S.A.ENGINEERING COLLEGE, CHENNAI
M.E. COMMUNICATION SYSTEMS
REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULA AND SYLLABI
SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA4101	Mathematics for communication Engineers	FC	3	1	0	4	4
2.	RM4101	Research Methodology and IPR	RMC	3	0	0	3	3
3.	EC4101	Advanced Discrete Signal Processing	PCC	3	0	0	3	3
4.	EC4102	Digital Communication Techniques	PCC	3	0	0	3	3
5.	EC4103	Advanced Wireless Communication	PCC	3	0	0	3	3
6.	EC4104	Radiating Systems	PCC	3	0	0	3	3
7.		Audit Course – I*	AC	2	0	0	2	0
PRACTICALS								
8.	EC4105	Communication Systems I Laboratory	PCC	0	0	3	3	3
			TOTAL	**20**	**1**	**3**	**24**	**22**

*Audit course is optional

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EC4201	MIC & RF System Design	PCC	3	0	0	3	3
2.	EC4202	Advanced Wireless Networks	PCC	3	0	0	3	3
3.	EC4203	Electromagnetic Interference and Compatibility	PCC	3	0	0	3	3
4.	EC4204	MIMO & OFDM Systems	PCC	3	0	0	3	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.		Professional Elective II	PEC	3	0	0	3	3
7.		Audit Course – II*	AC	2	0	0	2	0
PRACTICALS								
8.	EC4205	Communication System II Laboratory	PCC	0	0	3	3	3
9.	EC4206	Term Paper Writing and seminar	EEC	0	0	2	2	1
			TOTAL	**20**	**0**	**5**	**25**	**22**

*Audit course is optional

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EC4301	Millimeter wave Communication	PCC	3	0	0	3	3
2.		Professional Elective III	PEC	3	0	0	3	3
3.		Professional Elective IV	PEC	3	0	0	3	3
4.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
5.	EC4302	Project Work I	EEC	0	0	12	12	6
			TOTAL	**12**	**0**	**12**	**24**	**18**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	EC4401	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 74

PROFESSIONAL ELECTIVES

SEMESTER II, ELECTIVE I

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	EC4207	Optical Communication & Networking	PEC	3	0	0	3	3
2.	EC4208	Software Defined Radios	PEC	3	0	0	3	3
3.	EC4209	VLSI for Wireless Communication	PEC	3	0	0	3	3
4.	EC4210	Soft Computing	PEC	3	0	0	3	3
5.	EC4211	Radar Signal Processing	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE II

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	EC4212	High Speed Switching and Networking	PEC	3	0	0	3	3
2.	EC4213	Cognitive Radio Networks	PEC	3	0	0	3	3
3.	EC4214	Speech Processing	PEC	3	0	0	3	3
4.	EC4215	Real Time Embedded systems	PEC	3	0	0	3	3
5.	EC4216	Analog and Mixed Signal VLSI Design	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE III

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	EC4303	Ultra Wide Band Communications	PEC	3	0	0	3	3
2.	EC4304	Network Routing Algorithms	PEC	3	0	0	3	3
3.	EC4305	Smart Antennas	PEC	3	0	0	3	3
4.	EC4306	Wavelets & sub-band Coding	PEC	3	0	0	3	3
5.	EC4307	Broadband Access Techniques	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE IV

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	EC4308	Advanced Antenna Design	PEC	3	0	0	3	3
2.	EC4309	Telecommunication System Modeling and simulation	PEC	3	0	0	3	3
3.	EC4310	Advanced Satellite Navigation Systems	PEC	3	0	0	3	3
4.	EC4311	Signal Detection and Estimation	PEC	3	0	0	3	3
5.	EC4312	Cryptography & Network Security	PEC	3	0	0	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	AX4091	English for Research Paper Writing	2	0	0	0
2.	AX4092	Disaster Management	2	0	0	0
3.	AX4093	Constitution of India	2	0	0	0
4.	AX4094	நற்றமிழ் இலக்கியம்	2	0	0	0

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA4101	Mathematics for Communication Engineers	3	1	0	4	I

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RM4101	Research Methodology and IPR	3	0	0	3	1

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EC4206	Term Paper Writing and Seminar	0	0	2	1	II
2.	EC4302	Project Work I	0	0	12	6	III
3.	EC4401	Project Work II	0	0	24	12	IV

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EC4101	Advanced Discrete Signal Processing	3	0	0	3	I
2.	EC4102	Digital Communication Techniques	3	0	0	3	I
3.	EC4103	Advanced Wireless Communication	3	0	0	3	I
4.	EC4104	Radiating Systems	3	0	0	3	I
5	EC4105	Communication Systems I Laboratory	0	0	3	3	I
6.	EC4201	MIC & RF System Design	3	0	0	3	II

7.	EC4202	Advanced Wireless Networks	3	0	0	3	II
8.	EC4203	Electromagnetic Interference and Compatibility	3	0	0	3	II
9.	EC4204	MIMO & OFDM Systems	3	0	0	3	II
10.	EC4205	Communication System II Laboratory	0	0	3	3	II
11.	EC4301	Millimeter wave Communication	3	0	0	3	III

PROFESSIONAL ELECTIVE COURSES (PEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EC4207	Optical Communication & Networking	3	0	0	3	II
2.	EC4208	Software Defined Radios	3	0	0	3	II
3.	EC4209	VLSI for Wireless Communication	3	0	0	3	II
4.	EC4210	Soft Computing	3	0	0	3	II
5	EC4211	Radar Signal Processing	0	0	3	3	II
6.	EC4212	High Speed Switching and Networking	3	0	0	3	II
7.	EC4213	Cognitive Radio Networks	3	0	0	3	II
8.	EC4214	Speech Processing	3	0	0	3	II
9.	EC4215	Real Time Embedded systems	3	0	0	3	II
10.	EC4216	Analog and Mixed Signal VLSI Design	0	0	3	3	II
11.	EC4303	Ultra Wide Band Communications	3	0	0	3	III
12.	EC4304	Network Routing Algorithms	3	0	0	3	III
13.	EC4305	Smart Antennas	3	0	0	3	III
14.	EC4306	Wavelets & sub-band Coding	3	0	0	3	III
15.	EC4307	Broadband Access Techniques	3	0	0	3	III
16.	EC4308	Advanced Antenna Design	3	0	0	3	III
17.	EC4309	Telecommunication System Modeling and simulation	3	0	0	3	III
18.	EC4310	Advanced Satellite Navigation Systems	3	0	0	3	III
19.	EC4311	Signal Detection and Estimation	3	0	0	3	III
20.	EC4312	Cryptography & Network Security	3	0	0	3	III

SUMMARY

Sl. No.	NAME OF THE PROGRAMME: M.E. COMMUNICATION SYSTEMS					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	04	00	00	00	04
2.	PCC	15	15	03	00	33
3.	PEC	00	06	06	00	12
4.	RMC	03	00	00	00	03
5.	OEC	00	00	03	00	03
6.	EEC	00	01	06	12	19
7.	Non Credit/Audit Course	✓	✓	00	00	
8.	**TOTAL CREDIT**	**22**	**22**	**18**	**12**	**74**

MA4101 MATHEMATICS FOR COMMUNICATION ENGINEERS

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

The objective of this course is to enable the student to

Encourage students to develop a working knowledge of the ventral ideas of linear algebra

Grasp the basic concepts of Probability, Random variables, correlation and regression.

Characterize the phenomena which evolve with respect to time in a probabilistic manner.

Acquire skills in analyzing Queueing Models.

Develop a fundamental understanding of linear programming models and apply the simplex method for solving linear programming problems.

UNIT I LINEAR ALGEBRA

Vector spaces – Norms – Inner products – Eigenvalues using QR transformations – QR factorization – Generalized eigenvectors – Jordan Canonical forms – Singular value decomposition and applications – Least square approximations **12**

UNIT II PROBABILITY AND RANDOM VARIABLES

Probability Concepts – Axioms of probability – Conditional probability – Bayes theorem – Random variables – Probability functions – Two-dimensional random variables – Joint distributions – Marginal and conditional distributions – Correlation – Linear Regression. **12**

UNIT III RANDOM PROCESSES

Classification – Stationary random process – Markov process – Markov chain – Poisson process –Gaussian process – Auto correlation – Cross correlation. **12**

UNIT IV QUEUEING THEORY

Markovian queues – Single and multi-server models – Little's formula – Steady state analysis – Self-service queue. **12**

UNIT V LINEAR PROGRAMMING

Formulation – Graphical solution – Simplex method – Big M method – Variants of Simplex method – Transportation problems – Assignment models. **12**

TOTAL : 60 PERIODS

COURSE OUTCOMES:

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

CO1 Apply various methods in Linear Algebra to solve the system of linear equations.

CO2 Use two-dimensional random variables, correlations and regression in solving application problem.

CO3 Apply the ideas of Random Processes

CO4 Understand the basic characteristic features of a queueing system and acquire skills in analyzing queueing models.

CO5 Apply the Simplex method for solving linear programming problems.

TEXTBOOKS:

1. Friedberg A.H, Insel A.J. and Spence L, "Linear Algebra", Prentice Hall of India, New Delhi, 2004. (Unit-I)
2. T. Veerarajan, "Probability, Statistics and Random Process with Queueing Theory and Queueing Network, Tata McGraw Hill, 4th Edition,2017(Unit-II, Unit-III & Unit -IV)

3. Taha H.A., “Operations Research: An Introduction”, 9th Edition, Pearson Education Asia, New Delhi,2016.(Unit -V)

REFERNCES:

1.Miller,S.L. and Childers D.G., “Probability and Random Processes with Applications to Signal Processing and Communications”, Academic Press,2004.
2.Gross, D., Shortie, J.F., Thompson, J.M and Harris, C.M., “Fundamentals of Queueing Theory”, 4th Edition, Wiley,2014.
3. Richard Bronson, ”Matrix Operations” Schaum’s outline series, McGraw Hill, 2nd Edition, New York,2011.
4.Oliver C. Ibe, “ Fundamentals of Applied Probability and Random Processes”, Academic Press, (An Imprint of Elsevier), Boston,2014.

RM4101 RESEARCH METHODOLOGY AND IPR

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Identify an appropriate research problem in their research domain
- Understand the preparation of a well-structured research paper and scientific presentations without violating professional ethics
- Understand the Data Analysis and Interpretation
- Understand the law of Patent and copyrights
- Understand the adequate knowledge on Patent rights and to know the new developments in IPR.

UNIT I RESEARCH DESIGN **9**

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT II DATA COLLECTION AND SOURCES **9**

Effective literature studies approaches, analysis Plagiarism, Effective technical writing, how to write report, Paper Developing a Research Proposal, a presentation and assessment by a review committee, Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III DATA ANALYSIS AND REPORTING **9**

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation. Data Analysis using Software Package-SPSS and R.

UNIT IV INTELLECTUAL PROPERTY RIGHTS **9**

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Biodiversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V PATENTS **9**

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filing, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents. New Developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 45 PERIODS

COURCE OUTCOMES:

- Ability to understand research problem formulation.
- Ability to understand the way of doing Literature review and to write proposal in an effective way
- Ability to understand the data collection, data analysis, data presentation and statistical software.
- Ability to understand the nature of Intellectual Property Rights, Patenting process and IPR in national and international level collaborations
- Ability to understand about Patent rights, Patent systems and new developments in IPR.

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
3. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007
4. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013
5. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'.
6. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.

EC4101	ADAVNCED DISCRETE SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

To learn the concept of mathematical description and modelling of discrete time random signals.

To learn the concept of estimation and signal modelling

To know about the different methods to analyze the performance of estimators.

To learn the relevant figures of merit such as power, energy, bias and consistency.

To familiar with estimation, prediction and filtering concepts and techniques.

UNIT I- DISCRETE RANDOM SIGNAL PROCESSING **9**

Discrete random processes – Ensemble averages – Wide sense stationary process – Properties - Ergodic process – Sample mean & variance - Auto-correlation and Auto-correlation matrices- Properties – White noise process – Weiner Khitchine relation - Power spectral density – Filtering random process – Spectral Factorization Theorem – Special types of Random Processes – AR,MA, ARMA Processes – Yule-Walker equations

UNIT II - PARAMETER ESTIMATION THEORY **9**

Principle of estimation and applications-Properties of estimates-unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE)-Cramer Rao bound-Efficient estimators; Criteria of estimation: Methods of maximum likelihood and its properties ; Bayesian estimation : Mean square error and MMSE, Mean Absolute error, Hit and Miss cost function and MAP estimation

UNIT III- SPECTRUM ESTIMATION **9**

Bias and Consistency of estimators - Non-Parametric methods – Periodogram – Modified Periodogram – Barlett's method – Welch's mehod – Blackman-Tukey method – Parametric methods – AR, MA and ARMA spectrum estimation - Performance analysis of estimators

UNIT IV- SIGNAL MODELING AND OPTIMUM FILTERS **9**

Introduction- Least square method – Pade approximation – Prony's method – Levinson Recursion – Lattice filter - FIR Wiener filter – Filtering – Linear Prediction – Non Causal and Causal IIR Weiner Filter -– Mean square error – Discrete Kalman filter.

UNIT V - ADAPTIVE FILTERS **9**

FIR Adaptive filters - Newton's steepest descent method – Widrow Hoff LMS Adaptive algorithm – Convergence – Normalized LMS – Applications – Noise cancellation - channel equalization – echo canceller – Adaptive Recursive Filters - RLS adaptive algorithm – Exponentially weighted RLS-sliding window RLS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Analyze discrete time random processes

CO2: Apply appropriate model for estimation and signal modelling for the given problem

CO3: Analyze non-parametric and parametric methods for spectral estimation

CO4: Design optimum filter for the given problem

CO5: Design adaptive filters for different applications

REFERNCES:

1. John G. Proakis, Dimitris G. Manolakis, “Digital Signal Processing”, Prentice Hall of India, New Delhi, 2005.
2. Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley and Sons Inc., New York, 2006.
3. P. P. Vaidyanathan, “Multirate Systems and Filter Banks”, Prentice Hall, 1992.
4. Simon Haykin, “Adaptive Filter Theory”, Prentice Hall, Englehood Cliffs, NJ1986.
5. S. Kay,” Modern spectrum Estimation theory and application”, Prentice Hall, Englehood Cliffs, NJ1988.
6. Sophoncles J. Orfanidis, “Optimum Signal Processing “, McGraw-Hill, 2000.

EC4102	DIGITAL COMMUNICATION TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

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

Coherent receivers – Optimum receivers in WGN – IQ modulation & demodulation – Noncoherent receivers in random phase channels; MFSK receivers – Rayleigh and Rician channels – Partially coherent receivers – DPSK; M-PSK; M-DPSK-BER Performance Analysis. Carrier Synchronization- Bit synchronization.

UNIT II - EQUALIZATION TECHNIQUES **9**

Band Limited Channels- ISI – Nyquist Criterion- Controlled ISI-Partial Response signals- Equalization algorithms – Viterbi Algorithm – Linear equalizer – Decision feedback equalization – Adaptive Equalization algorithms.

UNIT III- BLOCK CODES **9**

Architecture and performance – Binary block codes; Orthogonal; Biorthogonal; Transorthogonal – Shannon‟s channel coding theorem; Channel capacity; Matched filter; Concepts of Spread spectrum communication – Coded BPSK and DPSK demodulators– Linear block codes; Hammning; Golay; Cyclic; BCH ; Reed – Solomon codes. Space time block codes.

UNIT IV- CONVOLUTIONAL CODES **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.

UNIT V - MULTICARRIER AND MULTIUSER COMMUNICATIONS **9**

Single Vs multicarrier modulation, orthogonal frequency division multiplexing (OFDM), Modulation and demodulation in an OFDM system, An FFT algorithmic implementation of an OFDM system, Bit and power allocation in multicarrier modulation, Peak-to-average ratio in multicarrier modulation. Introduction to CDMA systems, multiuser detection in CDMA systems – optimum multiuser receiver, suboptimum detectors, successive interference cancellation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Differentiate coherent and non-coherent receivers and analyse their performance under AWGN channel conditions

CO2: Illustrate the effect of signalling through bandlimited channels and Equalization techniques used to overcome ISI

CO3: Determine the channel capacity and design various block coding techniques to combat channel errors

CO4: Construct convolutional coders and analyze the performance of different decoding techniques.
CO5: Describe the basics of OFDM as a multicarrier communication and CDMA as a multiuser communication technique.

REFERNCES:

1. Bernard Sklar, “Digital Communications”, second edition, Pearson Education, 2001.
2. John G. Proakis, “Digital Communication”, Fifth Edition, Mc Graw Hill Publication, 2008.
3. M.K.Simon, S.M.Hinedi and W.C.Lindsey, “Digital communication techniques; Signal Design and Detection”, Prentice Hall of India, New Delhi, 1995.
4. Richard Van Nee & Ramjee Prasad, “OFDM for Multimedia Communications” Artech House Publication, 2001.
5. Stephen G. Wilson, “Digital Modulation and Coding”, First Indian Reprint, Pearson Education, 2003.
6. Simon Haykin, “Digital communications”, John Wiley and sons, 1998.
7. Theodore S.Rappaport, „Wireless Communications”, 2nd edition, Pearson Education, 2002.

EC4103	ADVANCED WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the concept of Wireless Communication and various propagation methods .
- To learn about Channel Capacity
- To study about the concept of Diversity
- To familiarize with MIMO Communications
- To learn about multiple user techniques used in the mobile communication.

UNIT I- WIRELESS CHANNEL PROPAGATION AND MODEL **9**

Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-free space,two ray. Small scale fading- channel classification- channel models — COST -231 Hata model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, 5G Channel model requirements and Measurements, propagation scenarios, METIS channel models, Map-based model, stochasticmodel.

UNIT II - CAPACITY OF WIRELESS CHANNELS **9**

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

UNIT III- 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 IV- MIMO COMMUNICATIONS **9**

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

UNIT V - MULTI USER SYSTEMS **9**

Introduction to MUD, Linear decorrelator, MMSE MUD, Adaptive MUD, MIMO-MUD Application ofconvex optimization to wireless design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Analyze the wireless channel characteristics and identify appropriate channel models

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

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

CO4: Understand the concepts in MIMO Communications

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

REFERNCES:

1. David Tse and Pramod Viswanath, Fundamentals of wireless communications, Cambridge University Press, First Edition, 2012

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

EC4104	RADIATING SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the concept of Antenna basics .
- To learn about Antenna arrays and their characteristics
- To study about operating Antennas
- To familiarize with modern Antennas and Measurement Techniques
- To learn about recent trends in Antenna Design

UNIT I- ANTENNA FUNDAMENTALS **9**

Wave equations, radiation pattern, HPBW,FNBW, gain and directivity, polarization, equivalent circuit, radiation resistance, Radiation integrals, Radiation from surface and line current distributions – dipole, monopole, loop antenna, Antenna parameters, Image theory; Induction, reciprocity theorem, Balance to unbalance transformer, Introduction to numerical techniques.

UNIT II - RADIATION FROM APERTURES **9**

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, design considerations.

UNIT III- ARRAYS **9**

Introduction-General structure of phased array, linear array theory, variation of gain as a function of pointing direction, effects of phase quantization, frequency scanned arrays, analog beamforming Matrices-Active modules, digital beam forming, MEMS technology in phased Arrays-Retro directive and self-phased arrays.

UNIT IV- MICRO STRIP ANTENNA AND ANTENNA MEASUREMENTS **9**

Radiation mechanism from patch; Excitation techniques; Microstrip dipole; Rectangular patch, Circular patch, and Ring antenna – radiation analysis from transmission line model, cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Applications of microstrip array antenna. Mobile phone antenna, base station, hand set antenna, UWB antenna, PIFA, Vivaldi antenna, Antenna for automobiles, Broadband antenna, antenna factor, Gain, impedance and radiation pattern measurements, Test sites and anechoic chamber.

UNIT V - MODERN TRENDS IN ANTENNAS **9**

UWB antenna arrays – Vivaldi antenna arrays – Artificial magnetic conductors/High impedance surfaces – Antennas in medicine – Plasma antennas – Antennas for millimeter wave communication - optimization techniques – Numerical methods

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the fundamentals behind the different techniques in antenna technology.

CO2: Understand the challenges associated in designing antennas based on different technologies

CO3: Understand the capability and assess the performance of various antennas.

CO4: Identify the antennas specific to the applications, design and characterize.

CO5: Understand the need for optimizing in antenna design and the methodologies for the same.

REFERNCES:

1. Balanis.A, “Antenna Theory Analysis and Design”, John Wiley and Sons, New York, 1982.
2. Hubregt.J.Visser “Antenna Theory and Applications” 1st Edition, John Wiley & Sons Ltd,New York,2012.
3. S.Drabowitch et.al., ”Modern Antennas”, 2nd Edition Springer science business Media,Inc.2005
4. Xavier Begaud, “Ultra Wide Band Antennas” , 1st Edition, ISTE Ltd and John Wiley & Sons Ltd, New York,2013.
5. Zhijun Zhang” Antenna Design for Mobile Devices” 1st Edition, John Wiley & Sons (Asia) Ltd, New York,2011.

EC4105 COMMUNICATION SYSTEM I LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

- To acquire knowledge on Transmission line and S- parameter estimation of microwave devices.
- To introduce the basics of Microstrip Patch Antenna and its analysis.
- To study & measure the performance of digital communication systems
- To learn about the design of digital filter and its adaptive filtering algorithms.

LIST OF EXPERIMENTS USE NETWORK ANALYSER FOR THE FOLLOWING EXPERIMENTS:

1. Measurement of transmission line parameters.

2. S-parameter estimation of Microwave devices.

3. Design and testing of a Microstrip coupler.

4. Characteristics of Microstrip patch antenna.

USE APPROPRIATE SIMULATION TOOLS FOR THE FOLLOWING EXPERIMENTS:

1. Generation & detection of binary digital modulation techniques.

2. Spread Spectrum communication system-Pseudo random binary sequence generation-Baseband DSSS.

3. Digital Filter Design

4. Performance evaluation of simulated CDMA system

5. Channel equalizer design(LMS,RLS)

6. Antenna Radiation Pattern measurement

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the completion of course, students are able to

CO1: Measure and analyze various transmission line parameters.

CO2: Design Microstrip patch antennas.

CO3: Implement the adaptive filtering algorithms

CO4: To generate and detect digital communication signals of various modulation techniques using MATLAB. Evaluate cellular mobile communication technology and propagation model.

CO5: Evaluate cellular mobile communication technology and propagation model

EC4201 MIC AND RF SYSTEM DESIGN

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the fundamentals of RF design and Microwave integrated circuits.
- To understand the various components of RF system for Wireless Communications.
- To know the basic techniques needed for analysis of RF systems.

UNIT I - CMOS PHYSICS, TRANSCEIVER SPECIFICATIONS AND ARCHITECTURES **9**

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. Transceiver Architectures: Receiver: Homodyne, Heterodyne, Image reject, Low IF Architectures, Transmitter: Direct up conversion, two step up conversion schemes.

UNIT II - IMPEDANCE MATCHING AND AMPLIFIERS **9**

Review of S-parameters and 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 schemes.

UNIT III - FEEDBACK SYSTEMS AND POWER AMPLIFIERS **9**

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, OSILLATOR, MIXER **9**

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 **9**

Introduction to MICs, Fabrication Technology, Advantages and applications, MIC components- Micro strip components, coplanar circuits: Transistors, switches, active filters. Coplanar microwave amplifiers: LNA design and Medium power amplifiers.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Interpret the basics of CMOS physics and transceiver architectures with their parameters

CO2: Anlyse the performance of impedance matching circuit and high frequency amplifier circuit

CO3: Analyze the key performance aspects of feedback systems and power amplifiers

CO4: Explore the fundamental working principle of RF filter, oscillator and mixer circuit

CO5: Comprehend the theoretical foundations of MIC components and fabrication technique.

REFERNCES:

1. T. Lee, "Design of CMOS RF Integrated Circuits", Cambridge, 2004.
2. B.Razavi, "RF Microelectronics", Pearson Education, 1997.
3. Jan Crols, Michiel Steyaert, "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.
6. Ingo Wolff," Coplanar Microwave Integrated circuits", John Wiley and sons, New Jersey, 2006.

EC4202	ADAVANCED WIRELESS NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Describe the main classes of wireless networks and the characteristics that differentiate them.

Analyse cellular networks for better mobility management and learn optimal routing protocols deployed for Ad- Hoc networks.

Analyse optimal transmission radius in sensor Networks and address security challenges.

Apply compound auctioning in multi-hop cognitive cellular networks

UNIT I –INTRODUCTION **9**

Generalized network model of advanced wireless networks. Wireless network design with small world properties. Frequency channels backup. Generalised network model. Routing Protocols. Network Performance. Node, route , topology and network robustness, Power consumption, Protocol complexity, , Performance Evaluation , Adaptive network layer.

UNIT II – MOBILITY MANAGEMENT **9**

Cellular Networks , cellular systems with prioritized handoff ,cell residing time distribution , mobility prediction in pico and micro cellular networks.

UNIT III- AD- HOC NETWORKS **9**

Routing Protocols , Hybrid routing protocol, scalable routing strategies , multipath routing , clustering protocols , cashing schemes for routing , Distributed QoS routing.

UNIT IV- SENSOR NETWORKS AND SECURITY **9**

Sensor Network parameters , sensor network architecture , mobile sensor network deployment , directed diffusion , aggregation in WSN, boundary estimation , optimal transmission radius in sensor networks , , Data funnelling, Equivalent transport control protocol in sensor networks . Security – Authentication , Security architecture , Key management , Security in Ad- Hoc networks and sensor networks

UNIT V-CONITIVE NETWORKS **9**

Technology background , Spectrum auctions for multi-hop cognitive networks , compound auctioning in multi – hop cognitive cellular networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the main classes of wireless networks and the characteristics that differentiate them

CO2: Apply mobility management strategies in pico and micro cellular networks.

CO3: Analyse the routing protocols for Ad- Hoc networks.

CO4: Analyse **sensor** networks parameters and the security challenges in their networks.

CO5: Analyse the security challenges in their networks

CO6: Understand spectrum auctioning in Cognitive networks

REFERENCES:

Advanced Wireless Networks , Technology and Business Models , Third Edition , Savo Glisic , Wiley Publications.

EC4203 ELECTRO MAGNETIC INTERFERENCE AND COMPATIBILITY L T P C
3 0 0 3

COURSE OBJECTIVES:

The students should be made to be familiar with:

- The basics of EMI ,Sources and its problem
- Coupling Mechanism
- Solution methods in PCB.
- Standards and Measurements techniques for emission.
- Measurement techniques for immunity.

UNIT I BASIC THEORY 9

Introduction to EMI and EMC, Intra and inter system EMI, Elements of Interference, Sources and Victims of EMI, Conducted and Radiated EMI emission and susceptibility, Case Histories, Radiation hazards to humans, Various issues of EMC, EMC Testing categories EMC Engineering Application.

UNIT II COUPLING MECHANISM 9

Electromagnetic field sources and Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling, Radioactive coupling, Ground loop coupling, Cable related emissions and coupling, Transient sources, Automotive transients.

UNIT III EMI MITIGATION TECHNIQUES 9

Working principle of Shielding and Murphy's Law, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketting and sealing, PCB Level shielding, Principle of Grounding, Isolated grounds, Grounding strategies for Large systems, Grounding for mixed signal systems, Filter types and operation, Surge protection devices, Transient Protection.

UNIT IV STANDARD AND REGULATION 9

Need for Standards, Generic/General Standards for Residential and Industrial environment, Basic Standards, Product Standards, National and International EMI Standardizing Organizations; IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. Electro Magnetic Emission and susceptibility standards and specifications, MIL461E Standards.

UNIT V EMI TEST METHODS AND INSTRUMENTATION 9

Fundamental considerations, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber, EMI test receivers, Spectrum analyzer, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes, MIL -STD test methods, Civilian STD test methods.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the basics of EMI ,Sources and its problem.

CO2: Remember the Coupling Mechanism and its types.

CO3: Discuss EMI mitigation techniques.

CO4: Understand various standards.

CO5: Compare EMI test methods.
CO6: Remember the Real time application in EMIC.

REFERENCES:

1. Bemhard Keiser, “Principles of Electromagnetic Compatibility”, 3 rd Ed, Artech house, Norwood, 1986.
2. Clayton Paul, “Introduction to Electromagnetic Compatibility”, Wiley Interscience, 2006.
3. Daryl Gerke and William Kimmel, “EDN‟s Designer’s Guide to Electromagnetic Compatibility”, Elsevier Science & Technology Books, 2002.
4. Dr Kenneth L Kaiser, “The Electromagnetic Compatibility Handbook”, CRC Press 2005.
5. Electromagnetic Compatibility by Norman Violette ,Published by Springer, 2013
6. Electromagnetic Interference and Compatibility: Electrical noise and EMI specifications Volume 1 of A Handbook Series on Electromagnetic Interference and Compatibility, Donald R. J. White Publisher-Don white consultants Original from the University of Michigan Digitized 6 Dec 2007
7. Henry W. Ott, “Electromagnetic Compatibility Engineering”, John Wiley & Sons Inc, Newyork,2009
8. V Prasad Kodali, “Engineering Electromagnetic Compatibility”, IEEE Press, Newyork, 2001.
9. W Scott Bennett, “Control and Measurement of Unintentional Electromagnetic Radiation”, John Wiley & Sons Inc., (Wiley Interscience Series) 1997.

EC4204	MIMO & OFDM SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To obtain impulse response coefficients from the power delay profiles of the fading channels.
- To determine the capacity and bit error rate of MIMO OFDM system for a given power delay profile of the MIMO channel.
- To analyze the performance of MIMO OFDM physical channel in WiMAX /LTE wireless standards

UNIT I - SAMPLED SIGNAL AND MULTIPATH FADINGCHANNEL MODELS **9**

Physical scattering models- Extended channel models Signal model for SISO, SIMO, MISO and MIMO ITU Channel Models- 3GPPP Channel Models - Extended ITU Models- Spatial Channel Model SCM Extension Channel Model, WINNER Channel Model

.

UNIT II - CAPACITY ANALYSIS & BIT ERROR RATE ANALYSIS **9**

Capacity in Frequency Flat Fading channel, Capacity in Frequency Selective Fading Channel - Transmit Beam forming- Receiver Selection Combining- Receiver Equal Combining- Receiver Maximal Ratio Combining

UNIT III - SPATIAL DIVERSITY AT TRANSMITTER AND RECEIVER **9**

Diversity gain- Transmit and receive Antenna diversity- Diversity order and performance- Combined space and path diversity- Indirect transmit diversity- space time coding for frequency flat channels- frequency selective channels- Receivers for SISO, SIMO and MIMO

UNIT IV - CHANNEL ESTIMATION AND TIMING & FREQUENCY SYNCHRONIZATION **9**

MIMOLS Estimation- MMSE Estimation- Robust MMSE Estimation-Coarse Time Synchronization- Fine Time Synchronization- Coarse Frequency Synchronization- Fine Frequency Synchronization

UNIT V - OFDM AND SPREAD SPECTRUM MODULATION **9**

SISO-OFDM- MIMO OFDM- SISO SS modulation- MISO SS modulation, Model, capacity and receiver gain of MIMO MAC, MIMO BC, MIMO MU

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand various channel models for MIMO OFDM systems

CO2: Analyse the capacity and BER performance to various MIMO OFDM systems

CO3: Estimate the MIMO channel impulse response using least square, MMSE and robust MMSE estimationalgorithms

CO4 : Estimate and correct the timing offset in the signal received at the MIMO OFDM receiver.

REFERNCES:

1. Paulraj, R. Nabar and D Gore, “Introduction to Space-Time Wireless

Communications", Cambridge University Press, First Edition, 2008.
2. D.Tse and P.Viswanath, "Fundamentals of Wireless Communications", Cambridge University Press, First Asian Edition, 2006.
3. Stefania Sesia, Issam Toufik, Matthew Baker, "LTE - The UMTS Long Term Evolution: From Theory to Practice", Wiley, 2nd Edition, 2011.
4. Y.S.Cho,J.Kim,Won Young Yang, Chung G. Kang, " MIMO OFDM Wireless Communications with MATLAB" John Wiley & sons(Asia) private Ltd, First Edition, 2010.
5. L. Hanzo, Y.A. Li Wang, M. Jiang "MIMO-OFDM for LTE, Wi-Fi andWiMAX ", John Wiley & Sons Ltd, First Edition,2010.
6. T.M. Duman, A. Ghrayeb "Coding for MIMO Communication Systems" John Wiley & Sons Ltd, First Edition,2007.
7. E. Biglieri, R. Calderbank, A. Constantinides, A. Goldsmith, A. Paulraj, "MIMO Wireless Communications", Cambridge University press, First Edition, 2010.
8. Erik. G. Larsson, "Space Time Block Coding for Wireless Communications", Cambridge University Press, First Edition, 2008.

EC4205 COMMUNICATION SYSTEMS LAB II L T P C

0 0 4 3

COURSE 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:

(ADS/IE3D/HFSS/CST or any similar/ equivalent tool may be used for the design)

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 micro strip patch antennas
7. Design and characterization of LNA
8. Design and characterization of Mixer
9. Design and characterization of VCO
10. Determination of Maximum bit rate of a digital fiber optic link

TOTAL 45 PERIODS

COURSE OUTCOMES:

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

CO1: Apply knowledge to identify a suitable architecture and systematically design an RF system.

CO2: Comprehensively record and report the measured data.

CO3: Analyze and interpret the experimentally measured data and produce meaningful conclusions.

CO4: Design RF components using microstrip technology

CO5: Develop microstrip filters.

EC4301 MILLIMETER WAVE COMMUNICATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVE:

To understand the basics about Millimetre Wave Communication

To analyse the antenna arrays and radio wave propagation

To understand the digital baseband circuits

To design the physical layer

UNIT I MILLIMETER WAVE COMMUNICATIONS **9**

Millimetre wave characteristics- millimetre 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 millimetre wave communications.

UNIT II RADIO WAVE PROPAGATION FOR MMWAVE **9**

Large-Scale Propagation Channel Effects, Small Scale Channel Effects, Spatial Characterization of Multipath and Beam Combining, Angle Spread and Multipath Angle of Arrival, Antenna Polarization, Outdoor and Indoor Channel Models.

UNIT III ANTENNAS AND ARRAY FOR MMWAVE APPLICATIONS **9**

Fundamentals of On-Chip and In-Package mm Wave Antennas, Fundamentals of On-Chip and In-Package mm Wave Antennas, In Package Antennas, Antenna Topologies for mm Wave Communications, Techniques to Improve Gain of On-Chip Antennas, Adaptive Antenna Arrays — Implementations for mm Wave Communications, Characterization of On-Chip Antenna Performance.

UNIT IV MULTI-GBPS DIGITAL BASEBAND CIRCUITS9 **9**

Sampling and Conversion for ADCs and DACs, Device Mismatches: An Inhibitor to ADCs and DACs, Goals and Challenges in ADC Design, Encoders, Trends and Architectures for mm Wave Wireless ADCs, Digital to Analog Converters.

UNIT V MMWAVE PHYSICAL LAYER DESIGN AND ALGORITHMS **9**

Practical Transceivers, High-Throughput PHYs, PHYs for Low Complexity, High Efficiency, Future PHY Considerations, Challenges and Networking mm Wave Devices

TOTAL: 45 PERIODS

COURSE OUTCOMES: On the successful completion of the course the students will be able to

CO1:Understand the wireless channel characteristics and identify appropriate channel models

CO2:Examine the radio wave propagation for mm wave

CO3: Design of antennas and array for Microwave applications.

CO4:Analyze the digital baseband Circuits

CO5: Design of mm wave Physical layer.

CO6: Analyse the applications of mm wave

TEXT BOOKS:

1. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011. (Unit I)
2. Theodore S. Rappaport, Robert W. Heath, Robert C. Daniel, James N.Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014. (Unit I to Unit V)

REFERNCE BOOKS:

1. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications: Springer, 2016.
2. Manual Garcia Sanchez, “Millimeter-Wave (mmWave) Communications”, Electronics, MDPI, 2020.

WEB REFERENCES

1. https://archive.nptel.ac.in/courses/117/105/117105139/
2. https://nptel.ac.in/courses/108105179

EC4207	OPTICAL COMMUNICATION AND NETWORKING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

- To enable the student to understand the basic principles of operation of optical system components, the different network architectures and issues associated with network design.
- To enable the student to understand the differences in the design of data plane and the control plane and the routing, switching and the resource allocation methods and the network management and protection methods in vogue.

UNIT I OPTICAL SYSTEM COMPONENTS AND NETWORK DESIGN **9**

Optical System Components – MZIM, Multiplexers; filters; switches; wavelength converters; optical amplifiers – EDFA, Raman Amplifiers and hybrid; Transmission system Engineering – System Model, Aimer penalty – transmitter, receiver, cross talk, dispersion compensation, wavelength stabilization, FWM.

UNIT II COHERENT SYSTEMS **9**

Basic principles of Coherent detections – Practical constraints – Injection laser line width state of polarization, local oscillator power, fiber limitations; Modulation formats – ASK, FSK, PSK, DPSK and polarization shift keying (POL SK); Demodulation schemes – Homodyne, Heterodyne – Synchronous and Non synchronous detection; Comparison; Carrier recovery in Coherent detection.

UNIT III OPTICAL NETWORK ARCHITECTURES **9**

Introduction to Optical Networks; First Generation optical networks –SONET / SDH Network,Second Generation (WDM) Optical Networks, Need for Multilayered Architecture-, Layers and Sub-layers, Spectrum partitioning, Optical Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays.

UNIT IV NETWORK CONNECTIONS **9**

Connection Management and Control; Static Networks, Wavelength Routed Networks; Linear Light wave networks; Logically Routed Networks; Routing and Wavelength Assignment , Traffic Grooming in Optical Networks

UNIT V OPTICAL NETWORK SURVIVABILITY **9**

Protection and Restoration Objectives, Fault Protection and Restoration Techniques in the Logical Layer – Point-to-Point Systems, SONET Self-Healing Rings, Interconnection Techniques,Architectures with Arbitrary Mesh Topologies ,Optical-Layer Protection: Point-to-Point and Ring Architectures, Mesh Architectures

COURSE OUTCOMES:

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

CO1: Demonstrate an understanding of the differences and challenges involved in the design of optical systems and networks.

CO2: Apply his knowledge for designing a fiber optic system addressing the channel impairments.

CO3: Familiar with the architectures and the protocol stack in use.in optical networks and would be able to identify a suitable backbone infrastructure for our present and future communication needs.

CO4: Understand how connections are managed in the network and the pros and cons of the different approaches

CO5: Appreciate the need for network survivability and the methodologies used.

CO6: Evaluate the methods for network performance.

TOTAL: 45 PERIODS

REFERNCES

1. Max Ming-Kang Liu, “Principles and Applications of Optical Communication”, Tata McGraw Hill Education Pvt., Ltd., New Delhi. 2010
2. Thomas E. Stern, Georgios Ellinas, Krishna Bala, “Multiwavelength Optical Networks – Architecture, Design and control “, Cambridge University Press, 2nd Edition, 2009.
3. Biswanath Mukherjee, “Optical Communication Networks”, McGrawHill Revised Edition 2006.
4. J.Gower, "Optical Communication System", Prentice Hall of India, 2001

5. C.Siva Ram Moorthy and Mohan Gurusamy, “WDM Optical Networks :Concept, Design and Algorithms”,Prentice Hall of India, First Edition, 2002.
6. Hussein T.Mouftab and Pin-Han Ho, “Optical Networks: Architecture and Survivability”, Kluwer Academic Publishers, 2002

EC4208	SOFTWARE DEFINED RADIOS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Basic function model for Software defined Radio Systems
- Designing the Architecture level for Digital Aspects of SDR
- Designing the Receiver of Multiband and Coverage Systems

UNIT I INTRODUCTION **12** **9**

The requirement for software defined radio, the benefits of multi-standard terminals, operational requirements, business models for software defined radio, new base station and network architectures, smart antenna systems.

UNIT II BASIC ARCHITECTURE OF A SOFTWARE DEFINED RADIO **9**

Software defined radio architectures; Ideal Software defined radio architectures, Required hardware specifications, Digital aspects of a Software Defined radio, Current technology limitations.

UNIT III FLEXIBLE RF RECEIVER ARCHITECTURES **12** **9**

Receiver architecture options, implementation of a digital receiver: frequency up conversion using under sampling, achieving processing gain using oversampling, Noise figure, Receiver sensitivity, ADC spurious signals.

UNIT IV MULTI-BAND AND GENERAL COVERAGE SYSTEMS **9**

Multiband Flexible receiver design, The problem of the Diplexer, Achieving Image rejection, Dynamic range enhancement, feedback and feed forward Technique

UNIT V FLEXIBLE TRANSMITTERS AND POWER AMPLIFIERS **12** **9**

Analog quadrature up conversion, quadrature up conversion with interpolation, Interpolated band pass up conversion, PLL based transmitters, Active All-pass filter, Use of high pass and low pass filters, Polyphase filtering.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand requirements, benefits and different models for Software Defined Radio

CO2: Understand in detail about Software Defined Radio Architecture for performance optimization.

CO3: Acquire complete knowledge regarding functioning of different blocks associated with Software Defined Radio

CO4: Design circuits at different multirate signalling technique for frequency conversion and sampling issues..

CO5: Comprehend various hardware and software requirements for software defined radios.

REFERENCES:

1. P Kenington, “RF and Baseband Techniques for Software Defined Radio”, Artec House,2005
2. Tony J Rouphael, RF and DSP for SDR, Elsevier Newnes Press, 2008.
3. Jouko Vanakka, “Digital Synthesizers and Transmitter for Software Radio”, Springer,2005
4. Wally H. W. Tuttlebee, “Software Defined Radio: Baseband Technologies for 3G Handsets and Base stations”, John Wiley & sons, 2003.

EC4209 VLSI FOR WIRELESS COMMUNICATION

L	T	P	C
3	0	0	3

COURSE 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 transmitters 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 TRANSMITTER ARCHITECTURES & POWER AMPLIFIERS **9**

Transmitter back end design – Quadrature LO generator – Power amplifier design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Recollect basic wireless communication concepts.

CO2: Understand the parameters in receiver and design a low noise amplifier

CO3:. Apply the knowledge on various types of mixers designed for wireless communication.

CO4:. Design PLL and VCO

CO5:. Understand the concepts of transmitters and utilize the power amplifiers in wireless communication.

REFERNCES:

1. Bosco H Leung “VLSI for Wireless Communication”, Pearson Education, 2002.
2. B.Razavi ,”RF Microelectronics” , Prentice-Hall ,1998.
3. Behzad Razavi, “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

EC4210	SOFT COMPUTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

To give the knowledge of soft computing theories fundamentals

To provide the mathematical background for carrying out the optimization associated with neural network learning

To familiarize the ideas of fuzzy sets, fuzzy logic, use of heuristics and Fuzzy Logic Control Systems

To introduce the mathematical background for genetic algorithms

To expose the hybrid soft computing systems and its applications

UNIT I SOFT COMPUTING FUNDAMENTALS **9**

Introduction: Soft Computing Constituents – From Conventional Al to Computational Intelligence – Applications - Introduction, characteristics- learning methods - taxonomy - Evolution of neural networks - Artificial Neural Network (ANN): Fundamental Concept – Basic Terminologies – Neural Network Architecture – Learning Process – Fuzzy logic: Introduction – crisp - sets- fuzzy sets - crisp relations and fuzzy-relations: Cartesian product.

UNIT II NEURAL NETWORKS **9**

Fundamental Models of ANN: McCulloch- Pitts Model –Hebb Network – Linear Separability Pitts Model –Hebb Network - Supervised Learning Networks: Perceptron Network – Adaline and Madaline Networks – Back Propagation Network – Radial Basis Function Network - Unsupervised Learning Networks: Kohonen Self Organizing Network – ART network - Hopfield Network - Special Network– Support Vector Machine- Kernel methods for Pattern classification- Kernel methods for function optimization.

UNIT III FUZZY COMPUTING AND MODELING **9**

Fuzzy Equivalence and Tolerance Relation – Value assignments- Fuzzy Composition- Membership Functions–Fuzzification- Defuzzification: lambda cuts - Fuzzy Arithmetic – Extension Principle – Fuzzy Measures –Fuzzy Classification – Fuzzy Rules and Fuzzy Reasoning: Fuzzy Propositions – Formation of Rules – Decomposition of Rules – Aggregation of Rules – Approximate Reasoning – Fuzzy Inference and Expert Systems – Fuzzy Decision Making – Fuzzy Logic Control Systems.

UNIT IV GENETIC ALGORITHM AND APPLICATIONS **9**

Genetic Algorithm: Fundamental Concept – Basic Terminologies – Traditional Vs Genetic Algorithm - Elements of GA - Encoding - Fitness Function – Genetic Operators: Reproduction – CrossOver - Inversion and Deletion - Mutation – Simple and General GA - The Schema Theorem- difference between GA and GP- Applications of GA. Multi-objective Optimization- Real-life case studies - optimization of traveling salesman problem using genetic algorithms

UNIT V HYBRID SOFT COMPUTING AND APPLICATIONS **9**

Case Studies: Neuro-fuzzy Hybrid system- genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetic hybrid systems - simplified fuzzy ARTMAP – Applications: A fusion approach of multispectral images with SAR - Knowledge Leverage Based TSK

Fuzzy System Modeling - Fuzzy C-Means algorithms for very large Data. Hybrid GA for Feature Selection- Multiobjective Genetic Fuzzy Clustering for pixel classification- Clustering Wireless Sensor Network Using Fuzzy Logic
and Genetic Algorithm

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Apply various soft computing concepts for practical applications

CO2: Choose and design suitable neural network for real time problems

CO3: Use fuzzy logic rules and reasoning to handle uncertainty and develop decision making andexpert system

CO4: Describe the importance of genetic algorithms for solving combinatorial optimization problems

CO5: Analysis the various hybrid soft computing techniques and apply in real time problems

CO6: To be familiar with the design of fuzzy logic, neural networks and soft computing techniques

TEXTBOOKS

1. S.N. Sivanandam, S.N. Deepa, "Principles of Soft Computing", Wiley, Second Edition, 2011.
2. S. Rajasekaran, G.A.V Vijayalakshmi Pai, "Neural Networks, Fuzzy Systems and EvolutionaryAlgorithms: Synthesis and Applications" Prentice Hall, Second Edition, 2017.

REFERNCES

1. Timothy J. Ross, "Fuzzy Logic with Engineering Applications, 4th Edition, Wiley 2016.

2. David E. Goldberg, Genetic Algorithm in Search Optimization and Machine Learning Pearson Education India, 2013.

3.James A. Freeman, David M. Skapura, Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Education India, 2011.

4. J. -S. R. Jang, C.-T. Sun, E. Mizutani, "Neuro Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, Pearson, 2015.

5. Simon Haykin, Neural Networks Comprehensive Foundation Third Edition, Pearson Education,.2016.

EC4211	RADAR SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the Radar Signal acquisition and sampling in multiple domains
- To provide clear instruction in radar DSP basics
- To equip the skills needed in both design and analysis of common radar algorithms
- To understand the basics of synthetic aperture imaging and adaptive array processing.
- To illustrate how theoretical results are derived and applied in practice

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, The waveform matched filter, Matched filtering of moving targets, The ambiguity function, The pulse burst waveform, frequency-modulated pulse compression waveforms, Range sidelobe 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 center antenna processing

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Perform radar signal acquisition and sampling

CO2: Perform algorithm on radar processing

CO3: Design basic radar algorithm.

CO4 Design on aperture imaging and array processing.

CO5: Illustrate theoretical results are derived and applied in practice

.

REFERNCES:

1. Michael O Kolawole, "Radar systems, Peak Detection and Tracking", Elseveir. 2003
2. Introduction To Radar Systems 3/E, Skolnik, McGraw Hill. 2017
3. Radar Principles, Peyton Z. Peebles, Wiley India 2009
4. And Marvin N. Cohen, Fred E. Nathanson, Radar Design Principles-Signal Processing and the environment PHI, 2nd edition, 2006.
5. Merrill Skolnik, “Introduction to Radar Systems”, McGraw-Hill Education, 4th edition, September 2021.

EC4212 HIGH SPEED SWITCHING AND NETWORKING L T P C

3 0 0 3

COURSE OBJECTIVE:

- To explore the various space division switches
- To enable the various network performance analysis
- To get the clear idea about the various multimedia application
- To get a clear idea about the traffic and Queuing systems.
- Interpret the basics of security management and the various attacks & its countermeasures

UNIT I SWITCHING ARCHITECTURES 9

Shared medium switches – Shared memory switches – Space division switches – Cross bar based switching architecture – Input queued, Output queued and Combined input-output queued switches – Non blocking and blocking cross bar switches – Banyan networks – Batcher Banyan networks – Optical switches – Unbuffered and buffered switches – Buffering strategies – Optical packet switches and Optical burst switches – MEMS optical switches

UNIT II NETWORK PERFORMANCE ANALYSIS 9

Objectives and requirements for Quality of Service (QoS) in high performance networks. Architecture of high performance networks (HPN), design issues, protocols for HPN, VHF backbone networks, virtual interface architectures, virtual interface for networking, High-speed switching and routing - internet and PSTN IP switching techniques, SRP protocols, SRP authentication, and key exchange, comparison of TCP/IP, FTP, TELNET, queuing systems, network modeling as a graph

UNIT III 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 IV PACKET QUEUES AND DELAY ANALYSIS 9

Littles theorem, Birth and Death process, queueing discipline- Control & stability -, Markovian FIFO queueing system, Non-markovian - PollaczekKhinchin formula and M/G/1, M/D/1, self-similar models and Batch-arrival model, Networks of Queues – Burkes theorem and Jackson Theorem.

UNIT V NETWORK SECURITY AND MANAGEMENT 9

Principles of cryptography – Elliptic-AES Authentication – integrity – key distribution and certification– Access control and: fire walls – DoS-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:45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the fundamental concepts of the switching architecture involved in various switching types.

CO2: Interpret the basics of various protocols and QOS in the network performance.

CO3: Understand the various types of multimedia networking application

CO4: Recognize the concepts of various analysis method involved in the processing

CO5: Understand fundamental issues involved in providing the security as well as the management.

CO6: Address various multimedia communication standards

REFERNCES

1. Damitri P Bertsekas and Gallager, “Data Networks”, 2nd edition, PHI,1992.

2. H.Jonathan Chao and Bin Liu, “High Performance Switches and Routers”,John Wiley and Sons, 2007.

3. Howard C Berkowitz, “Designing Routing and Switching Architectures for Enterprise Networksǁ”, Sams, 1999.

4. Luc De Ghein, “MPLS Fundamentals”, Cisco Press 2014

5. Hersent Gurle & petit, “IP Telephony, Packet Pored Multimedia Communication Systems”, Pearson Education 2003.

EC4213	COGNITIVE RADIO NETWORKS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understand the fundamental concepts of cognitive radio networks.
- Develop the cognitive radio, as well as techniques for spectrum holes detection that
- Cognitive radio takes advantages in order to exploit it.
- Understand the functions of MAC layer and Network layer and its various protocols
- Understand fundamental issues regarding dynamic spectrum access, the radio-resource
- management and trading
- Interpret the basics of security management and the various attacks & its countermeasures

UNIT I INTRODUCTION TO COGNITIVE RADIO **9**

Cognitive Radio : Techniques and signal processing History and background, Communication policy and Spectrum Management, Cognitive radio cycle, Cognitive radio architecture, SDR architecture for cognitive radio, Spectrum sensing Single node sensing: energy detection, cyclo stationary and wavelet based sensing- problem formulation and performance analysis based on probability of detection Vs SNR. Cooperative sensing: different fusion rules, wideband spectrum

UNIT II SPECTRUM SENSING AND TRADING **9**

Introduction –Spectrum Sensing – Multiband Spectrum Sensing – Sensing Techniques – Other algorithms – Comparison – Performance Measure & Design Trade-Offs : Receiver operating characteristics – Throughput Performance measure –Fundamental limits and trade-off. Introduction to spectrum trading, classification to spectrum trading, radio resource pricing, brief discussion on economics theories in DSA (utility, auction theory), classification of auctions (single auctions, double auctions, concurrent, sequential)

UNIT III MAC PROTOCOLS AND NETWORK LAYER DESIGN **9**

Functionality of MAC protocol in spectrum access –classification –Interframe spacing and MAC challenges – QOS – Spectrum sharing in CRAHN –CRAHN models – CSMA/CA based MAC protocols for CRAHN – Routing in CRN– Centralized and Distributed protocols – Geographical Protocol

UNIT IV DYNAMIC SPECTRUM ACCESS AND MANAGEMENT **9**

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

UNIT V TRUSTED COGNITIVE RADIO NETWORKS AND RESEARCH CHALLENGES **9**

Trust for CRN :Fundamentals – Models – Effects of Trust Management –Security properties in CRN – Route Disruption attacks –Jamming attacks –PU Emulation attacks. Network layer and transport layer issues, cross layer design for cognitive radio networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the fundamental concepts of cognitive radio networks.

CO2: Interpret the basics of various spectrum sensing techniques and algorithms

CO3: Understand the functions of MAC layer and Network layer and its various protocols

CO4: Recognize the concepts of cooperative spectrum sensing and handoff process

CO5: Understand fundamental issues regarding dynamic spectrum access, the radio-resource management and trading, as well as a number of optimization techniques for better spectrum exploitation.

REFERENCES

1. Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems", Hüseyin Arslan, Springer, ISBN 978-1-4020-5541-6 (HB), 2007.
2. Linda Doyle, "Essentials of Cognitive Radio", Cambridge University Press, 2009.
3. Kwang-Cheng Chen, Ramjee Prasad, "Cognitive radio networks", John Wiley & Sons Ltd., 2009.
4. Cognitive Radio Technology", by Bruce A. Fette, Elsevier, ISBN 10: 0-7506-7952-2, 2006.
5. Alexander M. Wyglinski, Maziar Nekovee, and Y. Thomas Hou, "Cognitive Radio Communications and Networks - Principles and Practice", Elsevier Inc., 2010

EC4214	SPEECH PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce speech production and related parameters of speech.
- To illustrate the concepts of speech signal representations and coding.
- To understand different speech modeling procedures such Markov and their implementation issues.
- To gain knowledge about text analysis and speech synthesis.
- To introduce speech production and related parameters of speech.

UNIT I FUNDAMENTALS OF SPEECH PROCESSING **9**

Introduction – Spoken Language Structure – Phonetics and Phonology – Syllables and Words –Syntax and Semantics – Probability, Statistics and Information Theory – Probability Theory –Estimation Theory – Significance Testing – Information Theory.

UNIT II - SPEECH SIGNAL REPRESENTATIONS AND CODING **9**

Overview of Digital Signal Processing – Speech Signal Representations – Short time Fourier Analysis – Acoustic Model of Speech Production – Linear Predictive Coding – Cepstral Processing– Formant Frequencies – The Role of Pitch – Speech Coding – LPC Coder, CELP, Vocoders.

UNIT III- SPEECH RECOGNITION **9**

Hidden Markov Models – Definition – Continuous and Discontinuous HMMs – Practical Issues –Limitations. Acoustic Modeling – Variability in the Speech Signal – Extracting Features – Phonetic Modeling – Adaptive Techniques – Confidence Measures – Other Techniques.

UNIT IV- TEXT ANALYSIS **9**

Lexicon – Document Structure Detection – Text Normalization – Linguistic Analysis – Homograph Disambiguation – Morphological Analysis – Letter-to-sound Conversion – Prosody – Generation schematic – Speaking Style – Symbolic Prosody – Duration Assignment – Pitch Generation

UNIT V - SPEECH SYNTHESIS **9**

Attributes – Formant Speech Synthesis – Concatenative Speech Synthesis – Prosodic Modification of Speech – Source-filter Models for Prosody Modification – Evaluation of TTS Systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Model speech production system and describe the fundamentals of speech.

CO2: Extract and compare different speech parameters.

CO3: Choose an appropriate statistical speech model for a given application.

CO4: Design a speech recognition system.

CO5: Use different text analysis and speech synthesis techniques.

REFERNCES:

1. Ben Gold and Nelson Morgan, “Speech and Audio Signal Processing, Processing and Perception of Speech and Music”, Wiley- India Edition, 2006
2. Claudio Becchetti and Lucio Prina Ricotti, “Speech Recognition”, John Wiley and Son 1999.
3. Daniel Jurafsky and James H Martin, “Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition”, Pearson Education, 2002.
4. Frederick Jelinek, “Statistical Methods of Speech Recognition”, MIT Press, 1997.
5. Lawrence Rabiner and Biing-Hwang Juang, “Fundamentals of Speech Recognition” Pearson Education, 2003.
6. Steven W. Smith, “The Scientist and Engineer‟s Guide to Digital Signal Processing” California Technical Publishing, 1997.
7. Thomas F Quatieri, “Discrete-Time Speech Signal Processing – Principles and Practice”, Pearson Education, 2004

EC4215	REAL TIME EMBEDDED SYSTEMS	L	T	P	C
		3	0	0	3

COURSE 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: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Choose suitable embedded processor for a given application

CO2: Design the hardware and software for the embedded system

CO3: Design and develop the real time kernel/operating system functions, task control block structure and analyze different task states

CO4: Implement different types of inter task communication and synchronization techniques

CO5: Know about the aspects embedded connectivity in real time systems

REFERNCES:

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.

EC4216	ANALOG AND MIXED SIGNAL VLSI DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To design and analyze mixed-signal integrated circuits

To analyze and design switched-capacitor circuits

To know mixed signal circuits like DAC, ADC

To gain knowledge on design in mixed signal design.

To acquire knowledge on design different architectures in mixed signal mode

UNIT I CURRENT MIRRORS 9

Analog Octagon - Simple CMOS current mirror - source degenerated current mirrors – high output impedance current mirrors- Bipolar current mirrors - Advanced current mirrors : Cascode stage Wilson current mirror - Bipolar current mirrors – Bipolar gain stages - Widlar current mirror - folded cascade and current mirror op amp - Mixed Cell Layout.

UNIT 2 OPERATIONAL AMPLIFIER DESIGN **9**

Performance Parameters - All NMOS enhancement mode Operational Amplifier Design - Two stage CMOS op amp – Gain Boosting - op amp as a comparator - Charge injection errors - Linear settling time revisited, fully differential op amp - Stability and Frequency Compensation - Phase margin - Latched Comparators - Basics of OTA Amplifiers Design.

UNIT 3 SWITCHED CAPACITOR CIRCUITS **9**

Basic SC circuits: Parallel - Series – Series - Parallel - Bilinear Operation and Analysis - Switched capacitor amplifier -Switched capacitor integrators - SC Trans resistance circuits - Z Domain Model Representation of Switched Capacitor Circuits - Switched Capacitor filter Design - First order and Second order.

UNIT 4 DATA ACQUISITION SYSTEMS **9**

Basics of Sample and hold circuits - CMOS S/H circuits - Bipolar and BiCMOS S/H circuits - translinear gain cell -Translinear multiplier - Band gap reference basics: Supply Independent Biasing, Temperature Independent References, PTAT Current Generation - High speed A/D and D/A converters - High resolution converters - Sigma delta A/D converter - Interpolative Modulators - Testing of converters.

UNIT 5 SU-MICRONS CMOS CIRCUIT DESIGN **9**

New VLSI device structures from bulk to SOI to multi-gate, Double gate MOSFET, FinFET, SiGe technology, Strain influence on electron mobility, Strain enhanced Si based transistors, Strained Si CMOS, SiGe HBTs, SiGe MODFETs, Nanowires.

COURSE OUTCOMES:

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

CO1: Design and implementation of current mirrors.

CO2: Design and analysis of operational amplifier.

CO3: Comprehensive understanding of Switched Capacitor circuits.

CO4: Study of data acquisition systems.

CO5: Understanding of basic Submicron CMOS circuits design.

CO6: Design, principles, operation and analysis of mixed signal circuits.

TOTAL: 45 PERIODS

REFERNCES

1. Gray, Hurst, Lewis, and Meyer, "Analysis and Design of Analog Integrated Circuits", 5 th Edition Wiley, 2009**..(UNIT 1)**
2. Gray R.Paul, Hurst J. Paul, Lewis H. Stephen and Meyer G. Robert, "Analysis and Design of Analog Integrated Circuits", 5th Edition, John Wiley and Sons, 2012**.(UNIT 2)**
3. Philip E. Allen and Douglas R. Holberg, "CMOS Analog Circuit Design", 3 rd Edition, Oxford University Press, 2012**..(UNIT 3)**
4. Rudy Van de Plassche "CMOS Integrated A/D and D/A converters", Kluwer Academic Publisher, 2012**.(UNIT 4)**
5. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", 2 nd Edition, McGraw Hill, 2017 **(UNIT 5)**
6. Tahira Parveen, "Textbook of Operational Transconductance Amplifier and Analog Integrated Circuits", I.K International Publishing house Pvt. Ltd, 2013.
7. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", 2 nd Edition, McGraw Hill, 2017.
8. Gray, Hurst, Lewis, and Meyer, "Analysis and Design of Analog Integrated Circuits", 5 th Edition Wiley, 2009.

EC4303	ULTRA WIDE BAND COMMUNICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

To give fundamental concepts related to Ultra-wide band

To understand the channel modelling and signal processing

To acquire knowledge about UWB antennas and regulations

To acquire knowledge in the UWB signal processing

To design UWB antenna for various applications

UNIT 1 UWB STANDARDS **9**

History, Definition, FCC Mask, UWB features, Benefits and challenges, UWB Interference: IEEE802.11.a Interference, Signal to Interference ratio calculation, Interference with other wireless services.

UNIT II UWB TECHNOLOGIES AND CHANNEL MODELS **9**

Impulse Radio, Pulsed Multiband, Multiband OFDM, features: Complexity, Power Consumption, Security and achievable data rate. MIMO Multiband OFDM, Differential multiband OFDM, Performance characterization, Ultra Wide Band Wireless Channels Channel model: Impulse Response Modeling of UWB Wireless Channels, IEEE UWB channel model, Path loss, Delay profiles, Time and frequency modeling.

UNIT III UWB SIGNAL PROCESSING **9**

Data Modulation schemes, UWB Multiple Access Modulation, BER, Rake Receiver, Transmit- Reference (T-R) Technique, UWB Range- Data Rate Performance, UWB Channel Capacity, UWB Wireless Locationing: Position Locationing Methods, Time of Arrival Estimation, NLOS Location Error Locationing with OFDM

UNIT IV UWB ANTENNAS **9**

Antenna Requirements, UWB in 5G MIMO antenna, Radiation Mechanism of the UWB Antennas, Types of Broad band antennas, Parameters, Analysis of UWB Antennas, Link Budget for UWB System. Design examples of broad band UWB antennas.

UNIT V UWB APPLICATIONS AND REGULATIONS **9**

Ultra wide band receiver architecture, Wireless Ad hoc Networking, UWB Wireless Sensor, RFID, Consumer Electronics and Personal, Asset Location, Medical applications, UWB Regulation and standards in various countries , UWB Regulation in ITU, IEEE Standardization.

TOTAL 45 PERIODS:

COURSE OUTCOMES:

CO1: Understand the basic concepts of UWB

CO2: Understand the basic concepts of UWB technologies

CO3: Analyze the performance of UWB channels

CO4: Apply the UWB signal processing

CO5: Design UWB antenna for various applications

CO6: Analyze of wireless channel and OFDM

TEXTBOOK:

1. Homayoun Nikookar and Ramjee Prasad, "Introduction to Ultra Wideband for Wireless Communications"1st Edition, Springer Science & Business Media B.V. 2010.
2. Thomas Kaiser, Feng Zheng "Ultra Wideband Systems with MIMO", 1st Edition, John Wiley& Sons Ltd, New York, 2010
3. W. Pam Siriwongpairat and K. J. Ray Liu, "Ultra-Wideband Communications Systems: Multiband OFDM approach" John Wiley and IEEE press, New York 2008.

REFERNCE BOOK:

1. Huseyin Arslan,Zhi Ning Chen,Maria-Gabriella Di Benedetto "Ultra Wideband Wireless communication" Wiley-Interscience; 1st edition 2006.
2. M. Ghavami, L. B. Michael and R. Kohno, "Ultra Wideband signals and systems in Communication Engineering", 2nd Edition, John Wiley & Sons, NY, USA, 2007.
3. Jeffrey H. Reed, "An Introduction to Ultra Wideband Communication systems", Prentice Hall Inc., NJ, USA, 2012.

EC4304	NETWORKING ROUTING ALGORITHMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

- To expose the students to the layered architecture for communication networks and the specific functionality of the network layer.
- To enable the student to understand the basic principles of routing and the manner this is implemented in conventional networks and the evolving routing algorithms based on internetworking requirements, optical backbone and the wireless access part of the network.
- To enable the student to understand the different routing algorithms existing and their performance characteristics.

UNIT I NETWORK ROUTING **9**

ISO OSI Layer Architecture, TCP/IP Layer Architecture, Functions of Network layer, General Classification of routing, Routing in telephone networks, Dynamic Non-hierarchical Routing (DNHR), Trunk status map routing (TSMR), real-time network routing (RTNR), Distance vector routing, Link state routing, Hierarchical routing.

UNIT II INTERNET ROUTING **9**

Interior protocol: Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Bellman Ford Distance Vector Routing. Exterior Routing Protocols: Exterior Gateway Protocol (EGP) and Border Gateway Protocol (BGP). Multicast Routing: Pros and cons of Multicast and Multiple Unicast Routing, Distance Vector Multicast Routing Protocol (DVMRP), Multicast Open Shortest Path First (MOSPF), MBONE, Core Based Tree Routing.

UNIT III ROUTING IN OPTICAL WDM NETWORKS **9**

Classification of RWA algorithms, RWA algorithms, Fairness and Admission Control, Distributed Control Protocols, Permanent Routing and Wavelength Requirements, Wavelength Rerouting- Benefits and Issues, Light path Migration, Rerouting Schemes, Algorithms- AG, MWPG.

UNIT IV MOBILE - IP NETWORKS **9**

Macro-mobility Protocols, Micro-mobility protocol: Tunnel based: Hierarchical Mobile IP, Intra domain Mobility Management, Routing based: Cellular IP, Handoff Wireless Access Internet Infrastructure (HAWAII).

UNIT V MOBILE AD –HOC NETWORKS **9**

Internet-based mobile ad-hoc networking communication strategies, Routing algorithms — Proactive routing: destination sequenced Distance Vector Routing (DSDV), Reactive routing: Dynamic Source Routing (DSR), Ad hoc On-Demand Distance Vector Routing (AODV), Hybrid Routing: Zone Based Routing (ZRP).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Explain basic concepts, OSI reference model, services and role of each layer of OSI model and TCP/IP, networks devices and transmission media, Analog and digital data transmission

CO2: Analysis of prototype and configure IP routing in a simulation environment

CO3: Understand WDM optical network architecture, Wavelength routed networks.

CO4: Understand the new trends in mobile/wireless communications networks.

CO5: Understand of the current topics in MANETs and WSNs, both from an industry and research point of views

CO6: Understand Wireless LANs & Wireless Sensor Networks Operation

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TEXTBOOKS

1. S. Keshav, "An engineering approach to computer networking",Addison Wesley 1999.(UNIT I)
2. William Stallings, "High speed Networks TCP/IP and ATM Design Principles", Prentice Hall, New York, 1998.(UNIT II)
3. C.Sivaramamurthy & M.Gurusamy, WDM optical Networks, PHI, 2002. (UNIT III)
4. Jochen Schiller, "Mobile Communications", 2nd edition, Pearson Education, 2009. (UNIT IV)
5. C.Siva Ram Murthy and B.S.Manoj, "Ad hoc Wireless Networks Architectures and protocols", 2nd edition, Pearson Education. 2007.(UNIT V)

REFERNCES

1. A.T Campbell et al., — Comparison of IP Micromobility Protocols, IEEE Wireless Communications Feb.2002, pp 72-82.
2. C.E Perkins, "Ad Hoc Networking", Pearson Education India, 2008.
3. C.Siva Rama Murthy and Mohan Gurusamy, "WDM Optical Networks — Concepts, Design and Algorithms", Prentice Hall of India Pvt. Ltd, New Delhi –2002.
4. Ian F. Akyildiz, Jiang Xie and Shantidev Mohanty, "A Survey of mobility Management in Next generation All IP- Based Wireless Systems", IEEE Wireless Communications Aug.2004, pp 16-27.
5. M. Steen Strub, "Routing in Communication network", Prentice Hall International, Newyork,1995.
6. William Stallings, "High speed networks and Internets Performance and Quality of Service", IV Edition, Pearson Education Asia. Reprint India 2011.

EC4305	SMART ANTENNAS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To gain an understanding and experience with smart antenna environments, algorithms and implementation
- To estimate DOA, AOA Estimations
- To develop adaptive algorithms for smart antennas
- To have an exposure to design the smart antennas using simulation tools

UNIT I- INTRODUCTION 9

Spatial processing- Adaptive antennas- Beam forming networks, Switched Beam systems, Spatial Processing Receivers, Adaptive Antenna Systems, Transmission Beam forming, Digital radio receiver techniques and software radios.

UNIT II- MULTI-USER SPATIAL PROCESSING TECHNIQUES 9

Multi-user spatial Processing, Dynamic re-sectoring- Range and capacity extension Range and Capacity analysis using smart antennas. Spatial – temporal channel models. Wireless Multipath Channel Models, Environment, and Signal Parameters, Spatial-Temporal Channel Models for Smart Antenna design, Spatial Channel Measurements, Application of Spatial Channel Models, Environment and signal parameters. Geometrically based single bounce elliptical model.

UNIT III- DOA ESTIMATION 9

DOA estimation – conventional and subspace methods. ML estimation techniques. Estimation of the number of sources using Eigen decomposition.DOA Estimation under Coherent Signal Conditions, The Integrated Approach to DOA Estimation, Direction finding and true ranging PL systems. Elliptic and hyperbolic PL systems. TDOA estimation techniques, In

UNIT IV DIELECTRIC RESONATOR ANTENNA 9

Introduction to Dielectric Resonator Antennas, Major Characteristics, Simple-Shaped Dielectric Resonator Antennas - The Hemispherical DRA. The Cylindrical DRA. The Rectangular DRA, Coupling to DRAs, Hybrid DRAs Bandwidth Enhancement of DRAs, Low Profile and Compact DRAs, DRAs with High Dielectric Constants, Circular-Polarized and Dual-Polarized DRAs, Ferrite Resonator Antennas.

UNIT V SIMULATION AND MEASUREMENT 9

Introduction to Simulation tools for smart antenna design- ADS, CST Microwave Studio, and ANSYS. Antenna measurement and instrumentation –Gain, Impedance and antenna factor measurement; Introduction to Vector Network Analyzer, Antenna test range design.

TOTAL :45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Understand the fundamental concepts spatial processing, digital radio receivers and software radios.

CO2: Analyze multi-user spatial processing techniques

CO3: Apply the concepts of DOA estimation.

CO4: Understand the concepts dielectric resonator antenna.

CO5: Evaluate the requirements for the design and implementation of smart antenna systems

CO6: Design, simulate and test the smart antennas for various applications

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REFERNCES:

1. T.S.Rappaport, J.C.Liberti, "Smart Antennas for Wireless Communication", Springer, First Edition, 2008.
2. R.Janaswamy, Radio Wave Propagation and Smart Antennas for Wireless Communication, Springer, Second Edition, 2008.
3. Bronzel, "Smart Antennas", John Wiley and Sons, First Edition, 2004.
4.Smart Antennas, T. K. Sarkar, Michael C. Wicks, M. Salazar-Palma, Robert J. Bonneau, John Wiley & Sons, 2005
5. Introduction to Smart Antennas, Constantine A. Balanis, Panayiotis I.Ioannides, Morgan & Claypool Publishers, 2007
6. Software Radio A Modern Approach to Radio Engineering, J. H. Reed, Pearson Education,2002.
7. Wireless and Cellular Communications, William C. Y. Lee, McGraw-Hill,2006
8. Wireless Communications- Principles and Practices, Theodore S. Rappaport, PHI,Pearson Education,2010.

Extensive Reading:

- http://www.ebook3000.com/Introduction-to-Smart-Antennas_92802.html
- http://www.4gamericas.org/documents/MIMO%20and%20Smart%20Antennas_July%202013_FINAL.pdf
- http://books.google.co.in/books/about/Introduction_to_Smart_Antennas.html?id=Tsx27uY1CrsC&redir_esc=y

EC4306 **WAVELETS & SUB-BAND CODING** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To familiarize with wavelet theory and signal representation.
- To construct Discrete Wavelet Transform by designing filter banks.
- To learn about Continuous Wavelet Transform and its properties
- To study the significance of wavelets in multi resolution analysis.
- To understand the compression techniques for various signals and to apply coding techniques

UNIT-I **WAVELET THEORY** **9**

Stationary and non-stationary signals, Signal representation using basis and frames, Brief introduction to Fourier transform and Short time Fourier transform, Time-frequency analysis, Bases of time frequency: orthogonal, Filter banks, Multi resolution formulation: Wavelets from filters, Classes of wavelets.

UNIT-II **DISCRETE WAVELET TRANSFORM AND FILTERBANKS** **9**

Orthogonal and bi-orthogonal two-channel filter banks, Design of two-channel filter banks, Tree-structured filter banks, Discrete wavelet transform, Non-linear approximation in the Wavelet domain, multi resolution analysis, Construction and Computation of the discrete wavelet transform, the redundant discrete wavelet transform

UNIT-III **CONTINUOUS WAVELET TRANSFORM** **9**

Continuous Wavelet Transform (CWT), Time and frequency resolution of the continuous wavelet transform, Construction of continuous wavelets: Spline, orthonormal, bi-orthonormal, Inverse continuous wavelet transform, Redundancy of CWT, Zoom property of the continuous wavelet transform, Filtering in continuous wavelet transform domain.

UNIT-IV **MULTI RESOLUTION ANALYSIS** **9**

Axiomatic Definition of Multiresolution Analysis, Construction of Wavelets Using Fourier Techniques - Meyer's Wavelet, Wavelet Bases for Piecewise Polynomial Spaces, Daubechies' Family of Regular Filters and Wavelets, Wavelet Series and Its Properties, Multiresolution Analysis and Two-Scale Equation, Generalization of Haar Basis to Multiple Dimensions, Design of Multidimensional Wavelets.

UNIT-V **SIGNAL COMPRESSION & SUB-BAND CODING** **9**

Speech Compression, High-Quality Audio Compression, Image Compression- Transform and Lapped Transform Coding of Images, Pyramid Coding of Images, Sub-band and Wavelet Coding of Images, Video Compression, Sub-band Decompositions for Video Representation and Compression, Joint Source- Channel Coding.

TOTAL: 45 PERIODS

Course Outcomes: On completion of course students will be able to

CO1: Understand the terminology that is used in the wavelets literature.

CO2: Apply DWT for multi resolution analysis

CO3: Analyze the time frequency representation of CT signals using CWT

CO4: Apply wavelets and multi resolution techniques to a problem at hand tool.

CO5: Understand the compression techniques for various signals and to apply coding techniques

CO6: Apply the compression techniques for various signal using Matlab.

TEXT BOOKS:

1. Wavelets and Sub band Coding, M. Vetterli and J. Kovacevic, Prentice Hall, 2007.
2. A Wavelet Tour of Signal Processing, 2nd edition, S. Mallat, Academic Press, 2008.
3. Wavelet transforms: Introduction, Theory and applications, Raghuveer rao and Ajit S. Bopardikar, Pearson Education Asia, 2000.

REFERENCE BOOKS:

1. Fundamentals of Wavelets: Theory, Algorithms, and Applications, J.C. Goswami and A.K. Chan, 2nd ed., Wiley, 2011.
2. Wavelets and their Applications, Michel Misiti, Yves Misiti, Georges Oppenheim, Jean-Michel Poggi, John Wiley & Sons, 2010.

EC4307	BROADBAND ACCESS TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

- To understand the current and emerging wired and wireless access technologies
- To acquire knowledge about cable modems and fiber access technologies.
- To have an exposure to different systems standards for next generation broadband
- To understand 5G Radio access techniques in.

UNIT I DIGITAL SUBSCRIBER LINES , CABLE MODEM **9**

Asymmetric Digital subscriber lines (ADSL) – Rate Adaptive subscriber line (RADSL)-ISDN Digital subscriber line (IDSL) - High bit rate DSL (HDSL) ,Cable Modem, DOCSIS – Physical Cabling, Dual Modem Operation, Hub Restriction, Upstream Operation – Downstream operation

UNIT II FIBER ACCESS TECHNOLOGIES **9**

Optical Fiber in access networks, Architecture and Technologies- Hybrid fiber – Coax (HFC) system, Switched Digital Video (SDV) – Passive optical networks (PON) – FTTX (FTTH, FTTB, FTTC, FTT cab) comparison, Broadband PON, Gigabit-Capable PON.

UNIT III BROAD BAND WIRELESS SERVICES **9**

Fixed Wireless, Direct Broadcast Satellite (DBS), Multi-channel multi point distribution services (MMDS), Local multi point distribution services (LMDS), and Wideband integrated Digital Interactive Services (WIDIS), Mobile Wireless 3G – IMT 2000, Introduction to LTE-A.

UNIT IV RADIO ACCESS TECHNIQUES **9**

Access Design Principles for Multi-user Communications – Multi-carrier with Filtering – Non-orthogonal Schemes for Efficient Multiple Access – Radio Access for Dense Deployments – Radio Access for V2X Communication.

UNIT V THE 5G ARCHITECTURE **9**

NFV and SDN, Basics about RAN architecture, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional split alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfil 5G Requirements, Enhanced Multi-RAT coordination features, Physical architecture and 5G deployment

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Understand the concept of digital subscriber lines and cable modem

CO2: Understand the fiber access technologies and their architectures

CO3: Design and Differentiate various wired and wireless broadband technology systems

CO4: Study the in-depth functioning of 5G radio access technologies.

CO5: Understand the concept of 5G architecture

CO6: Understand the industry requirements for man power in next generation networks

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TEXTBOOK:

1. Dennis J. Rauschmayer, "ADSL/VDSL Principles: A Practical and Precise Study of Asymmetric Digital Subscriber Lines and Very High Speed Digital Subscriber Lines", Macmillan Technology Series, 1998.
2. Gilbert Held, "Next Generation Modems: A Professional Guide to DSL and Cable Modems", John Wiley & Sons, 2000.
3. Leonid G. Kazovsky, Ning Cheng, Wei-Tao Shaw, David Gutierrez, Shing-Wa Wong, "Broadband Optical Access Networks", John Wiley and Sons, New Jersey, 2011.
4. 5G NR: The Next Generation Wireless Access Technology Erik Dahlman, Stefan Parkvall, Johan Sko¨ld Elsevier First Edition 2016
5. 5G Mobile and Wireless Communications Technology Afif Osseiran, Jose F. Monserrat, Patrick Marsch Cambridge University Press ,2016

REFERNCE BOOK:

1.Martin P. Clarke, "Wireless Access Network: Fixed Wireless Access and WLL Network Design and Operation", John Wiley & Sons 2000.
2. Niel Ransom and Albert A. Azzam, "Broadband Access Technologies: ADSL, VDSL Cable Modem, Fiber and LMDS", McGraw Hill, 1999.
3. Sassan Ahmadi, "LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies", Elsevier, 2014.
4. Walter J Woralski, "ADSL and DSL Technologies", McGraw Hill Computer Communication Series, Second Edition Oct 2001.
5. William Webb, "Introduction to Wireless Local Loop Broadband and Narrow Band System", Mobile Communication Series, Artech House Publishers, Second Edition 2000.
6. Fundamentals of 5G Mobile Networks Jonathan Rodriguez Wiley First Edition 2010

EC4308	ADVANCED ANTENNA DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

- To understand the antenna radiation characteristics and arrays.
- To enhance the student knowledge in the area of various antenna design.
- To enhance the student knowledge in the area of antenna for practical applications

UNIT I FUNDAMENTAL CONCEPTS **9**

Physical concept of radiation, Radiation pattern, near- and far-field regions, reciprocity, directivity, and gain, effective aperture, polarization, input impedance, efficiency, Friis transmission equation, radiation integrals and auxiliary potential functions

UNIT II THIN LINEAR ANTENNAS AND ARRAYS **9**

Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop, N-Element Linear Array, Antenna element spacing without grating lobes, Linear broadside array with non-uniform distributions, Gain of regularly spaced planar arrays with $d = \lambda/2$, Tchebyscheff Array antennas. Design wired antennas and development of micro strip network.

UNIT III SECONDARY SOURCES AND APERTURE ANTENNAS **9**

Magnetic currents, Duality, Images of electric and magnetic currents, electric and magnetic currents as sheet sources, Impressed and induced current sources, Induction and equivalence theorems, Field of a secondary or Huygens source, Radiation from open end of a coaxial line, Radiation through an aperture in conducting screen, slot antenna.

UNIT IV EFFECT OF MUTUAL COUPLING ON ANTENNAS **9**

Accounting for mutual effects for dipole array compensation using open-circuit voltages, compensation using the minimum norm formulation, Effect of mutual coupling- constant Jammers, Constant Signal, Compensation of mutual coupling-constant Jammers, Constant Signal, Result of different elevation angle. Design of wide band antenna.

UNIT V ADAPTIVE ARRAY CONCEPT **9**

Motivation of using Adaptive Arrays, Adaptive Array problem statement, Signal Environment, Array Element Spacing considerations, Array Performance, Concept of optimum Array Processing, Recursive Methods for Adaptive Error Processing.

TOTAL PERIODS: 45

COURSE OUTCOMES:

At the end of the course the student Can able to

CO1: Acquire the knowledge about basic antenna parameters.

CO2: Analyze wire antennas and arrays

CO3: Analyze secondary sources, aperture, broadband and frequency independent antennas

CO4: Apply the knowledge of mutual coupling on antennas, applications and numerical techniques
CO5: Understanding about adaptive array concept.

CO6: Design of smart antennas using Simulation Tools

TEXTBOOK:

1. Balanis, C., Antennas, John Wiley and sons (2007) 3rd
2. Milligan, Thomas A., Modern Antenna Design 2nd edition, IEEE press, Wiley Interscience (2005).
3. David B. Davidson, Computational Electromagnetics for RF and Microwave Engineering, Cambridge University Press 2005.

REFERNCE BOOK:

1. Neelakanta, Perambur S., and Chatterjee, Rajeswari, Antennas for Information Super Skyways: An Exposition on Outdoor and Indoor Wireless Antennas, Research Studies Press Ltd. (2004).
2.Godara, Lal Chand, Smart Antennas, CRC Press (2004).
3. Munk, Ben A., Finite Antenna Arrays and FSS, John Wiley and Sons (2003)

EC4309	TELECOMMUNICATION SYSTEM MODELING AND SIMULATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To enable the student to understand the various aspects of simulation methodology and performance
- To appreciate the significance of selecting sampling frequency and modeling different types of signals and processing them
- To expose the student to the different simulation techniques, their pros and cons and enable him to understand and interpret results using case studies

UNIT 1 SIMULATION METHODOLOGY **9**

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

UNIT II RANDOM SIGNAL GENERATION & PROCESSING **9**

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

UNIT III MONTE CARLO SIMULATION **9**

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

UNIT IV ADVANCED MODELS & SIMULATION TECHNIQUES **9**

Modelling and simulation of non-linearities : Types, Memoryless non-linearities, Non-linearity with memory, Modelling 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.

UNIT V EFFICIENT SIMULATION TECHNIQUES **9**

Tail extrapolation, pdf estimators, Importance Sampling methods, Case study: Simulation of a Cellular Radio System, wireless networks and satellite networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the different signal generation and processing methods

CO2: Mathematically model a physical phenomenon.

CO3: Simulate a phenomena so as to depict the characteristics that may be observed in a real experiment

CO4: Apply knowledge of the different simulation techniques for designing a communication system or channel

CO5: Validate a simulated system performance so as to match a realistic scenario

CO6 : Estimate Bit Error Rate for Wireless Communication Link

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REFERNCES:

1. William.H.Tranter, K. Sam Shanmugam, Theodore. S. Rappaport, Kurt L. Kosbar, Principles of Communication Systems Simulation, Pearson Education (Singapore) Pvt. Ltd, 2004.
2. M.C. Jeruchim, P.Balaban and K. Sam Shanmugam, Simulation of Communication Systems: Modeling, Methodology and Techniques, Plenum Press, New York, 2001.
3. Averill.M.Law and W. David Kelton, Simulation Modeling and Analysis, McGraw Hill Inc., 2000. 4. Geoffrey Gorden, System Simulation, Prentice Hall of India, 2nd Edition, 1992. 61
5. Jerry Banks, John S. Carson, Barry L. Nelso and David M. Nico, Discrete Event System Simulation, Prentice Hall of India, Fourth edition 2009.

EC4310 ADVANCED SATELLITE NAVIGATION SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVE:

- To Learn M2M developments and satellite applications.
- To understand satellite communication in IPv6 environment.

UNIT 1 NAVIGATION CONCEPTS **9**

Fundamentals of navigation systems and Position Fixing – Categories of navigation – Geometric concepts of Navigation – The Earth in inertial space – Different Coordinate Systems – Coordinate Transformation – Euler angle formulations – Direction cosine matrices formulation – Quaternion formulation.

UNIT II M2M DEVELOPMENTS AND SATELLITE APPLICATIONS **9**

Exploration 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 COMMUNICATION IN IPV6 ENVIRONMENT **9**

Review of IPv6 and its benefits for Satellite Networks - 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 – Key results and recommendations.

UNIT IV SATELLITE NAVIGATION AND GLOBAL POSITIONING SYSTEM **9**

Concepts of Radio and Satellite Navigation, GPS Principles, Signal model and Codes, Satellite Signal Acquisition, Mathematical model of GPS observables, Methods of processing GPS data GPS Receiver Operation and Differential GPS. IRNSS, GAGAN, GLONASS and Galileo.

UNIT V DEEP SPACE NETWORKS AND INTER PLANETARY MISSIONS **9**

Functional description - Design procedure and performance Criterion-Mars exploration Rover- Mission and space craft Summary-Telecommunication subsystem overview Ground Subsystem- Telecom subsystem and Link Performance Telecom Subsystem Hardware and software-Chandrayaan-1 Mission - Mission and space craft Summary-Telecommunication Subsystem Overview-Ground Subsystem

TOTAL 45 PERIODS:

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

CO1: Understand the Concept of satellite navigation systems.

CO2: Analyze M2M applications and services.

CO3: Analyze satellite communication in IPv6 environment.

CO4: Understand and characterize the satellite navigation with GPS.

CO5: Analyze deep space networks and Inter planetary subsystems.

C06 : Analyze the Application and navigation systems with Real-time standard

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TEXTBOOK:

1.Global Navigation Satellite Systems: New Technologies and Applications 2nd Edition, Kindle Edition by Basudeb Bhatta (Author) Format: Kindle Edition, March 2021

2. G. Maral, M. Bousquet, and Z. Sun, Satellite Communications Systems: Systems, Techniques and Technology. John Wiley & Sons. Febuaray 2020.

REFERNCE BOOK:

1. B. Sklar, Digital Communications: Fundamentals and Applications. Upper Saddle River, NJ, USA: Prentice-Hall, Inc. Jan 2018.

2. Global Navigation Satellite Systems, Inertial Navigation, and Integration (English, Hardcover, Grewal Mohinder S.), John Wiley & Sons, January 2021

EC4311 SIGNAL DETECTION AND ESTIMATION

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To understand the concepts of detection and estimation
- To learn the basics of multi-user detection theory
- To understand the theory behind various estimation techniques.
- To understand Wiener filter and Kalman filter in detail.
- To Design and analyze different receiver structure.

UNIT I PROBABILITY AND STOCHASTIC PROCESS **9**

Conditional Probability, Bayes' Theorem , Random Variables, Conditional Distributions and Densities, moments and distribution of random variables., Stationary Processes Cyclostationary Processes Averages and Ergodicity Autocorrelation Function Power Spectral Density Discrete Time Stochastic Processes, Spatial Stochastic Processes, Random Signals, Relationship of Power Spectral Density and Autocorrelation Function.

UNIT II SINGLE AND MULTIPLE SAMPLE DETECTION **9**

Hypothesis Testing and the MAP Criterion, Bayes Criterion, Minimax Criterion, Neyman -Pearson Criterion, Sequential Detection, The Optimum Digital Detector in Additive Gaussian Noise ,Performance of Binary Receivers in AWGN.

UNIT III FUNDAMENTALS OF ESTIMATION THEORY **9**

Formulation of the General Parameter Estimation Problem, Relationship between Detection and Estimation Theory, Types of Estimation Problems, Properties of Estimators, Bayes estimation, Minimax Estimation, Maximum-Likelihood Estimation, Comparison of Estimators of Parameters.

UNIT IV WIENER AND KALMAN FILTERS **9**

Orthogonality Principle, Autoregressive Techniques, Discrete Wiener Filter, Continuous Wiener Filter, Generalization of Discrete and Continuous Filter Representations, Linear Least-Squares Methods, Minimum-Variance Weighted Least-Squares Methods, Minimum-Variance, Least Squares, Kalman Algorithm - Computational Considerations, Signal Estimation, Continuous Kalman Filter, Extended Kalman Filter.

UNIT V APPLICATIONS **9**

Detector Structures in Non-Gaussian Noise , Examples of Noise Models, Receiver Structures, and Error-Rate Performance, Estimation of Non-Gaussian Noise Parameters Fading Multipath Channel Models, Receiver Structures with Known Channel Parameters, Receiver Structures without Knowledge of Phase, Receiver Structures without Knowledge of Amplitude or Phase, Receiver Structures and Performance with No Channel Knowledge.

TOTAL: 45 PERIODS

COURSEOUTCOMES:

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

CO1: Able to understand the basics of probability and stochastic process concepts in detection and estimation.

CO2: To design optimum detector and estimator for AWGN channel

CO3: Able to Implement and analyze the performance of various estimators.

CO4: To design Wiener and Kalman filters to solve linear estimation problems.

CO5: To Understand the basics of noise models and error rate of receivers.

CO6: To Apply his knowledge to design and develop novel receiver structures suitable for modern technology.

TEXT BOOKS

1. H. L. Van Trees, " Detection, Estimation and Modulation Theory: Part I, II, and III ", John Wiley & NY, 2004.
2. S. M. Kay, "Fundamentals of Statistical Signal Processing: Estimation Theory", Prentice Hall PTR, 2003.

REFERENCES

1. Ludeman, Lonnie C. Random processes: filtering, estimation, and detection. John Wiley & Sons, Inc., 2003

2. Sergio Verdu‟ Multi User Detection” Cambridge University Press, 1998

3. Steven M. Kay, "Fundamentals of Statistical Processing, Volume I: Estimation Theory”, Prentice Hall Signal Processing Series, Prentice Hall, PTR, NewJersy, 1993.

4. Thomas Schonhoff, "Detection and Estimation Theory”, Prentice Hall, NewJersy, 2007.

EC4312 CRYPTOGRAPHY AND NETWORK SECURITY

L	T	P	C
3	0	0	3

COURSE OBJECTIVE:

- To make the student understand the importance and goals of network security and cyber security and introduce them to the different types of attacks
- To expose the student to the different approaches in handling security and the algorithms in use for maintaining data integrity and authenticity.
- To enable the student to appreciate the practical aspects of security features design and their implementation in wired and wireless internetworking domains.

UNIT I OUTLINE OF NETWORK SECURITY AND CYBER SECURITY **9**

Security Goals, Cryptographic attacks, Security services and mechanisms Techniques: Cryptography and Steganography, Traditional Symmetric-Key Ciphers: Substitution Ciphers and Transposition Ciphers, Mathematics for Cryptography. Cyber Security Concepts: layers of security, Vulnerability, Threat, Internet Governance - Controls – Authentication, Attacks, Methods of defence, Security Models, risk management, Cyber Threats and its countermeasures.

UNIT II SYMMETRIC & ASYMMETRIC KEY ALGORITHMS **9**

Introduction to Block Ciphers and Stream Ciphers, Data Encryption Standards (DES), Advanced Encryption Standard (AES), RC4, Principle of asymmetric key algorithms, RSA Cryptosystem.

UNIT III INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT **9**

Message Integrity, Hash functions: SHA 512, Whirlpool, Digital signatures: Digital signature standards. Authentication: Entity Authentication: Biometrics, Key management Techniques.

UNIT IV NETWORK SECURITY, FIREWALLS AND WEB SECURITY **9**

Introduction on Firewalls, Types of Firewalls, IP Security, E-mail security: PGP-S/MIME, Web security: SSL-TLS, SET.

UNIT V WIRELESS NETWORK SECURITY **9**

Security Attack issues specific to Wireless systems: Worm hole, Tunneling, DoS. Security for WLAN, Security for Broadband networks: Security challenges in 4G and 5G deployments, Introduction to side channel attacks and their counter measures.

TOTAL 45 PERIODS:

COURSE OUTCOMES:

At the end of the course the student would be

CO1: Able to demonstrate an understanding of the ways in which network security and cyber security may get compromised and the basic principles of security algorithm design.

CO2: Familiar with the different types of security attacks, approaches to handling security and the algorithms in use for maintaining data integrity and authenticity

CO3: Able to implement and analyse the different algorithms and compare their performances.

CO4: Able to appreciate the practical aspects of security features design and their implementation in wired and wireless internetworking domains

CO5: Apply knowledge for designing or modifying existing algorithms and implementing them through simulation.

TEXTBOOK:

1. Behrouz A. Forouzan ,"Cryptography and Network security", McGraw- Hill, 2011
2. William Stallings, "Cryptography and Network security: principles and practice", Prentice Hall of India, New Delhi, 2nd Edition, 2002
3. Atul Kahate , "Cryptography and Network security", Tata McGraw-Hill, 2nd Edition, 2008.
4. B. B. Gupta, D. P. Agrawal, Haoxiang Wang, Computer and Cyber Security: Principles, Algorithms, Applications, and Perspectives, CRC Press, 2018.

REFERNCE BOOK:

1. R.K.Nichols and P.C. Lekkas , "Wireless Security: Models , threats and Solutions", McGraw- Hill, 2001.
2. H. Yang et al., "Security in Mobile Ad Hoc Networks: Challenges and Solution", IEEE Wireless Communications, Feb. 2004.
3. Nina Godbole, Sunit Belapure, "Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives", Wiley India Pvt. Ltd. , 2011
4. "Securing Ad Hoc Networks", IEEE Network Magazine, vol. 13, no. 6, pp. 24-30, December 1999.
5. "Security of Wireless Ad Hoc Networks," http://www.cs.umd.edu/~aram/wireless/ survey.pdf
6. David Boel et.al, "Securing Wireless Sensor Networks – Security Architecture", Journal of networks , Vol.3. No. 1. pp. 65 -76, Jan 2008.
7. Perrig, A., Stankovic, J., Wagner, D., "Security in Wireless Sensor Networks", Communications of the ACM, 47(6), 53-57, 2004.
8. Introduction to side channel attacks – http://gauss.ececs.uc.edu/Courses/ c653/ lectures/ SideC /intro.pdf.