication – integrity – key distribution and certification – Access control and: fire walls – attacks and counter measures – security in many layers. Infrastructure for network management – The internet standard management framework – SMI, MIB, SNMP, Security and administration – ASN.1		
	Total Contact Hours : 45	

Course Outcomes:

On completion of the course, students will be able to

- Understand the basic concepts of TCP/IP and ISDN
- Describe about multimedia networking
- Analyze the security and tunneling methods of advanced networks.
- Assign the suitable the traffic models for the given network layer
- Manage network security

Reference Books(s) / Web links:

1. J.F. Kurose & K.W. Ross,"Computer Networking- A top down approach featuring the internet", Pearson, 2nd edition, 2003.
2. Walrand .J. Varatya, High performance communication network, Morgan Kauffman – Harcourt Asia Pvt. Ltd. 2nd Edition, 2000.
3. LEOM-GarCIA, WIDJAJA, "Communication networks", TMH seventh reprint 2002.
4. Aunuragkumar, D. MAnjunath, Joy kuri, "Communication Networking", Morgan Kaufmann Publishers, 1Ed. 2004.
5. HersentGurle& petit, "IP Telephony, packet Pored Multimedia communication Systems", Pearson education 2003.
6. Fred Halsall and Lingana Gouda Kulkarni,"Computer Networking and the Internet" fifth edition, Pearson education
7. Nader F.Mir, Computer and Communication Networks, first edition.
8. Larry l.Peterson& Bruce S.David, "Computer Networks: A System Approach"-1996

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom -
- Survey on various security models
- Implementation of small module

SUGGESTED EVALUATION METHODS (if any) (UNIT/ Module Wise) – could suggest topic

- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23A15.1	3	1	1	1	2	2
CU23A15.2	2	1	1	1	2	2
CU23A15.3	3	2	2	2	3	2
CU23A15.4	3	2	3	2	3	2
CU23A15.5	2	2	2	2	2	2
Average	**2.6**	**1.6**	**1.8**	**1.6**	**2.4**	**2**

PROFESSIONAL ELECTIVE -II

Subject Code	Subject Name	Category	L	T	P	C
CU23B11	RF MEMS	PE	3	0	0	3

Objectives:	
	To learn the basic building blocks of RF electronics and Its improved feature
	To acquire knowledge on RF switches and various passive components.
	To understand the concepts of RF filters and oscillators
	To study the basics of MEMS phase shifters
	To acquire knowledge on reliability and packaging.

UNIT-I	INTRODUCTION OF RF MEMS	9
Basic building blocks of RF system, RF MEMS Features- High Frequency effects, Introduction to Microwave Engineering, RF transmission lines: theory, Types of transmission lines, Impedance matching, S – parameters and ABCD Parameters, Smith Chart for Impedance matching.		
UNIT-II	**SWITCHES AND PASSIVE COMPONENTS**	**9**
Introduction, basic design, case studies, Micromachined passive components, theory, features, tunable capacitors, inductors, RF modeling of passive RF MEMS components. MEM switches: shunt MEM switch, low voltage hinged MEM switch, push-pull series switch, folded beam springs suspension series switch		
UNIT-III	**FILTERS AND OSCILLATORS**	**9**
Design concepts, Mechanical filters: design approaches, MEMS RF filters; Microwave filters: SAW and BAW filters, Micro machined tunable filter, RF MEMS Oscillators – fundamentals, Micromachined cavity oscillator, MEMS based voltage controlled oscillator.		
UNIT-IV	**PHASE SHIFTERS**	**9**
Introduction, RF MEMS Phase shifters, Design of switched delay line phase shifters Antennas: Introduction, Microstrip antennas, Micromachined antennas, Micromachined Transmission lines and components for sub millimeter wave applications, Reconfigurable antennas		
UNIT-V	**RELIABILITY AND PACKAGING**	**9**
MEMS packaging, RF MEMS packaging, Wafer level packaging.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Understand various parameters of RF signals and their interpretation in MEMS.
	Design passive RF MEMS components and switches
	Optimize the design of RF MEMS oscillators and filters
	Design and fabricate antennas using MEMS technology
	Understand the significance of packaging for improved performance.

Reference Books(s) / Web links:	
1	Gabriel M. Rebeiz, RfMems: Theory, Design, And Technology, Wiley.
2	Vijay K.Varadan, K.J. Vinoy, K.A. Jose., "RF MEMS and their Applications", John Wiley and sons, LTD, 2002
3	Hector J. De Los Santos, "RF MEMS Circuit Design for Wireless Communications", Artech House, 2002.
4	Stepan Lucyszyn, Advanced RF MEMS (The Cambridge RF and Microwave Engineering Series)" Cambridge University Press, 2010, ISBN: 0521897718.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions:
- Flipped classroom – Introduction to MEMS
- Survey on various Filters and Oscillators

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23B11.1	3	3	2	3	2	1
CU23B11.2	2	3	2	3	2	1
CU23B11.3	2	3	3	3	2	1
CU23B11.4	2	2	2	2	2	1
CU23B11.5	2	2	2	2	3	3
Average	**2.2**	**2.6**	**2.2**	**2.6**	**2.2**	**1.4**

Subject Code	Subject Name	Category	L	T	P	C
CU23B12	**DIGITAL COMMUNICATION RECEIVERS**	**PE**	**3**	**0**	**0**	**3**

Objectives: Students will be able to		
	Understand the basic communication techniques	
	Gain knowledge about optimum receivers	
	Know about channel fading and its effects	
	Know various synchronization techniques	
	Learn various adaptive channel equalization	
UNIT-I	**REVIEW OF DIGITAL COMMUNICATION TECHNIQUES**	**9**
Base band communication; signal space representation, linear and nonlinear modulation techniques, Error tracking and Spectral characteristics of digital modulation.		
UNIT-II	**OPTIMUM RECEIVERS FOR AWGN CHANNEL**	**9**
Correlation demodulator matched filter, maximum likelihood sequence detector, optimum receiver for CPM signals, M-ary orthogonal signals, envelope detectors for M-ary and correlated binary signals.		
UNIT-III	**RECEIVERS FOR FADING CHANNELS**	**9**
Characterization of fading multiple channels, statistical models, flat and frequency selective fading, diversity technique, Optimal receivers for data detection and synchronization parameter estimation, coded waveform for fading channel.		
UNIT-IV	**SYNCHRONIZATION TECHNIQUES**	**9**
Carrier and signal synchronization, carrier phase estimation-PLL, Decision directed loops, symbol timing estimation, maximum likelihood and non-decision directed timing estimation, joint estimation.		
UNIT-V	**VADAPTIVE EQUALIZATION**	**9**
Zero forcing algorithm, LMS algorithm, adaptive decision-feedback equalizer and Equalization of Trellis-coded signals. Kalman algorithm, blind equalizers and stochastic gradient algorithm.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course	
□	Students are enriched with the basics of baseband communication
□	Students are able to analyze the various receivers for AWGN channel.
□	Students are able to characterize the fading multiple channels
□	Students are able to know the various synchronization techniques
□	Students can able to design receivers

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Flipped classroom – Comparison of various synchronization tecniques
- Survey on implementation of adaptive equalization

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- CAT
- Assignment

Reference Books(s) / Web links:	
1	Heinrich Meyer, Mare Moeneclacy, Stefan.A.Fechtel, " Digital communication receivers ", Vol I &Vol II, John Wiley, New York, 1997.
2	U.Mengali&A.N.D'Andrea, Synchronization Techniques for Digital Receivers, Kluwer, 1997.
3	John.G.Proakis, "Digital communication "4th Edition, McGraw-Hill, New York, 2001.
4	E.A.Lee and D.G. Messerschmitt, "Digital communication ", 2nd Edition, Allied Publishers, New Delhi, 1994.
5	Simon Marvin, "Digital communication over fading channel; An unified approach to performance Analysis ", John Wiley, New York, 2000.
6	H.Meyr&G.Ascheid, Synchronization in Digital Communications, John Wiley, 1990.
7	R. G. Gallager, Principles of Digital Communication, Cambridge University Press, 2008.

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CU23B12.1	3	3	3	1	1	1
CU23B12.2	3	3	3	1	1	1
CU23B12.3	3	3	3	1	1	1
CU23B12.4	3	3	3	1	1	1
CU23B12.5	3	3	3	1	1	1
Average	**3**	**3**	**3**	**1**	**1**	**1**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU23B13	**COGNITIVE RADIO**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
□	To enable the student to understand the evolving paradigm of cognitive radio communication and the enabling technologies for its implementation.
□	To enable the student to become knowledgeable in the essential functionalities and requirements in designing software defined radios and their usage for cognitive communication.
□	To expose the student to the evolving next generation wireless networks and their associated challenges.

UNIT-I	**INTRODUCTION TO SDR**	**9**
Definitions and potential benefits, software radio architecture evolution – foundations, technology trade-offs and architecture implications		
UNIT-II	**SDR ARCHITECTURE**	**9**

Essential functions of the software radio, architecture goals, quantifying degrees of programmability, top level component topology, computational properties of functional components, interface topologies among plug and play modules, architecture partitions.		
UNIT-III	**INTRODUCTION TO COGNITIVE RADIOS**	**9**
Making radio self-aware, the cognition cycle, organization of cognition tasks, structuring knowledge for cognition tasks, Enabling location and environment awareness in cognitive radios – concepts, architecture, design considerations.		
UNIT-IV	**COGNITIVE RADIO ARCHITECTURE**	**9**
Primary Cognitive Radio functions, Behaviors, Components, A–Priori Knowledge taxonomy, observe – phase data structures, Radio procedure knowledge encapsulation, components of orient, plan, decide phases, act phase knowledge representation, design rules		
UNIT-V	**NEXT GENERATION WIRELESS NETWORKS**	**9**
The XG Network architecture, spectrum sensing, spectrum management, spectrum mobility, spectrum sharing, upper layer issues, cross – layer design.		
Total Contact Hours : 45		

Course Outcomes:	
On completion of the course, students will be able to	
□	Understand the concepts of SDR.
□	Understand the various architectures of SDR.
□	Appreciate the motivation and the necessity for cognitive radio communication strategies.
□	Appreciate new techniques and demonstrate their feasibility using mathematical validations and simulation tools.
□	Demonstrate the impact of the evolved solutions in future wireless network design.

Reference Books(s) / Web links:	
1	Alexander M. Wyglinski, MaziarNekovee, And Y. Thomas Hou, "Cognitive Radio Communications and Networks - Principles and Practice", Elsevier Inc., 2010.
2	"E. Biglieri, A.J. Goldsmith. L.J. Greenstein, N.B. Mandayam, H.V. Poor, Principles ofCognitive Radio", Cambridge University Press, 2013.
3	Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks", John Wiley & Sons, Ltd, 2009.
4	Khattab, Ahmed, Perkins, Dmitri, Bayoumi, Magdy, "Cognitive Radio Networks - From Theory to Practice", Springer Series: Analog Circuits and Signal Processing, 2009.
5	J. Mitola, "Cognitive Radio: An Integrated Agent Architecture for software defined radio", PhD thesis, Royal Institute Technology, Sweden 2000.
6	Simon Haykin, "Cognitive Radio: Brain –empowered wireless communications", IEEE Journal on selected areas in communications, Feb 2005.
7	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.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Flipped classroom – SDR concepts
- Survey on wireless networks

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- CAT
- Assignment

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23B13.1	2	3	2	3	2	1
CU23B13.2	2	3	2	3	2	1
CU23B13.3	2	3	3	3	2	1
CU23B13.4	3	3	3	2	3	1
CU23B13.5	2	2	2	2	3	3
Average	**2.2**	**2.7**	**2.4**	**2.6**	**2.4**	**1.4**

Subject Code	Subject Name	Category	L	T	P	C
CU23B14	**VLSI FOR WIRELESS COMMUNICATION**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
	To understand the concepts of basic wireless communication concepts.
	To study the parameters in receiver and low noise amplifier design.
	To study the various types of mixers designed for wireless communication.
	To study and design PLL and VCO.
	To understand the concepts of VLSI architecture for multiplier and power amplifiers in wireless communication.

UNIT-I	**COMMUNICATION CONCEPTS**	**9**
Introduction – Overview of Wireless systems – Standards – Access Methods – Modulation schemes – Classical channel – Wireless channel description – Path loss – Multipath fading – Standard Translation		
UNIT-II	**RECEIVER ARCHITECTURE & LOW NOISE AMPLIFIERS**	**9**
Receiver front end – Filter design – Non-idealities – Design parameters – Noise figure & Input intercept point. LNA Introduction – Wideband LNA design – Narrow band LNA design: Impedance matching & Core amplifier.		
UNIT-III	**MIXERS**	**9**
Balancing Mixer - Qualitative Description of the Gilbert Mixer - Conversion Gain – Distortion – Noise - A Complete Active Mixer. Switching Mixer – Distortion, Conversion Gain & Noise in Unbalanced Switching Mixer - A Practical Unbalanced Switching Mixer. Sampling Mixer - Conversion Gain, Distortion, Intrinsic & Extrinsic Noise in Single Ended Sampling Mixer.		
UNIT-IV	**FREQUENCY SYNTHESIZERS**	**9**
PLL – Phase detector – Dividers – Voltage Controlled Oscillators – LC oscillators – Ring Oscillators – Phase noise – Loop filters & design approaches – A complete synthesizer design example (DECT) – Frequency synthesizer with fractional divider.		
UNIT-V	**IMPLEMENTATIONS & POWER AMPLIFIERS**	**9**
VLSI architecture for Multitier Wireless System - Hardware Design Issues for a Next generation CDMA System– Power amplifier design.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
	Design LNA and Mixers
	Evaluate frequency synthesizers
	Design and analyze power amplifiers

Reference Books(s) / Web links:	
1	Bosco H Leung "VLSI for Wireless Communication", Pearson Education, 2002.
2	B.Razavi ,"RF Microelectronics" , Prentice-Hall ,1998.
3	BehzadRazavi, "Design of Analog CMOS Integrated Circuits" McGraw-Hill, 1999.
4	Emad N Farag and Mohamed I Elmasry, "Mixed Signal VLSI wireless design – Circuits & Systems", Kluwer Academic Publishers, 2000.
5	J. Crols and M. Steyaert, "CMOS Wireless Transceiver Design," Boston, Kluwer Academic Pub., 1997.

6	Thomas H.Lee, "The Design of CMOS Radio – Frequency Integrated Circuits", Cambridge University Press ,2003.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Flipped classroom – Modulation schemes
- Survey on various mixers

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- CAT
- Assignment

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23B14.1	3	2	2	2	2	3
CU23B14.2	3	2	2	2	2	3
CU23B14.3	3	3	2	2	2	2
CU23B14.4	3	2	2	2	2	2
CU23B14.5	3	2	2	2	2	2
Average	3	2.2	2	2	2	2.4

Subject Code	Subject Name	Category	L	T	P	C
CU23B15	**DIGITAL COMMUNICATION OVER FADING CHANNELS**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
	To study and understand the wireless channels
	To learn how to model the fading channels mathematically
	To understand the coherent and non-coherent detections
	To investigate the performance metrics of the digital communication
	To derive the error rates of the wireless communication systems

UNIT-I	**FADING CHANNEL CHARACTERIZATION AND MODELING**	**9**
System Performance Measures: average SNR, outage probability, average bit error probability, amount of fading, average outage duration. Main characteristics of fading channels: Slow and fast fading, flat and frequency selective fading- Models. Multipath modelling using Rayleigh, Nakagami-m, Rice distributions. Log normal Shadowing-Applications..		
UNIT-II	**COHERENT AND NON-COHERENT DETECTIONS**	**9**
Ideal Coherent Detection: M-ary Phase-Shift-Keying (M-PSK), Differentially Encoded M-ary Phase-Shift-Keying (M-PSK), $\pi/4$-QPSK, Offset QPSK (OQPSK) or Staggered QPSK (SQPSK), Minimum-Shift-Keying (MSK) Non ideal Coherent Detection, Non-Coherent Detection. Comparison of coherent and non-coherent detections		
UNIT-III	**USEFUL EXPRESSIONS FOR EVALUATING ERROR PERFORMANCE**	**9**
Integrals Involving the Gaussian Q-Function: Rayleigh Fading Channel, Nakagami-q (Hoyt), Nakagami-n (Rice) Integrals Involving the Incomplete Gamma Function: Rayleigh, Nakagami-n (Rice), Nakagami-m, Log-Normal Shadowing Channel Integrals Involving Other Functions: M-PSK Error Probability Integral, Rayleigh Fading Channel, Nakagami-m, Arbitrary Two-Dimensional Signal Constellation Error Probability Integral, Rayleigh Fading Channel, Nakagami-m Fading Channel		
UNIT-IV	**PERFORMANCE OF MULTICHANNEL RECEIVERS**	**9**
Diversity Combining: Diversity Concept, Mathematical Modelling, Brief Survey of Diversity Combining Techniques, Pure Combining Techniques, Hybrid Combining Techniques, Complexity–Performance Trade-offs. Maximal-Ratio Combining (MRC): Receiver Structure, PDF-Based Approach, MGF-Based Approach: Average Bit Error Rate of Binary Signals, Average Symbol Error Rate of Square M-QAM Signals. Overview of post detection combining		

UNIT-V	ANALYSIS OF SELECTION COMBINING AND SWITCHED DIVERSITY		9
Selection Combining: MGF of Output SNR, Average Output SNR, Outage Probability and Analysis, Average Probability of Error, BDPSK and Non-Coherent BFSK, Coherent BPSK and BFSK. Switched Diversity: Dual-Branch Switch-and-Stay Combining (SSC), Multi-Branch switch -and -Examine combining, Performance of SSC over Independent Identically Distributed Branches, Effect of Branch Unbalance, Effect of Branch Correlation..			
	Total Contact Hours	**:**	**45**

Course Outcomes: On completion of the course, students will be able to	
	Model the fading channel mathematically
	Differentiate the coherent and non-coherent detections
	Appreciate the various analytical tools used in the evaluation of wireless systems
	Can derive performance metrics such as outage, error probability and capacity analysis
	Understand the transmission of signals over signal antenna and multiple antennas

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom -
- Survey on various
- Activity Based Learning

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Reference Books(s) / Web links:	
1	M.K.Simon, M.-S. Alouini,"Digital Communication over Fading Channels" John Wiley &Sons Inc., 2nd Edition, 2000.
2	John Proakis, MasoudSalehi "Digital Communication", McGraw Hill Education, 5th Edition, 2014.
3	Frontmatter - Digital Communication over Fading Channels - Wiley Online Library
4	Fading Channel Characterization and Modeling | part of Digital Communication over Fading Channels | Wiley-IEEE Press books | IEEE Xplore

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23B15.1	3	3	3	3	2	2
CU23B15.2	3	3	3	3	2	2
CU23B15.3	3	3	3	3	2	2
CU23B15.4	3	3	2	2	1	2
CU23B15.5	3	3	2	3	2	2
Average	**3**	**3**	**2.6**	**2.8**	**1.8**	**2**

PROFESSIONAL ELECTIVE- III

Subject Code	Subject Name	Category	L	T	P	C
CU23C11	SPEECH AND AUDIO SIGNAL PROCESSING	PE	3	0	0	3

Objectives:	
	To study the basic concepts of speech and audio.
	To study the analysis of various M-band filter banks for audio coding.
	To learn various transform coders for audio coding.
	To study the speech processing methods in time and frequency domain.
	To study the audio coding methods.

UNIT-I	**FUNDAMENTALS OF SPEECH AND AUDIO**	**9**
Introduction - Review of Signal Processing Theory-Speech production mechanism – Nature of Speech signal – Discrete time modeling of Speech production – Classification of Speech sounds – Phones – Phonemes – Phonetic and Phonemic alphabets – Articulatory features. Absolute Threshold of Hearing - Critical Bands- Simultaneous Masking, Masking-Asymmetry, and the Spread of Masking- Non-simultaneous Masking - Perceptual Entropy - Basic measuring philosophy -Subjective versus objective perceptual testing - The perceptual audio quality measure (PAQM) - Cognitive effects in judging audio quality.		
UNIT-II	**TIME AND FREQUENCY DOMAIN METHODS FOR SPEECH**	**9**
Time domain parameters of Speech signal – Methods for extracting the parameters: Energy, Average Magnitude – Zero crossing Rate – Silence Discrimination using ZCR and energy, Short Time Fourier analysis – Formant extraction – Pitch Extraction using time and frequency domain methods. Homomorphic Speech Analysis: Cepstral analysis of Speech – Formant and Pitch Estimation – Homomorphic Vocoder		
UNIT-III	**LINEAR PREDICTIVE ANALYSIS OF SPEECH**	**9**
Formulation of Linear Prediction problem in Time Domain – Basic Principle – Auto correlation method – Covariance method – Solution of LPC equations – Cholesky method – Durbin's Recursive algorithm – lattice formation and solutions – Comparison of different methods – Application of LPC parameters – Pitch detection using LPC parameters – Formant analysis – VELP – CELP..		
UNIT-IV	**TIME-FREQUENCY ANALYSIS: FILTER BANKS AND TRANSFORMS**	**9**
Introduction -Analysis-Synthesis Framework for M-band Filter Banks- Filter Banks for Audio Coding: Design Considerations - Quadrature Mirror and Conjugate Quadrature Filters- Tree-Structured QMF and CQF M-band Banks - Cosine Modulated "Pseudo QMF" M-band Banks - Cosine Modulated Perfect Reconstruction (PR) M- band Banks and the Modified Discrete Cosine Transform (MDCT) - Discrete Fourier and Discrete Cosine Transform - Pre-echo Distortion- Pre-echo Control Strategies		
UNIT-V	**AUDIO CODING AND TRANSFORM CODERS**	**9**
Lossless Audio Coding-Lossy Audio Coding- ISO-MPEG-1A,2A,2A Advanced, 4AudioCoding - Optimum Coding in the Frequency Domain - Perceptual Transform Coder -Brandenburg-Johnston Hybrid Coder - CNET Coders - Adaptive Spectral Entropy Coding -Differential Perceptual Audio Coder - DFT Noise Substitution -DCT with Vector Quantization -MDCT with Vector Quantization.		
	Total Contact Hours :	**45**

Course Outcomes: On completion of the course, students will be able to	
	Model Speech production system and describe the fundamentals of speech
	Use different speech analysis technique
	Choose an appropriate audio coder
	Analyze the time and frequency domain methods for speech processing
	Design a speech processing system for study of articulatory phonetics

SUGGESTED ACTIVITIES (if any)

- Flipped classroom - Comparing SOA with Client-Server and Distributed architectures
- Implementation of small module

SUGGESTED EVALUATION METHODS (if Any)

- Assignment problems
- Quizzes
- Class Presentation/Discussion

Reference Books(s) / Web links:	
1	Digital Processing of Speech signals – L.R.Rabiner and R.W.Schaffer - Prentice Hall –1978.
2	Digital Audio Signal Processing, Second Edition, Udo Zölzer**,** A John Wiley& sons Ltd Publicatioons
3	Applications of Digital Signal Processing to Audio And Acoustics Mark Kahrs, Karlheinz Brandenburg, Kluwer Academic Publishers New York, Boston, Dordrecht, London , Moscow

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CU23C11.1	3	3	3	2	2	2
CU23C11.2	3	3	3	3	3	2
CU23C11.3	3	3	3	3	3	3
CU23C11.4	3	3	3	3	3	2
CU23C11.5	2	2	2	2	2	2
Average	**2.8**	**2.8**	**2.6**	**2.6**	**2.6**	**2.2**

Subject Code	**Subject Name**	**Category**	**L**	**T**	**P**	**C**
CU23C12	**DIGITAL IMAGE AND VIDEO PROCESSING**	**PE**	**3**	**0**	**0**	**3**

Objectives: Students will be able to	
	Know the digital image fundamentals and transforms
	Study various techniques for image enhancement and restoration.
	Learn various techniques for image segmentation and compression.
	Acquire the knowledge of extracting information from surveillance videos.
	Understand the models used for recognition Human Activity, Face and Gait.

UNIT-I	**DIGITAL IMAGE FUNDAMENTALS AND IMAGE ENHANCEMENT**	**9**
Steps in digital image processing, Elements of digital image processing systems and visual perception, brightness, contrast, hue, saturation, mach band effect, Pixel relationship, 2D image transforms-DFT, DCT, KLT, SVD.		
UNIT-II	**IMAGE ENHANCEMENT AND RESTORATION**	**9**
Gray level transformations, Spatial averaging, Directional Smoothing, Median, Geometric mean, Harmonic mean, Contra harmonic mean filters, Homomorphic filtering, Color image enhancement. Reasons for image degradation, Image degradation model, Inverse filter, Wiener filter		
UNIT-III	**IMAGE SEGMENTATION AND COMPRESSION**	**9**
Edge detection, Thresholding, Region based segmentation – Region growing, Region splitting and Merging. Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, Transform coding, JPEG and MPEG compression standards.		
UNIT-IV	**VIDEO ANALYTICS**	**9**
Introduction – Video Basics – Fundamentals for Video Surveillance, Object Detection and Tracking: Adaptive Background Modelling and Subtraction – Pedestrian Detection and Tracking, Vehicle Detection and Tracking – MPEG compression.		
UNIT V	**HUMAN ACTIVITY, FACE AND GAIT RECOGNITION**	**9**

The framework for activity inference – Human Activity Recognition – Activity modeling using 3D shape, Video summarization – Suspicious Activity Detection – Human Face Recognition from video – Human Recognition using gait: HMM Framework for Gait Recognition.			
	Total Contact Hours	**:**	**45**

Course Outcomes:	
On completion of the course, students will be able to	
□	Describe digital image fundamentals and transforms.
□	Exhibit various image enhancement and restoration techniques.
□	Demonstrate various image segmentation and compression techniques.
□	Describe surveillance videos for analytics.
□	Model a framework for Human Activity, Face and Gait Recognition.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Activity Based Learning

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Assignment problems
- Quizzes

Text Book(s):	
1	Rafael C. Gonzalez, Richard E. Woods, , Digital Image Processing', Pearson , Second Edition, 2004.
2	Michael Berthold, David J.Hand, "Intelligent Data Analysis", Springer, 2007.

Reference Books(s) / Web links:	
1	Anil K. Jain, Fundamentals of Digital Image Processing', Pearson 2002.
2	Rafael C. Gonzalez, Richard E. Woods, Steven Eddins,' Digital Image Processing using MATLAB', Pearson Education, Inc., 2004.
3	AnandRajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.
4	Yunqian Ma, Gang Qian, "Intelligent Video Surveillance: Systems and Technology", CRC Press (Taylor and Francis Group), 2009
5	Rama Chellappa, Amit K.Roy– Chowdhury, Kevin Zhou.S, "Recognition of Humans and their Activities using Video", Morgan & Claypool Publishers, 2005

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CU23C12.1	3	3	3	2	2	2
CU23C12.2	3	3	3	2	2	2
CU23C12.3	3	3	3	2	2	2
CU23C12.4	3	3	3	2	2	3
CU23C12.5	3	3	3	2	3	3
Average	**3**	**3**	**3**	**2**	**2.2**	**2.4**

Subject Code	Subject Name	Category	L	T	P	C
CU23C13	RADAR SIGNAL PROCESSING	PE	3	0	0	3

UNIT-I	**INTRODUCTION TO RADAR SYSTEMS**	**9**
History and application of radar, basic radar function, elements of pulsed radar, review of signal processing concepts and operations, A preview of basic radar signal processing, radar system components, advanced radar signal processing		
UNIT-II	**SIGNAL MODELS**	**9**
Components of a radar signal, amplitude models, types of clutters, noise model and signal-to-noise ratio, jamming, frequency models: the doppler shift, spatial models, spectral model		
UNIT-III	**SAMPLING AND QUANTIZATION OF PULSED RADAR SIGNALS**	**9**
Domains and criteria for sampling radar signals, Sampling in the fast time dimension, Sampling in slow time: selecting the pulse repetition interval, sampling the Doppler spectrum, Sampling in the spatial and angle dimension, Quantization, I/Q Imbalance and Digital I/Q		
UNIT-IV	**RADAR WAVEFORMS**	**9**
Introduction, waveform matched filter, Matched filtering of moving targets, The ambiguity function, The pulse burst waveform, frequency-modulated pulse compression waveforms, Range side lobe control for FM waveforms, the stepped frequency waveform, Phase-modulated pulse compression waveforms, COSTAS Frequency Codes.		
UNIT-V	**DOPPLER PROCESSING**	**9**
Alternate forms of the Doppler spectrum, Moving target indication (MTI), Pulse Doppler processing, dwell-to- dwell stagger, Pulse pair processing, additional Doppler processing issues, clutter mapping and the moving target detector, MTI for moving platforms: adaptive displaced phase centre antenna processing.		
	Total Contact Hours :	**45**

Course Outcomes:	
On completion of the course, students will be able to	
□	Understand the concepts of radar processing
□	Analyze the various amplitude and frequency models
□	Outline the concepts of sampling and quantization
□	Analyze the various radar waveforms
□	Explain the processing of radar signal and its associated issues.

Reference Books(s) / Web links:	
1	Fundamentals of Radar Signal Processing, Mark A. Richards McGraw-Hill, New York, 2005
2	Principles of Radar and Sonar Signal Processing, Francois Le Chevalier, Artech House
3	systems, Peak Detection and Tracking, Michael O Kolawole ,2010,Elseveir
4	Introduction to Radar Systems 3/E, Skolnik, McGraw Hill.
5	Radar Principles, Peyton Z. Peebles, 2009 Wiley India
6	Radar Design Principles-Signal Processing and the environment, Fred E. Nathanson, PHI

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Activity Based Learning

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Assignment problems
- Quizzes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23C13.1	3	3	3	3	3	3
CU23C13.2	3	3	3	2	2	2
CU23C13.3	3	3	3	3	3	2
CU23C13.4	3	3	3	3	3	2
CU23C13.5	3	3	3	2	2	2
Average	**3**	**3**	**3**	**2.6**	**2.6**	**2.2**

Subject Code	Subject Name	Category	L	T	P	C
CU23C14	**ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
	To understand the basic concepts of EMI
	To acquire knowledge on EMI problems
	To gain ideas on control methods for EMI
	To learn EMC design for PCBs
	To understand EMI measurement technique

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- Shielding Material-Shielding integrity at discontinuities, Filtering- Characteristics of Filters-Impedance and Lumped element filters-Telephone line filter, Power line filter design, Filter installation and Evaluation, Grounding-Measurement of Ground resistance-system grounding for EMI/EMC-Cable shielded grounding, Bonding, Isolation transformer, Transient suppressors, Cable routing, Signal control. EMI gaskets		
UNIT-IV	**EMC DESIGN OF PCBS**	**9**
EMI Suppression Cables-Absorptive, ribbon cables-Devices-Transient protection hybrid circuits ,Component selection and mounting; PCB trace impedance; Routing; Cross talk control Electromagnetic Pulse-Noise from relays and switches, 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. Frequency assignment - spectrum conversation. British VDE standards, Euro norms standards in japan - comparisons. EN Emission and Susceptibility standards and Specifications.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Familiar with the concepts related to electromagnetic interference and compatibility
	Familiar with the principles of EMI coupling techniques
	Able to apply control techniques to cancel electromagnetic interference
	Able to propose solutions for minimizing EMI in PCBs
	Able to analyze Electromagnetic environment and carryout measurements as per standards

Reference Books(s) / Web links:	
1	V.P.Kodali, "Engineering EMC Principles, Measurements and Technologies", IEEE Press, Newyork, 1996.
2	Clayton R.Paul," Introduction to Electromagnetic Compatibility", John Wiley Publications, 2008
3	Henry W.Ott.,"Noise Reduction Techniques in Electronic Systems", A Wiley Inter Science Publications, John Wiley and Sons, Newyork, 1988.
4	Bemhard Keiser, "Principles of Electromagnetic Compatibility", 3rd Ed, Artech house, Norwood, 1986.
5	Don R.J.White Consultant Incorporate, "Handbook of EMI/EMC", Vol I-V, 1988.
6	Christopoulos C, Principles and Techniques of Electromagnetic Compatibility, CRC Press, Second Edition, Indian Edition, 2013.
7	Scott Bennett W, Control and Measurement of Unintentional Electromagnetic Radiation, John Wiley& Sons Inc., Wiley Interscience Series, 1997.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom
- Survey on electromagnetic interference and compatibility issues
- Activity based learning
- Implementation of small module

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23C14.1	3	2	-	-	1	2
CU23C14.2	3	2	1	1	1	2
CU23C14.3	3	3	3	3	3	1
CU23C14.4	3	3	3	3	3	2
CU23C14.5	3	3	3	3	3	2
Average	**3**	**2.6**	**2.5**	**2.5**	**2.2**	**1.8**

Subject Code	Subject Name	Category	L	T	P	C
CU23C15	SOFT COMPUTING	PE	3	0	0	3

Objectives:	
	To learn the key aspects of soft computing and neural networks.
	To know about the components and building block hypothesis of Genetic algorithm.
	To understand the features of neural network and its applications
	To gain insight onto Neuro Fuzzy modeling and control.
	To gain knowledge in machine learning through Support vector machines.

UNIT-I	INTRODUCTION TO SOFT COMPUTING	9
Evolution of Computing - Soft Computing Constituents – From Conventional AI to Computational Intelligence - Machine Learning Basics.		
UNIT-II	**NEURAL NETWORKS**	**9**
Machine Learning using Neural Network, Adaptive Networks – Feed Forward Networks– Supervised Learning Neural Networks – Radial Basis Function Networks - Reinforcement Learning – Unsupervised Learning Neural Networks – Adaptive Resonance Architectures –Advances in Neural Networks.		
UNIT-III	**GENETIC ALGORITHMS**	**9**
Introduction, Building block hypothesis, working principle, Basic operators and Terminologies like individual, gene, encoding, fitness function and reproduction, Genetic modeling: Significance of Genetic operators, Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator, GA optimization problems, JSPP (Job Shop Scheduling Problem), TSP (Travelling Salesman Problem),Differences & similarities between GA & other traditional methods, Applications of GA.		
UNIT-IV	**FUZZY LOGIC**	**9**
Fuzzy Sets – Operations on Fuzzy Sets – Fuzzy Relations – Membership Functions-Fuzzy Rules and Fuzzy Reasoning – Fuzzy Inference Systems – Fuzzy Expert Systems – Fuzzy Decision Making.		
UNIT-V	**NEURO-FUZZY MODELING**	**9**
Adaptive Neuro-Fuzzy Inference Systems – Coactive Neuro-Fuzzy Modeling – Classification and Regression Trees – Data Clustering Algorithms – Rule base Structure Identification – Neuro-Fuzzy Control – Case Studies.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Understand machine learning through neural networks.
	Remember various learning algorithm used in neural network.
	Write Genetic Algorithm to solve the optimization problem
	Apply fuzzy logic concepts for decision making
	Analyze Neuro Fuzzy system for clustering and classification

Reference Books(s) / Web links:

1	Jyh-Shing Roger Jang, Chuen-Tsai Sun, EijiMizutani, "Neuro-Fuzzy and Soft Computing", Prentice-Hall of India, 2003.
2	KwangH.Lee, "First course on Fuzzy Theory and Applications", Springer–Verlag Berlin Heidelberg, 2005.
3	George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic-Theory and Applications", Prentice Hall, 1995.
4	James A. Freeman and David M. Skapura, "Neural Networks Algorithms, Applications, and Programming Techniques", Pearson Edn., 2003.
5	David E. Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Addison Wesley, 2007.
6	Mitsuo Gen and RunweiCheng,"Genetic Algorithms and Engineering Optimization", Wiley Publishers 2000.
7	Mitchell Melanie, "An Introduction to Genetic Algorithm", Prentice Hall, 1998.
8	S.N.Sivanandam, S.N.Deepa, "Introduction to Genetic Algorithms", Springer, 2007.
9	Eiben and Smith "Introduction to Evolutionary Computing" Springer
10	E. Sanchez, T. Shibata, and L. A. Zadeh, Eds., "Genetic Algorithms and Fuzzy Logic Systems: Soft Computing Perspectives, Advances in Fuzzy Systems - Applications and Theory", Vol. 7, River Edge, World Scientific, 1997.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom
- Survey on electromagnetic interference and compatibility issues
- Activity based learning
- Implementation of small module

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23C15.1	3	2	1	-	3	2
CU23C15.2	1	3	3	2	3	2
CU23C15.3	1	3	3	2	1	1
CU23C15.4	1	2	3	2	1	-
CU23C15.5	1	2	3	2	1	-
Average	**1.4**	**2.4**	**2.6**	**2**	**1.8**	**1.7**

PROFESSIONAL ELECTIVE- IV

Subject Code	Subject Name	Category	L	T	P	C
CU23D11	DETECTION AND ESTIMATION THEORY	PE	3	0	0	3

Objectives:	
	To learn the usage of tools from probability and signal processing domains
	To gain knowledge on detection of deterministic signals
	To obtain optimum detector/estimator for an digital communication system
	To learn the detection of random signals with unknown parameters
	To identify the (error) performance bounds of any detector/estimator adopted in communication systems

UNIT-I	**STATISTICAL DECISION THEORY**	**9**
Bayesian, minimax, and Neyman-Pearson decision rules, likelihood ratio, receiver operating characteristics, composite hypothesis testing, locally optimum tests, detector comparison techniques, asymptotic relative efficiency.		
UNIT-II	**DETECTION OF DETERMINISTIC SIGNALS**	**9**
Matched filter detector and its performance; generalized matched filter; detection of sinusoid with unknown amplitude, phase, frequency and arrival time, linear model		
UNIT-III	**DETECTION OF RANDOM SIGNALS**	**9**
Estimator-correlator, linear model, general Gaussian detection, detection of Gaussian random signal with unknown parameters, weak signal detection.		
UNIT-IV	**NONPARAMETRIC DETECTION**	**9**
Detection in the absence of complete statistical description of observations, sign detector, Wilcoxon detector, detectors based on quantized observations, robustness of detectors.		
UNIT-V	**ESTIMATION OF SIGNAL PARAMETERS**	**9**
Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound, sufficient statistics, minimum statistics, complete statistics; linear models; best linear unbiased estimation; maximum likelihood estimation, invariance principle; estimation efficiency; Bayesian estimation: philosophy, nuisance parameters, risk functions, minimum mean square error estimation, maximum a posteriori estimation.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	State various detection issues in hypotheses testing framework
	Demonstrate various estimation algorithms for detection of deterministic signals
	Develop algorithms for estimation of random signals
	Design various sequential procedures for detection/estimation challenges
	Formulate algorithms for tracking and estimation of signal parameters

Reference Books(s) / Web links:	
1	H. L. Van Trees, "Detection, Estimation and Modulation Theory: Part I, II, and III", John Wiley, NY, 1968.
2	H. V. Poor, "An Introduction to Signal Detection and Estimation", Springer, 2/e, 1998.
3	S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", Prentice Hall PTR, 1993.
4	S. M. Kay, "Fundamentals of Statistical Signal Processing: Detection Theory", Prentice Hall PTR, 1998.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom
- Activity Based Learning

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23D11.1	3	3	3	2	3	2
CU23D11.2	3	3	3	3	2	2
CU23D11.3	3	3	3	3	2	2
CU23D11.4	3	3	3	3	3	3
CU23D11.5	3	3	3	3	3	2
Average	**3**	**3**	**3**	**2.8**	**2.6**	**2.2**

Subject Code	Subject Name	Category	L	T	P	C
CU23D12	**INTERNETWORKING MULTIMEDIA**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
□	To discuss the various multimedia standards
□	To understand the different broadband technologies
□	To analyze the transport protocols and its applications
□	To study various multimedia communication standards
□	To analyze multimedia across Wireless Network

UNIT-I	**MULTIMEDIA NETWORKING**	**9**
Digital Sound, Video and Graphics – Basic Multimedia Networking – Multimedia Characteristics – Evolution of Internet Services Model – Network Requirements for Audio/ Video Transform – Multimedia Coding and Compression for Text, Image Audio And Video.		
UNIT-II	**BROADBAND NETWORK TECHNOLOGY**	**9**
Broadband Services – ATM and IP, IPV6, High Speed Switching – Resource Reservation, Buffer Management – Traffic Shaping – Caching – Scheduling and Policing, Throughput, Delay and Jitter Performance – Storage and Media Services – Voice and Video Over IP – MPEG–2 over ATM/IP – Indexing Synchronization of Requests – Recording and Remote Control.		
UNIT-III	**RELIABLE TRANSPORT PROTOCOL AND APPLICATIONS**	**9**
Multicast over Shared Media Network – Multicast Routing and Addressing – Scaling Multicast and NBMA Networks – Reliable Transport Protocols – TCP Adaptation Algorithm – RTP, RTCP – MIME – Peer–to–Peer Computing – Shared Application – Video Conferencing, Centralized and Distributed Conference Control – Distributed Virtual Reality – Light Weight Session Philosophy		
UNIT-IV	**MULTIMEDIA COMMUNICATION STANDARDS**	**9**
Objective of MPEG – 7 Standard – Functionalities and Systems of MPEG–7 MPEG–21 Multimedia Framework Architecture – Content Representation – Content Management and Usage – Intellectual Property Management – Audio Visual System – H322: Guaranteed QOS LAN Systems – MPEG_4 Video Transport across Internet.		
UNIT-V	**MULTIMEDIA COMMUNICATION ACROSS NETWORKS**	**9**
Packet Audio/Video in The Network Environment –Video Transport across Generic Networks – Layered Video Coding– Error Resilient Video Coding Techniques – Scalable Rate Control – Streaming Video Across Internet – Multimedia Transport Across ATM Networks and IP Network – Multimedia Across Wireless Networks.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
□	Apply various communication standards in multimedia communication
□	Utilize different networks for multimedia communication

□	Understand Broadband Network technology
□	Improve different protocols for efficient communication.
□	Address various multimedia communication standards

Reference Books(s) / Web links:	
1	B O Szuprowicz, "Multimedia Networking", McGraw Hill, Newyork, 1995.
2	K R Rao, Zoran S, Bojkovic and Dragorad A, Milovanovic "Multimedia communication systems", PHI, 2003.
3	Jon Crowcroft, Mark Handley, Ian Wakeman "Internetworking Multimedia" Harcourt, Singapore, 1998.
4	Tay Vaughan,"Multimedia Making it to work", 4th edition Tata McGraw Hill, NewDelhi, 2000.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23D12.1	3	3	3	2	2	2
CU23D12.2	3	3	3	3	2	2
CU23D12.3	3	3	3	3	2	2
CU23D12.4	3	3	3	3	3	2
CU23D12.5	3	3	3	3	3	2
Average	**3**	**3**	**3**	**2.8**	**2.4**	**2**

Subject Code	Subject Name	Category	L	T	P	C
CU23D13	**MILLIMETER WAVE COMMUNICATION**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
□	To understand the fundamentals of Millimeter wave devices and circuits.
□	To understand the various components of Millimeter wave Communications system.
□	To know the antenna design at Millimeter wave frequencies.

UNIT-I	**INTRODUCTION**	**9**
Millimeter wave characteristics- millimeter wave wireless, implementation challenges, Radio wave propagation for mm wave: Large scale propagation channel effects, small scale channel effects, Outdoor and Indoor channel models, Emerging applications of millimeter wave communications.		
UNIT-II	**MM WAVE DEVICES AND CIRCUITS**	**9**
Millimeter wave generation and amplification: Peniotrons, Ubitrons, Gyrotrons and Free electron lasers. HEMT, models for mm wave Transistors, transistor configurations, Analog mm wave components: Amplifiers, Mixers, VCO, PLL. Metrics for analog mm wave devices, Consumption factor theory, Trends and architectures for mm wave wireless, ADC's and DAC's.		
UNIT-III	**MM WAVE COMMUNICATION SYSTEMS**	**9**

Modulations for millimeter wave communications: OOK, PSK, FSK, QAM, OFDM, Millimeter wave link budget, Transceiver architecture, Transceiver without mixer, Receiver without Oscillator, Millimeter wave calibration, production and manufacture, Millimeter wave design considerations.		
UNIT-IV	**MM WAVE MIMO SYSTEMS**	**9**
Massive MIMO Communications, Spatial diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise coupling in MIMO system, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation.		
UNIT-V	**ANTENNAS FOR MM WAVE SYSTEMS**	**9**
Antenna beamwidth, polarization, advanced beam steering and beam forming, mm wave design consideration, On-chip and In package mm wave antennas, Techniques to improve gain of on-chip antennas, Implementation for mm wave in adaptive antenna arrays, Device to Device communications over 5G systems, Design techniques of 5G mobile.		
	Total Contact Hours : 45	

Course Outcomes:	
On completion of the course, students will be able to	
□	Understand the basic concepts of Millimeter wave devices and circuits
□	Analyze the Millimeter wave devices for various applications
□	Design antenna for Millimeter wave frequencies
□	Assess Knowledge of Millimeter wave technology.
□	Implementation of mm wave in adaptive antenna arrays

Reference Books(s) / Web links:	
1	K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
2	Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014. 3. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications: Springer, 2016.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Assignment problems
- Quizzes
- Class Presentation/Discussion

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23D13.1	3	3	3	2	2	1
CU23D13.2	3	3	3	1	2	1
CU23D13.3	3	3	3	2	1	2
CU23D13.4	3	3	3	2	1	2
CU23D13.5	3	3	3	2	1	1
Average	**3**	**3**	**3**	**1.8**	**1.4**	**1.4**

Subject Code	Subject Name	Category	L	T	P	C
CU23D14	COMMUNICATION NETWORK SECURITY	PE	3	0	0	3

Objectives:	
	To introduce the concept of classical encryption techniques
	To understand the various cryptographic techniques
	To introduce the fundamental concept of public key encryption and hash functions
	To introduce IP security
	To learn the concept of security attacks and recent trends in wireless network security

UNIT-I	INTRODUCTION TO SECURITY	9
Services – Mechanisms and Attacks – OSI security Architecture – Model for Network Security – Classical Encryption Techniques – Symmetric Cipher Model – Substitution Techniques – Transposition Techniques– Stenography – Block Ciphers and Data Encryption Standard – Simplified DES – Block Cipher Principles		
UNIT-II	**ENCRYPTION STANDARD**	**9**
Data Encryption Standard – Strength of DES Differential and Linear Crypt Analysis, Block Cipher Design Principles – Block Cipher Modes of Operation. Advanced Encryption Standard – Evaluation Criteria for AES, AES Cipher– Contemporary Symmetric Ciphers – Triple DES, Blowfish, RC5 – Characteristics of Advanced Symmetric Block Ciphers – RC4 Stream Cipher		
UNIT-III	**HASH FUNCTIONS AND DIGITAL SIGNARURES**	**9**
Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC –MD5 - SHA - HMAC – CMAC - Digital signature and authentication protocols – DSS – EI Gamal – Schnorr.		
UNIT-IV	**NETWORK SECURITY PRACTICE**	**9**
Authentication Applications – Kerberos – X.509 Authentication Service– Electronic Mail Security, Pretty Good Privacy – S/MIME– IP Security – IP Security Overview– IP Security Architecture, Authentication Header – EncapsulatingSecurityPayload–CombiningSecurityAssociations–WebSecurity–WebSecurityConsiderations– SecureSocketsLayerandTransportLayer,Security–SecureElectronicTransaction.		
UNIT-V	**WIRELESSNETWORKSECURITY**	**9**
SecurityAttackissuesspecifictoWirelesssystems:Wormhole,Tunnelling,DoS.WEPforWi-Finetwork,Security for4Gnetworks:SecureAdhocNetwork,SecureSensorNetwork.		
	Total Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
	Apply public key crypto system and analyze with the applications.
	Apply authentication protocols and web security methods.
	Address the basic issues and challenges in wireless networks.
	Address various Security attacks issues.
	Familiar with IP security.

SUGGESTED ACTIVITIES (if any) (UNIT/ Module Wise) – Could suggest topic

- Problem solving sessions
- Flipped classroom
- Survey on various encryption techniques
- Implementation of small module

SUGGESTED EVALUATION METHODS (if Any) (UNIT/ Module Wise) – could suggest topic

- Tutorial problems
- Assignment problems
- Quizzes
- Class Presentation/Discussion

Reference Books(s) / Web links:	
1	William Stallings, "Network Security Essentials", 2nd edition, Prentice Hall of India New Delhi, 2004.
2	Charlie Kaufman, "Network Security Private Communication in Public World" 2nd edition, Prentice Hall of India New Delhi, 2004.
3	William Stallings, "Cryptography and Network Security", 3rd edition, Prentice Hall of India, New Delhi, 2004.
4	R.K.Nichols and P.C. Lekkas ," Wireless Security" McGraw Hill 2002.
5	C K Shyamala, N Harini and Dr. T R Padmanabhan: Cryptography and Network Security, Wiley India Pvt.Ltd
6	BehrouzA.Foruzan, Cryptography and Network Security, Tata McGraw Hill 2007.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23D14.1	3	3	2	3	3	1
CU23D14.2	3	3	3	3	3	2
CU23D14.3	3	3	2	2	2	2
CU23D14.4	3	3	3	3	2	2
CU23D14.5	3	3	3	3	3	2
Average	**3**	**3**	**2.6**	**2.8**	**2.6**	**1.8**

Subject Code	Subject Name	Category	L	T	P	C
CU23D15	**5G COMMUNICATION TECHNOLOGY**	**PE**	**3**	**0**	**0**	**3**

Objectives:	
□	To make the students to know about the various propagation methods and channel models.
□	To understand the concepts of multi carrier waveforms in 5G.
□	To introduce the various multiple access schemes for multi user systems. .
□	To know the principles of MIMO techniques.
□	To understand the concepts of cooperative communication.

UNIT-I	**5G CHANNEL MODEL**	**9**
Modeling requirements and scenarios, Channel model requirements and Measurements, Propagation scenarios, METIS channel models, Map-based model, stochastic model, Comparison of Models		
UNIT-II	**MULTI-CARRIER WAVEFORMS FOR 5G**	9
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		
UNIT-III	**MULTIPLE ACCESS TECHNIQUES IN 5G**	9
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		
UNIT-IV	**MASSIVE MIMO**	9
Introduction-pilot design and channel estimation- uplink data transmission and downlink data transmission for Single cell systems and multi cell systems – capacity analysis		
UNIT-V	**COOPERATIVE COMMUNICATION**	9
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 Contact Hours : 45	

Course Outcomes: On completion of the course, students will be able to	
□	Able to analyze the performance of different channel models adopted in 5G wireless systems.
□	Able to design a transceiver for Multicarrier waveforms.
□	Able to Infer multiple access techniques in 5G networks.
□	Able to analyze capacity for single cell and multicell Massive MIMO.
□	Able to summarize different types of cooperative communications.
Reference Books(s) / Web links:	
1	5G Core networks: Powering Digitalization , Stephen Rommer, Academic Press,2019
2	An Introduction to 5G Wireless Networks : Technology, Concepts and Use cases, Saro Velrajan,First Edition, 2020.
3	5G Simplified: ABCs of Advanced Mobile Communications Jyrki. T.J.Penttinen,Copyrighted Material
4	5G system Design: An end to end Perspective , Wan Lee Anthony, Springer Publications,2019
5	AfifOsseiran, Jose.F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
6	Erik Dahlman, Stefan Parkvall, Johan Sköld, "5G NR: The Next Generation Wireless Access Technology", Elsevier, 1stEdition, 2016. 20

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6
CU23D15.1	3	3	2	2	2	2
CU23D15.2	3	3	3	2	2	2
CU23D15.3	3	3	2	2	2	2
CU23D15.4	3	3	3	3	2	2
CU23D15.5	3	3	3	3	3	2
Average	**3**	**3**	**2.6**	**2.4**	**2.2**	**2**