ANNA UNIVERSITY, CHENNAI
AFFILIATED INSTITUTIONS
M.E. COMMUNICATION AND NETWORKING
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM
CURRICULA AND SYLLABI

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

1. To enable graduates to pursue research, or have a successful career in academia or industries associated with **Communication and Networking**, or as entrepreneurs.
2. To provide students with strong foundational concepts and also advanced techniques and tools in order to enable them to build solutions or systems of varying complexity.
3. To prepare students to critically analyze existing literature in an area of specialization and ethically develop innovative and research oriented methodologies to solve the problems identified.

PROGRAM OUTCOMES (POs):
Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OBJECTIVES (PSOs)

1. To analyze, design and develop computing solutions by applying foundational concepts of Communication and Networking.
2. To apply communication and network engineering principles and practices for developing quality protocols for scientific and business applications.
3. To adapt to emerging information and communication technologies (ICT) to innovate ideas and solutions to existing/novel problems.

Provide mapping of 1) POs to PEOs and 2) PSOs to PEOs.
Use the following marking:

Contribution 1: Reasonable 2: Significant 3: Strong

MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES WITH PROGRAMME OUTCOMES:

A broad relation between the programme objective and the outcomes is given in the following table

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES											
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
1	3	3	3	3	2	1	1	1	1	1	2	1
2	2	3	3	3	3	1	1	1	1	2	2	2
3	2	3	2	3	2	2	1	1	2	1	2	2

MAPPING OF PROGRAM SPECIFIC OBJECTIVES WITH PROGRAMME OUTCOMES:

A broad relation between the Program Specific Objectives and the outcomes is given in the following table

PROGRAM SPECIFIC OBJECTIVES	PROGRAMME OUTCOMES											
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
1	3	3	3	3	3	1	1	1	2	1	2	2
2	3	3	3	3	1	1	1	1	2	1	2	2
3	3	3	3	3	1	1	1	2	2	2	2	2

M.E. COMMUNICATION AND NETWORKING
SEMESTER COURSE WISE PO MAPPING

YEAR	SEMESTER	COURSE TITLE	a	b	c	d	e	f	g	h	i	j	k	l
YEAR I	SEM I	Applied Mathematics for Communication Engineers	3	3	3	3	2	2	3	2	2	3	2	3
		Advanced Digital Signal Processing	3	3	3	1	3	1	1	2	2	3	2	3
		Advanced Digital Communication Techniques	3	2	3	2	1	2	1	1	2	3	1	3
		Advanced Wireless Communications Systems	3	3	2	3	1	2	2	2	2	3	1	3
		Communication Networks Modelling and Simulation	3	3	2	3	2	3	2	2	3	3	1	3
		Professional Elective I												
		Communication Systems Laboratory	3	3	2	2	3	3	3	2	3	3	2	3
	SEM II	Communication Network Security	3	2	2	2	3	3	3	2	1	3	2	3
		Cognitive Radio Networks	3	2	2	3	1	3	3	2	1	3	2	3
		Advanced Wireless Networks	3	2	2	3	1	2	3	1	2	3	2	3
		Professional Elective II												
		Professional Elective III												
		Professional Elective IV												
		Networking Laboratory	3	2	2	2	2	1	3	3	3	2	2	3
		Term Paper Writing and Seminar	3	2	2	2	2	1	3	2	3	2	2	3
YEAR II	SEM III	Internet of Things	3	3	2	2	2	2	2	3	3	2	2	3
		Professional Elective V												
		Professional Elective VI												
		Project Work Phase I	3	2	3	2	2	3	3	3	2	3	2	3
	SEM IV	Project Work Phase II	3	2	3	2	3	3	3	3	2	3	2	3

ELECTIVES														
	SEM I ELECTIVE I	Analysis and Design of CMOS Analog Integrated Circuits	3	3	3	3	1	2	1	1	2	3	2	3
		RF Integrated Circuits	2	1	3	2	3	3	3	2	1	1	2	3
		Real Time Embedded Systems	1	1	3	2	3	3	2	1	1	1	2	3
		MEMS and NEMS	1	2	3	2	3	3	2	1	2	1	3	3
		Signal Integrity for High Speed Design	2	2	3	1	3	3	2	1	2	1	3	3
	SEM II ELECTIVE II	VLSI for Wireless Communication	2	3	2	2	1	2	2	1	2	2	3	3
		Digital Communication Receivers	3	3	2	2	1	1	2	1	2	2	2	3
		Electromagnetic Interference and Compatibility	3	3	2	2	2	1	2	2	2	1	2	3
		Detection and Estimation Theory	3	3	2	2	2	1	2	3	2	1	3	3
		Advanced Satellite Communication and Navigation Systems	3	2	2	2	2	2	3	3	2	1	3	3
	SEM II ELECTIVE III	Fundamentals of Cloud Computing	3	2	2	2	2	2	3	2	3	2	2	3
		Advanced Digital Image Processing	3	2	2	2	1	2	3	2	3	2	2	3
		Radar Signal Processing	2	3	2	2	1	2	3	2	3	3	2	3
		Speech Processing and Synthesis	3	2	2	2	2	2	2	3	3	2	1	3
		Pattern Recognition and Machine Learning	3	2	2	2	2	1	2	3	3	2	2	3
	SEM II ELECTIVE IV	Wavelet Transforms and its Applications	3	2	2	2	1	2	2	3	3	2	2	3
		DSP Processor Architecture and Programming	3	2	2	2	1	2	2	3	3	2	2	3
		Space Time Wireless Communication	3	2	3	2	1	1	2	3	3	2	2	3
		Broad Band Wireless Access Technologies	3	2	3	2	2	1	2	3	2	3	2	3
		Software Defined Radio	3	2	2	2	2	1	2	3	2	3	2	3

	SEM III ELECTIVE V	Network Routing Algorithms	3	2	2	3	2	2	1	3	2	2	2	3
		Optical Networks	3	2	2	2	1	2	2	3	2	2	2	3
		Multimedia Compression Techniques	3	2	2	2	1	2	3	2	3	2	2	3
		Ultra Wide Band Communication	3	2	2	2	2	1	3	2	3	2	2	3
		Game theory for Wireless Communication and Networking	2	3	2	2	1	2	3	2	3	2	2	3
	SEM III ELECTIVE VI	Soft Computing Techniques	3	2	2	2	2	1	3	2	1	2	2	3
		Network Processors	3	2	2	2	1	2	2	1	1	2	2	3
		Network Management	3	2	2	2	1	3	2	3	1	2	2	3
		Wireless Adhoc and Sensor Networks	2	2	2	2	1	2	2	1	1	2	3	3
		Parallel Processing												

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SEMESTER - I

SL.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5154	Applied Mathematics for Communication Engineers	FC	4	4	0	0	4
2.	AP5152	Advanced Digital Signal Processing	PC	5	3	2	0	4
3.	CU5151	Advanced Digital Communication Techniques	PC	3	3	0	0	3
4.	CU5291	Advanced Wireless Communications Systems	PC	3	3	0	0	3
5.	NC5101	Communication Networks Modelling and Simulation	PC	3	3	0	0	3
6.		Professional Elective I	PE	3	3	0	0	3
PRACTICALS								
7.	CU5161	Communication Systems Laboratory	PC	4	0	0	4	2
			TOTAL	**25**	**19**	**2**	**4**	**22**

SEMESTER II

Sl.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	NC5291	Communication Network Security	PC	3	3	0	0	3
2.	NC5251	Cognitive Radio Networks	PC	3	3	0	0	3
3.	NC5252	Advanced Wireless Networks	PC	3	3	0	0	3
4.		Professional Elective II	PE	3	3	0	0	3
5.		Professional Elective III	PE	3	3	0	0	3
6.		Professional Elective IV	PE	3	3	0	0	3
PRACTICALS								
7.	NC5211	Networking Laboratory	PC	4	0	0	4	2
8.	CP5281	Term Paper Writing and Seminar	EEC	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

SEMESTER III

SI.NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	CP5292	Internet of Things	PC	3	3	0	0	3
2.		Professional Elective V	PE	3	3	0	0	3
3.		Professional Elective VI	PE	3	3	0	0	3
PRACTICALS								
4.	NC5311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER IV

SI. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	NC5411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL NO. OF CREDITS:70

FOUNDATION COURSES (FC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA5154	Applied Mathematics for Communication Engineers	FC	4	4	0	0	4

PROFESSIONAL CORE (PC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	AP5152	Advanced Digital Signal Processing	PC	5	3	2	0	4
2.	CU5151	Advanced Digital Communication Techniques	PC	3	3	0	0	3
3.	CU5291	Advanced Wireless Communications Systems	PC	3	3	0	0	3
4.	NC5101	Communication Networks Modelling and Simulation	PC	3	3	0	0	3
5.	CU5161	Communication Systems Laboratory	PC	4	0	0	4	2
6.	NC5291	Communication Network Security	PC	3	3	0	0	3
7.	NC5251	Cognitive Radio Networks	PC	3	3	0	0	3
8.	NC5252	Advanced Wireless Networks	PC	3	3	0	0	3
9.	NC5211	Networking Laboratory	PC	4	0	0	4	2
10.	CP5292	Internet of Things	PC	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSE (EEC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CP5281	Term Paper and Seminar	EEC	2	0	0	2	1
2.	NC5311	Project Work Phase – I	EEC	12	0	0	12	6
3.	NC5411	Project Work Phase – II	EEC	24	0	0	24	12

PROFESSIONAL ELECTIVES (PE)*

SEMESTER I
ELECTIVE I

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	NC5001	Analysis and Design of CMOS Analog Integrated Circuits	PE	3	3	0	0	3
2.	NC5002	RF Integrated Circuits	PE	3	3	0	0	3
3.	CU5092	Real Time Embedded Systems	PE	3	3	0	0	3
4.	VL5091	MEMS and NEMS	PE	3	3	0	0	3
5.	AP5094	Signal Integrity for High Speed Design	PE	3	3	0	0	3

SEMESTER II
ELECTIVE II

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CU5073	VLSI for Wireless Communication	PE	3	3	0	0	3
2.	CU5071	Digital Communication Receivers	PE	3	3	0	0	3
3.	CU5292	Electromagnetic Interference and Compatibility	PE	3	3	0	0	3
4.	CU5072	Detection and Estimation Theory	PE	3	3	0	0	3
5.	CU5091	Advanced Satellite Communication and Navigation Systems	PE	3	3	0	0	3

SEMESTER II
ELECTIVE III

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	NC5003	Fundamentals of Cloud Computing	PE	3	3	0	0	3
2.	DS5291	Advanced Digital Image Processing	PE	3	3	0	0	3
3.	DS5292	Radar Signal Processing	PE	3	3	0	0	3
4.	NC5004	Speech Processing and Synthesis	PE	3	3	0	0	3
5.	CU5096	Pattern Recognition and Machine Learning	PE	3	3	0	0	3

SEMESTER II
ELECTIVE IV

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	CU5093	Wavelet Transforms and its Applications	PE	3	3	0	0	3
2.	DS5191	DSP Processor Architecture and Programming	PE	3	3	0	0	3
3.	CU5095	Space Time Wireless Communication	PE	3	3	0	0	3
4.	NC5005	Broad Band Wireless Access Technologies	PE	3	3	0	0	3
5.	CU5094	Software Defined Radio	PE	3	3	0	0	3

SEMESTER III
ELECTIVE V

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	NC5071	Network Routing Algorithms	PE	3	3	0	0	3
2.	CU5192	Optical Networks	PE	3	3	0	0	3
3.	MU5091	Multimedia Compression Techniques	PE	3	3	0	0	3
4.	CU5074	Ultra Wide Band Communication	PE	3	3	0	0	3
5.	NC5006	Game theory for Wireless Communication and Networking	PE	3	3	0	0	3

SEMESTER III
ELECTIVE VI

Sl.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MP5092	Soft Computing Techniques	PE	3	3	0	0	3
2.	NC5072	Network Processors	PE	3	3	0	0	3
3.	NE5071	Network Management	PE	3	3	0	0	3
4.	CU5097	Wireless Adhoc and Sensor Networks	PE	3	3	0	0	3
5.	NC5007	Parallel Processing	PE	3	3	0	0	3

MA5154 APPLIED MATHEMATICS FOR COMMUNICATION ENGINEERS L T P C
4 0 0 4

OBJECTIVES:

The primary objective of this course is to demonstrate various analytical skills in applied mathematics and extensive experience with the tactics of problem solving and logical thinking applicable in communication engineering. This course also will help the students to identify, formulate, abstract, and solve problems in electrical engineering using mathematical tools from a variety of mathematical areas, including linear algebra, matrix linear programming, probability, numerical solution of ordinary differential equations and queuing models.

UNIT I LINEAR ALGEBRA 12

Vector spaces – Norms – Inner products – Eigenvalues using QR transformations – QR factorization - Generalized eigenvectors – Canonical forms – Singular value decomposition and applications - Pseudo inverse – Least square approximations - Toeplitz matrices and some applications.

UNIT II LINEAR PROGRAMMING 12

Formulation – Graphical solution – Simplex method – Big M method - Two phase method - Transportation problems - Assignment models.

UNIT III NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS 12

Runge - Kutta method of fourth order for system of IVPs - Numerical stability of Runge - Kutta method - Adams - Bashforth multistep method - Shooting method, BVP : Finite difference method and collocation method and orthogonal collocation method.

UNIT IV PROBABILITY AND RANDOM VARIABLES 12

Probability – Axioms of probability – Conditional probability – Baye's theorem - Random variables - Probability function - Two dimensional random variables - Joint distributions – Marginal and conditional distributions – Functions of two dimensional random variables – Regression curve – Correlation**.**

UNIT V QUEUEING MODELS 12

Poisson Process – Markovian queues – Single and multi - server models – Little's formula - Machine interference model – Steady state analysis – Self service queue.

TOTAL : 60 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Concepts on vector spaces, linear transformation, inner product spaces, eigenvalues and generalized eigenvectors.
- Apply various methods in linear algebra to solve system of linear equations.
- Could develop a fundamental understanding of linear programming models, able to develop a linear programming model from problem description, apply the simplex method for solving linear programming problems.
- Numerical solution of differential equations by single and multistep methods.
- Computation of probability, random variables and their associated distributions, correlations and regression.
- Conceptualize the principle of optimality and sub-optimization, formulation and computational procedure of dynamic programming.
- Exposing the basic characteristic features of a queuing system and acquire skills in analyzing queuing models.
- Using discrete time Markov chains to model computer systems.

REFERENCES :

1. Bronson, R. and Costa, G. B., “Linear Algebra”, 2nd Edition, Academic Press, 2007.
2. Burden, R. C. and Faires, J. D., "Numerical Analysis ", 9th Edition, Cengage Learning, 2016.
3. Gross, D., Shortle, J.F., Thompson, J. M. and Harris, C. M., "Fundamentals of Queueing Theory “, 4th Edition, Wiley, 2014.
4. Johnson, R.A., Miller, I and Freund J., "Miller and Freund’s Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.
5. Sastry, S. S., "Introductory Methods of Numerical Analysis ", 5th Edition, PHI Learning, 2015.
6. Taha H.A., “Operations Research: An Introduction”, 9th Edition, Pearson Education Asia, New Delhi, 2016.

AP5152	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	2	0	4

OBJECTIVES:

- The student comprehends mathematical description and modelling of discrete time random signals.
- The student is conversant with important theorems and random signal processing algorithms.
- The student learns relevant figures of merit such as power, energy, bias and consistency.
- The student is familiar with estimation, prediction, filtering, multirate concepts and techniques.

UNIT I DISCRETE RANDOM SIGNAL PROCESSING 9+6

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 SPECTRUM ESTIMATION 9+6

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 III SIGNAL MODELING AND OPTIMUM FILTERS 9+6

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 IV ADAPTIVE FILTERS 9+6

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.

UNIT V MULTIRATE SIGNAL PROCESSING 9+6

Decimation - Interpolation – Sampling Rate conversion by a rational factor I/D – Multistage implementation of sampling rate conversion – Polyphase filter structures – Applications of multirate signal processing.

TOTAL45+30: 75 PERIODS

OUTCOMES:

- Formulate time domain and frequency domain description of Wide Sense Stationary process in terms of matrix algebra and relate to linear algebra concepts.
- State W-K theorem, spectral factorization theorem, spectrum estimation, bias and consistency of estimators.
- Wiener filtering, LMS algorithms, Levinson recursion algorithm, applications of adaptive filters
- Decimation, interpolation, Sampling rate conversion, Applications of multirate signal processing

REFERENCES:

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. S. Kay,” Modern spectrum Estimation theory and application”, Prentice Hall, Englehood Cliffs, NJ1988.
5. Simon Haykin, “Adaptive Filter Theory”, Prentice Hall, Englehood Cliffs, NJ1986.
6. Sophoncles J. Orfanidis, “Optimum Signal Processing “, McGraw-Hill, 2000.

CU5151	ADVANCED 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 noncoherent 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 CODED DIGITAL COMMUNICATION 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 CODED DIGITAL COMMUNICATION 9

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

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

OUTCOMES:

Upon Completion of the course, the students will be able to

- Develop the ability to understand the concepts of signal space analysis for coherent and non- coherent receivers.
- Conceptually appreciate different Equalization techniques
- Possess knowledge on different block codes and convolutional codes.
- Comprehend the generation of OFDM signals and the techniques of multiuser detection.

REFERENCES:

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. Simon Haykin, "Digital communications", John Wiley and sons, 1998.
6. Stephen G. Wilson, "Digital Modulation and Coding", First Indian Reprint, Pearson Education, 2003.
7. Theodore S.Rappaport, 'Wireless Communications", 2nd edition, Pearson Education, 2002.

CU5291 ADVANCED WIRELESS COMMUNICATIONS SYSTEM L T P C
3 0 0 3

OBJECTIVES:

The students should be made to:

- Understand Concepts of MIMO diversity and spatial multiplexing.
- Learn Massive MIMO system
- Know millimeter wave communication

UNIT I INFORMATION THEORETIC ASPECTS OF MIMO 10

Review of SISO fading communication channels, MIMO Channel models, Classical i.i.d. and extended channels, Frequency selective and correlated channels models, Capacity of MIMO channels, Erogodic and outage capacity, capacity bounds and influence of channel properties on the capacity.

UNIT II MIMO DIVERSITY AND SPATIAL MULTIPLEXING 10

Sources and types of diversity, analysis under Rayleigh fading, Diversity and channel knowledge. Alamouti space time code. MIMO spatial multiplexing: Space time receivers, ML, ZF, MMSE and Sphere decoding, BLAST receivers and Diversity multiplexing trade - off.

UNIT III MASSIVE MIMO SYSTEM 9

Introduction - MIMO for LTE, capacity of massive MIMO, Pilot Design for massive MIMO, Resource allocation and transceivers design, Base band and RF implementation, Channel Models.

UNIT IV MILLIMETER WAVE COMMUNICATION 8

Spectrum regulation, Channel propagation, Hardware technology for mmW systems, architecture and mobility, Beam forming techniques, Beam finding, Physical layer techniques - Duplex scheme and Transmission Scheme.

UNIT V SOFTWRE DEFINED RADIO AND COGNITIVE RADIO 8

SDR - Definition, Origin, key characteristic, hardware and software architecture, waveforms. Cognitive Radio - Definitions, Cognitive theories, architectures, Cognitive radio as self controlling system, Ontology based cognitive radio.

TOTAL : 45 PERIODS

OUTCOMES:

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

- Analyze MIMO system.
- Discuss millimeter wave communication.
- Demonstrate software defined radio and cognitive radio.

REFERENCES:

1. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press 2005.
2. Hamid Jafarkhani, "Space - Time Coding: Theory and Practices", Cambridge University Press 2005.
3. Mischa Dohler, Jose F. Monserrat Afif Osseiran " 5G Mobile and Wireless Communication Technology", Cambridge University Press 2016.
4. Mieczyslaw M Kokar, Lezek Lechowicz, "Cognitive Radio Interoperability through Waveform Reconfiguration" ARTECH House 2016.

NC5101 COMMUNICATION NETWORKS MODELLING AND SIMULATION L T P C
3 0 0 3

OBJECTIVES:

The students should be made to be

- Learn modeling and simulation
- Understand Monte Carlo simulation
- Study channel modeling and mobility modeling

UNIT I INTRODUCTION TO MODELING AND SIMULATION 9

Introduction, Discrete-event Simulation, Modeling for Computer Simulation, Tools and Methods for Network Simulation, The Simulation Platform, Simulation Framework, Tools and Modeling Approaches for Simulating Hardware.

UNIT II MONTE CARLO SIMULATION 9

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

UNIT III LOWER LAYER & LINK LAYER WIRELESS MODELING 9

Physical Layer Modeling, Description of the Main Components of the PHY Layer, Accurate Simulation of Physical Layers, Physical Layer Modeling for Network Simulations, Link Layer Modeling, Medium Access Control (MAC) Protocols, Logical Link Control, Forward Error Detection and Correction, Backward Error Detection and Correction, Queueing and Processing Delay.

UNIT IV CHANNEL MODELING & MOBILITY MODELING 9

Channel Modeling :The Physics of Radiation, The Nature of Electromagnetic Radiation, Classification of Propagation Models, Deterministic Approaches by Classical Field Theory, Deterministic Geometric Optical Approaches, Empirical Path Loss Approaches, Stochastic Shadowing Models, Stochastic Fading Models, MIMO Channel Models. Mobility modeling :Categorization of Mobility Models, Mobility Models, Random Walk Model, Random Waypoint Model, Random Direction Model, Gauss-Markov Model, Manhattan Model, Column Model , Pursue Model, Nomadic Community Model, Selection of Appropriate Mobility Models.

UNIT V HIGHER LAYER MODELING & MODELING THE NETWORK TOPOLOGY 9

Higher Layer Modeling :Modeling the Network Layer and Routing Protocols, Components of a Routing Protocol, Metrics, Virtual Routing on Overlays, Modeling Transport Layer Protocols, Modeling Application Traffic. Modeling the Network Topology : Abstraction of Network Topologies by Graphs, Characterizing Graphs, Common Topology Models, Geometric Random Graphs – The Waxman Model, Hierarchical Topologies, Preferential Linking – The Barabási-Albert Model , Modeling the Internet.

TOTAL: 45 PERIODS

OUTCOMES:

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

- Apply Monte Carlo simulation
- Discuss Lower Layer and Link Layer Wireless Modeling
- Compare channel modeling and mobility modeling

REFERENCES:

1. Irene Karzela, “Modeling and Simulating Communications Networks”, Prentice Hall India, 1998.
2. K.Wehrie. Gunes, J.Gross, “Modeling and Tools for Network simulation”, Springer, 2010.
3. M.C. Jeruchim, P.Balaban and K. Sam Shanmugam, “Simulation of Communication Systems: Modeling, Methodology and Techniques”, Plenum Press, New York, 2001.
4. Nejat; Bragg, Arnold, “Recent Advances in Modeling and Simulation Tools for Communication Networks and Services”, Springer, 2007
5. William.H.Tranter, K. Sam Shanmugam, Theodore. S. Rappaport, Kurt L. Kosbar, “Principles of Communication Systems Simulation”, Pearson Education (Singapore) Pvt. Ltd, 2004.

CU5161	COMMUNICATION SYSTEMS LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To understand the functioning of various modulation and coding techniques in Wireless Environment.
- To understand the functioning of adaptive filters and equalizers
- To understand wireless channel simulation and pathloss measurements
- To understand about the OFDM, MIMO and STBC.

LIST OF EXPERIMENTS:

1. Simulation of Modulation and Coding in a AWGN/ wireless Communication Channel using SDR kit / Simulation Packages.
2. Implementation of Linear and Cyclic Codes
3. Implementation of Adaptive Filters, periodogram and multistage multirate system in DSP Processor
4. Simulation of QMF using Simulation Packages.
5. Wireless Channel simulation and characterization
6. Pathloss Measurement and Characterization of Wireless Channels
7. Wireless Channel equalizer design (ZF / LMS / RLS) using Simulation Packages.
8. OFDM transceiver design using Simulation Packages.
9. Simulation of MIMO systems using Simulation Packages.
10. Implementation of STBC using Simulation Packages

TOTAL: 60 PERIODS

OUTCOMES:

Upon Completion of the course, the students will be able to:

- Ability to design various modulation and coding techniques for Wireless Environment.
- Ability to design various filters and equalizers.
- Ability to design OFDM signals
- Ability to design MIMO system with STBC

NC5291 COMMUNICATION NETWORK SECURITY L T P C
3 0 0 3

OBJECTIVES :

The students should be made to:

- Understand the need and concept of security
- Learn cryptosystems

UNIT I INTRODUCTION AND NUMBER THEORY 9

Introduction to Information Security, Computer Security & Network Security. Need For Security. Security – Goals, Attacks, Security Services and Mechanisms, and Techniques. Number Theory and Mathematics for Symmetric Cryptography- Finite Arithmetic, Congruence Arithmetic-Linear Congruence and Quadratic Congruence. Mathematics for Asymmetric-Key Cryptography: Fermat‟s Theorem and Euler‟s Theorem, Primes, Primality Testing, Factorization, CRT, Exponentiation. Classical Symmetric-Key Ciphers –Substitution Ciphers, Transposition Ciphers.

UNIT II SYMMETRIC AND ASYMMETRIC CRYPTOSYSTEMS 9

Modern Symmetric-Key Cipher - Block Ciphers (DES, 3DES, AES and its mode of operations), Stream Ciphers, Asymmetric-Key Cryptosystem- RSA, ElGamal, ECC, Key Management - Diffie-Hellman (DH) Mechanism, Kerberos – Needham Schroeder Protocol.

UNIT III AUTHENTICATION, DIGITAL SIGNATURES AND CERTIFICATES 9

Message Integrity & Message Authentication - Message Authentication Code (MAC), Cryptographic Hash Functions – Birthday Attacks, Digital Signatures - Digital Signature Standards (FIPS 186-2), DSA (ANSI X9.30), RSA (ANSI X9.31) – Public Key Distribution – RSA schemes, Digital Certificates - PKI Certificates, PKI Life Cycle Management .

UNIT IV TRUSTED IDENTITY 9

Entity Authentication: Password System- Fixed and One time Passwords (S/Key) RFC 2289 – Callback Systems, Zero Knowledge, Challenge and Response Systems – RADIUS —- ITU-T X.509.

UNIT V SECURITY AT LAYERS 9

Network Layer Security - IPSec, Transport Layer Security- SSL/TLS, SSH, Application Layer Security –PGP, S/MIME, Firewall - Concepts, Architecture, Packet Filtering, Proxy Services and Bastion Hosts.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of this course, the students should be able to:

- Explain digital signature standards
- Discuss authentication
- Explain security at different layers

REFERENCES:

1. Behrouz A.Forouzan, “Cryptography and Network Security”, Special Edition, Tata McGraw Hill, 2007.
2. Bruce Scheneier, “Applied Cryptography”, John Wiley & Sons, 1994.
3. Charlie Kaufmann, Radia Perlman, Mike Speciner, "Network Security", Second Edition, Prentice Hall, 2002. .
4. Douglas R.Stinson, “Cryptography: Theory and Practice”, CRC Press Series on Discrete Mathematics and its Applications, 1995
5. David M. Durton, “Elementary Number Theory”, Tata Mcgraw Hill, Sixth Edition, 2009.
6. William Stallings “Cryptography and Network Security: Principles and Practice”, 3rd Edition, Pearson Education, 2002.
7. William Stallings “Network Security Essentials: Applications and Standards”, 2nd Edition, Pearson Education, 2000.

	COGNITIVE RADIO NETWORKS	L	T	P	C
NC5251		3	0	0	3

OBJECTIVES:

The students should be made to be

- Understand the concepts of cognitive radio
- Learn spectrum sensing and dynamic spectrum access

UNIT I INTRODUCTION TO SOFTWARE-DEFINED RADIO AND COGNITIVE RADIO 9

Evolution of Software Defined Radio and Cognitive radio: goals, benefits, definitions, architectures, relations with other radios, issues, enabling technologies, radio frequency spectrum and regulations.

UNIT II COGNITIVE RADIO ARCHITECTURE 9

Cognitive Radio – functions, components and design rules, Cognition cycle – orient, plan, decide and act phases, Inference Hierarchy, Architecture maps, Building the Cognitive Radio Architecture on Software defined Radio Architecture, Overview of IEEE 802.22 standard for broadband wireless access in TV bands.

UNIT III SPECTRUM SENSING AND DYNAMIC SPECTRUM ACCESS 9

Introduction – Primary user detection techniques – energy detection, feature detection, matched filtering, cooperative detection , Bayesian Approach, Neyman Pearson fusion rule for spectrum sensing, Optimum spectrum sensing - Kullback Leibler Divergence and other approaches, Fundamental Tradeoffs in spectrum sensing, Spectrum Sharing Models of Dynamic Spectrum Access - Unlicensed and Licensed Spectrum Sharing, Fundamental Limits of Cognitive Radio.

UNIT IV MAC AND NETWORK LAYER DESIGN FOR COGNITIVE RADIO 9

MAC for cognitive radios – Multichannel MAC - slotted ALOHA – CSMA, Network layer design – routing in cognitive radios, flow control and error control techniques.

UNIT V ADVANCED TOPICS IN COGNITIVE RADIO 9

Cognitive radio for Internet of Things - Features and applications – Enabling technologies and protocols – M2M technologies - Data storage and analysis techniques - Requirement and challenges of IoT – Energy efficiency– MIMO Cognitive Radio – Power allocation algorithms.

TOTAL : 45 PERIODS

OUTCOMES:

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

- Compare MAC and network layer design for cognitive radio
- Discuss cognitive radio for Internet of Things and M2M technologies

REFERENCES:

1. Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou, “Cognitive Radio Communications and Networks”, Academic Press, Elsevier, 2010.
2. Bruce Fette, “Cognitive Radio Technology”, Newnes, 2006.
3. Huseyin Arslan (Ed.), “Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems, Springer, 2007.
4. Kwang-Cheng Chen, Ramjee Prasad, “Cognitive Radio Networks”, John Wiley and Sons, 2009.
5. S.Shanmugavel, M.A.Bhagyaveni, R.Kalidoss, “Cognitive Radio-An Enabler for Internet of things”, River Publishers, 2017.

NC5252 ADVANCED WIRELESS NETWORKS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To study about advanced wireless network, LTE, 4G and Evolutions from LTE to LTE.
- To study about wireless IP architecture, Packet Data Protocol and LTE network architecture
- To study about adaptive link layer, hybrid ARQ and graphs routing protocol.
- To study about mobility management, cellular network, and micro cellular networks

UNIT I INTRODUCTION 9

. Introduction to 1G/2G/3G/4G Terminology. Evolution of Public Mobile Services -Motivation for IP Based Wireless Networks -Requirements and Targets for Long Term Evolution (LTE) - Technologies for LTE- 4G Advanced Features and Roadmap Evolutions from LTE to LTE-A - Wireless Standards. Network Model-Network Connectivity-Wireless Network Design with Small World Properties

UNIT II WIRELESS IP NETWORK ARCHITECTURES 9

3GPP Packet Data Networks - Network Architecture - Packet Data Protocol (PDP) Context -Configuring PDP Addresses on Mobile Stations - Accessing IP Networks through PS Domain – LTE network Architecture - Roaming Architecture- Protocol Architecture- Bearer Establishment Procedure -Inter-Working with other RATs.

UNIT III ADAPTIVE LINK AND NETWORK LAYER 9

Link Layer Capacity of Adaptive Air Interfaces-Adaptive Transmission in *Ad Hoc* Networks-Adaptive Hybrid ARQ Schemes for Wireless Links-Stochastic Learning Link Layer Protocol-Infrared Link Access Protocol-Graphs and Routing Protocols-Graph Theory-Routing with Topology Aggregation-Network and Aggregation Models

UNIT IV MOBILITY MANAGEMENT 9

Cellular Networks-Cellular Systems with Prioritized Handoff-Cell Residing Time Distribution-Mobility Prediction in Pico- and Micro-Cellular Networks

UNIT V QUALITY OF SERVICE 9

QoS Challenges in Wireless IP Networks - QoS in 3GPP - QoS Architecture, Management and Classes -QoS Attributes - Management of End-to-End IP QoS - EPS BearersandQoSin LTE networks.

TOTAL : 45 PERIODS

OUTCOMES:

- Familiar with the latest 4G networks and LTE
- Understand about the wireless IP architecture and LTE network architecture.
- Familiar with the adaptive link layer and network layer graphs and protocol.
- Understand about the mobility management and cellular network.
- Understand about the wireless sensor network architecture and its concept.

REFERENCES:

1. Ayman ElNashar, Mohamed El-saidny, Mahmoud Sherif, “Design, Deployment and Performance of 4G-LTE Networks: A Practical Approach”, John Wiley & Sons, 2014.
2. Crosspoint Boulevard, “Wireless and Mobile All-IP Networks”, Wiley Publication, 2005.
3. Jyh-Cheng Chen and Tao Zhang, “IP-Based Next-Generation Wireless Networks Systems, Architectures, and Protocols”, John Wiley & Sons, Inc. Publication,2006.
4. Minoru Etoh, “Next Generation Mobile Systems3G and Beyond,” Wiley Publications,2005.
5. Stefania Sesia, IssamToufik and Matthew Baker, “LTE – The UMTS Long Term Evolution From Theory to Practice”, John Wiley & Sons, Inc. Publication, Second Edition, 2011.
6. Savo Glisic,” advanced wireless networks-technology and business models”, Third Edition**,** John Wiley & Sons, Ltd, 2016
7. Savo Glisic,”Advanced Wireless Networks-4G Technologies”, John Wiley & Sons, Ltd,2006.

NC5211	NETWORKING LABORATORY (Experiments using NS2/ QUALNET /NS3/ OMNET/ Equivalent)	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To understand the functioning of various protocols in Wireless Environment.
- To understand the functioning of IP network
- To understand about the mobile ad hoc network
- To understand about the wireless routing protocol, Wi-Fi network and sensor protocol

LIST OF EXPERIMENTS:

1. Implement wireless to wireless communication using wireless protocol
2. Implement and test Wireless Network Design with Small World Properties.
3. Implement Packet Data Protocol wireless communication.
4. Implement IP Networks protocol.
5. Simulating a Mobile Adhoc Network.
6. Simulating a Wi-Fi Network.
7. Simulating a Wireless Sensor Network.
8. Implement Transport Control Protocol in Sensor Network.
9. Implement applications using TCP & UDP sockets like DNS (ii)SNMP (iii) File Transfer
10. Implement different routing protocols to select the network path with its optimum energy and cost during data transfer
    Link state routing (ii) Flooding (iii) Distance vector

TOTAL: 60 PERIODS

OUTCOMES:

Upon Completion of the course, the students will be able to:

- Ability to design WIRELESS NETWORK and routing protocols in Wireless Environment.
- Ability to design mobile ad hoc network and Wi-Fi network.
- Ability to design wireless routing in wireless network
- Ability to design wireless sensor and transport protocol in sensor environment

CP5281 TERM PAPER WRITING AND SEMINAR L T P C
0 0 2 1

In this course, students will develop their scientific and technical reading and writing skills that they need to understand and construct research articles. A term paper requires a student to obtain information from a variety of sources (i.e., Journals, dictionaries, reference books) and then place it in logically developed ideas. The work involves the following steps:

1. Selecting a subject, narrowing the subject into a topic
2. Stating an objective.
3. Collecting the relevant bibliography (atleast 15 journal papers)
4. Preparing a working outline.
5. Studying the papers and understanding the authors contributions and critically analysing each paper.
6. Preparing a working outline
7. Linking the papers and preparing a draft of the paper.
8. Preparing conclusions based on the reading of all the papers.
9. Writing the Final Paper and giving final Presentation

Please keep a file where the work carried out by you is maintained.
Activities to be carried Out

Activity	Instructions	Submission week	Evaluation
Selection of area of interest and Topic Stating an Objective	You are requested to select an area of interest, topic and state an objective	2nd week	**3 %** Based on clarity of thought, current relevance and clarity in writing
Collecting Information about your area & topic	1. List 1 Special Interest Groups or professional society 2. List 2 journals 3. List 2 conferences, symposia or workshops 4. List 1 thesis title 5. List 3 web presences (mailing lists, forums, news sites) 6. List 3 authors who publish regularly in your area 7. Attach a call for papers (CFP) from your area.	3rd week	**3%** (the selected information must be area specific and of international and national standard)

Collection of Journal papers in the topic in the context of the objective – collect 20 & then filter	• You have to provide a complete list of references you will be using- Based on your objective -Search various digital libraries and Google Scholar
	• When picking papers to read - try to:
	  • Pick papers that are related to each other in some ways and/or that are in the same field so that you can write a meaningful survey out of them,
	  • Favour papers from well-known journals and conferences,
	  • Favour "first" or "foundational" papers in the field (as indicated in other people's survey paper),
	  • Favour more recent papers,
	  • Pick a recent survey of the field so you can quickly gain an overview,
	  • Find relationships with respect to each other and to your topic area (classification scheme/categorization)
	• Mark in the hard copy of papers whether complete work or section/sections of the paper are being considered
		4th week	**6%**
			(the list of standard papers and reason for selection)

Reading and notes for first 5 papers	Reading Paper Process
	• For each paper form a Table answering the following questions:
	  • What is the main topic of the article?
	  • What was/were the main issue(s) the author said they want to discuss?
	  • Why did the author claim it was important?
	  • How does the work build on other's work, in the author's opinion?
	  • What simplifying assumptions does the author claim to be making?
	  • What did the author do?
	  • How did the author claim they were going to evaluate their work and compare it to others?
	  • What did the author say were the limitations of their research?
		5th week	**8%**
			(the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)

	• What did the author say were the important directions for future research? Conclude with limitations/issues not addressed by the paper (from the perspective of your survey)		
Reading and notes for next5 papers	Repeat Reading Paper Process	6th week	**8%** (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Reading and notes for final 5 papers	Repeat Reading Paper Process	7th week	**8%** (the table given should indicate your understanding of the paper and the evaluation is based on your conclusions about each paper)
Draft outline 1 and Linking papers	Prepare a draft Outline, your survey goals, along with a classification / categorization diagram	8th week	**8%** (this component will be evaluated based on the linking and classification among the papers)
Abstract	Prepare a draft abstract and give a presentation	9th week	**6%** (Clarity, purpose and conclusion) **6%** Presentation & Viva Voce
Introduction Background	Write an introduction and background sections	10th week	**5%** (clarity)
Sections of the paper	Write the sections of your paper based on the classification / categorization diagram in keeping with the goals of your survey	11thweek	**10%**(this component will be evaluated based on the linking and classification among the papers)
Your conclusions	Write your conclusions and future work	12th week	**5%** (conclusions – clarity and your ideas)
Final Draft	Complete the final draft of your paper	13th week	**10%** (formatting, English, Clarity and linking) **4%** Plagiarism Check Report
Seminar	A brief 15 slides on your paper	14th & 15th week	**10%**(based on presentation and Viva-voce)

TOTAL : 30 PERIODS

CP5292 **INTERNET OF THINGS** **L T P C**
3 0 0 3

OBJECTIVES:

- To understand the fundamentals of Internet of Things
- To learn about the basics of IOT protocols
- To build a small low cost embedded system using Raspberry Pi.
- To apply the concept of Internet of Things in the real world scenario.

UNIT I INTRODUCTION TO IoT **9**

Internet of Things - Physical Design- Logical Design- IoT Enabling Technologies - IoT Levels & Deployment Templates - Domain Specific IoTs - IoT and M2M - IoT System Management with NETCONF-YANG- IoT Platforms Design Methodology

UNIT II IoT ARCHITECTURE **9**

M2M high-level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - information model - functional model - communication model - IoT reference architecture

UNIT III IoT PROTOCOLS **9**

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus– Zigbee Architecture – Network layer – 6LowPAN - CoAP - Security

UNIT IV BUILDING IoT WITH RASPBERRY PI & ARDUINO **9**

Building IOT with RASPERRY PI- IoT Systems - Logical Design using Python – IoT Physical Devices & Endpoints - IoT Device -Building blocks -Raspberry Pi -Board - Linux on Raspberry Pi - Raspberry Pi Interfaces -Programming Raspberry Pi with Python - Other IoT Platforms - Arduino.

UNIT V CASE STUDIES AND REAL-WORLD APPLICATIONS **9**

Real world design constraints - Applications - Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT – Software & Management Tools for IoT Cloud Storage Models & Communication APIs - Cloud for IoT - Amazon Web Services for IoT.

TOTAL : 45 PERIODS

OUTCOMES:

Upon completion of the course, the student should be able to:

- Analyze various protocols for IoT
- Develop web services to access/control IoT devices.
- Design a portable IoT using Rasperry Pi
- Deploy an IoT application and connect to the cloud.
- Analyze applications of IoT in real time scenario

REFERENCES:

1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015
2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), “Architecting the Internet of Things”, Springer, 2011.
3. Honbo Zhou, “The Internet of Things in the Cloud: A Middleware Perspective”, CRC Press, 2012
4. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
5. Olivier Hersent, David Boswarthick, Omar Elloumi , “The Internet of Things – Key applications and Protocols”, Wiley, 2012

NC5001 ANALYSIS AND DESIGN OF CMOS ANALOG INTEGRATED CIRCUITS L T P C
3 0 0 3

OBJECTIVES:

- To learn the different biasing circuits for amplifiers.
- To study the different types of current mirrors
- To know the concepts of voltage and current reference circuits.

UNIT I SINGLE STAGE AMPLIFIERS 9

MOS physics, Large signal and Small signal analysis of Common source stage, Source follower, Common gate stage, Cascode stage. Single ended and differential operation of differential amplifier, Basic differential pair, Differential pair with MOS loads

UNIT II BIASING CIRCUITS 9

Basic current mirrors, cascode current mirrors, active current mirrors, voltage references, supply independent biasing, temperature independent references, PTAT current generation, Constant-Gm Biasing.

UNIT III FREQUENCY RESPONSE AND NOISE ANALYSIS 9

Miller effect ,Association of poles with nodes, frequency response of common source stage, Source followers, Common gate stage, zero value time constant model, Cascode stage, Differential pair amplifier, $PSRR^+$, $PSRR^-$, CMRR measurement of differential amplifier, Statistical characteristics of noise, noise in single stage amplifiers, noise in differential amplifiers.

UNIT IV OPERATIONAL AMPLIFIERS 9

Concept of negative feedback, Effect of loading in feedback networks, return ratio analysis of differential amplifier operational amplifier performance parameters, One-stage Op Amps, Two-stage Op Amps, Input range limitations, Gain boosting, slew rate, power supply rejection, noise in Op Amps.

UNIT V STABILITY AND FREQUENCY COMPENSATION 9

General considerations, Multipole systems, Phase Margin, Frequency Compensation, and Compensation of two stage Op Amps, Slewing in two stage Op Amps, and Other compensation techniques.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the student should be able to:

- Design the single stage amplifiers using pmos and nmos driver circuits with different loads.
- Analyze high frequency concepts of single stage amplifiers and noise characteristics associated with differential amplifiers

REFERENCES:

1. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, Tata McGraw Hill, 2001
2. Grebene, “Bipolar and MOS Analog Integrated circuit design”, John Wiley & sons,Inc., 2003.
3. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, Analysis and Design of Analog Integrated Circuits, 5th Edition, Wiley, 2009
4. Phillip E.Allen, Douglas R.Holberg, “CMOS Analog Circuit Design”, Second edition, Oxford University Press, 2002
5. Willey M.C. Sansen, “Analog design essentials”, Springer, 2006.

NC5002	RF INTEGRATED CIRCUITS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the fundamentals of integrated circuits operating at microwave frequencies.
- To learn RFIC design techniques, including system architecture, key building blocks and design methodologies in CMOS technology.

UNIT I BASIC RF IC COMPONENTS 9

Skin effect, Resistors, Capacitor, Inductor and Transformers at high frequency, Interconnect options. S-parameters with Smith chart, Impedance matching networks, Transmission lines, finite length effects, MOSFET characteristics, Noise: Two port Noise theory, Noise Figure, THD, IP2, IP3, Sensitivity, SFDR.

UNIT II RECEIVERS ARCHITECTURE AND LOW NOISE AMPLIFIERS 9

Homodyne Receiver, Heterodyne Receiver, Image reject, Low IF Receiver Architectures Direct up conversion Transmitter, Two step up conversion Transmitter, CMOS amplifiers, Single ended and Differential LNAs terminated with Resistors and Source Degeneration LNAs, OC Time constants in bandwidth estimation and enhancement, Power match and Noise match.

UNIT III FEEDBACK SYSTEMS AND POWER AMPLIFIERS 9

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

UNIT IV PLL AND FREQUENCY SYNTHESIZERS 9

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

UNIT V MIXERS AND OSCILLATORS 9

Mixer characteristics, Non-linear mixers, Multiplier based mixers, Single balanced and double balanced mixers, sub sampling mixers, Oscillators describing Functions, Resonators, Phase noise, Chip Design Examples: GPS Receiver, WLAN receiver.

TOTAL : 45 PERIODS

OUTCOMES:

- The ability to analyze and design the high frequency effects on basic circuit components.
- To design RF LNAs and receivers.
- To design RF power amplifiers.
- To design PLL and frequency synthesizers.

REFERENCES:

1. Devendra.K. Misra, "Radio Frequency and Microwave Communication Circuits – Analysis and Design", John Wiley and Sons,2004
2. John W.M.Rogers and Calvin Plett, "Radio Frequency Integrated Circuit Design", 2nd Edition, Artech House, Norwood, 2010.
3. Matthew M.Radmanesh "RF and Microwave Design Essentials", Author House, Bloomington,2007.
4. Thomas Lee," The Design of Radio Frequency CMOS Integrated Circuits", Cambridge University Press, 2nd Edition, Cambridge, 2004.

CU5092 REAL TIME EMBEDDED SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

- To study the basic concepts of ARM processors
- To understand the computing platform and design analysis of ARM processors
- To study the concepts of Operating systems in ARM
- To study the concept of embedded networks
- To understand case studies related to embedded systems

UNIT I INTRODUCTION TO ARM PROCEESORS 9

Fundamentals of ARM, ARM Instruction set, Thumb Instruction set, ARM assembly language programming, Digital Signal Processing in ARM, Exceptions & Interrupt Handling.

UNIT II COMPUTING PLATFORM AND DESIGN ANALYSIS 9

CPU buses – Memory devices – I/O devices – Memory Protection Units – Memory Management Units – Component interfacing – Design with microprocessors – Development and Debugging – Program design – Model of programs – Assembly and Linking – Basic compilation techniques – Analysis and optimization of execution time, power, energy, program size – Program validation and testing.

UNIT III PROCESS AND OPERATING SYSTEMS 9

Multiple tasks and multi processes – Processes – Context Switching – Scheduling policies - Multiprocessor – Inter Process Communication mechanisms – Evaluating operating system performance – Power optimization strategies for processes – Firmware and Operating Systems for ARM processor.

UNIT IV HARDWARE ACCELERATES & NETWORKS 9

Accelerators – Accelerated system design – Distributed Embedded Architecture – Networks for Embedded Systems – Network based design – Internet enabled systems.

UNIT V CASE STUDY 9

Hardware and software co-design - Data Compressor - Software Modem – Personal Digital Assistants – Set–Top–Box. – System-on-Silicon – FOSS Tools for embedded system development.

TOTAL: 45 PERIODS

OUTCOMES:

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

- Revise computing platform and design analysis
- Demonstrate multiple tasks and multi processes
- Discuss hardware and software co-design

REFERENCES:

1. Andrew N Sloss, Dominic Symes and Chris Wright, “ARM system developer’s guide – Designing and Optimizing System Software”, Morgan Kaufmann publishers, 2004.
2. David E-Simon, “An Embedded Software Primer”, Pearson Education, 2007.
3. K.V.K.K.Prasad, “Embedded Real-Time Systems: Concepts, Design & Programming”, Dreamtech Press, 2005.
4. Tim Wilmshurst, “An Introduction to the Design of Small Scale Embedded Systems”, Pal grave Publisher, 2004.
5. Wayne Wolf, “Computers as Components - Principles of Embedded Computer System Design”, Morgan Kaufmann Publisher, 2006.

VL5091 **MEMS AND NEMS** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the concepts of microelectromechanical devices.
- To know the fabrication process of Microsystems.
- To know the design concepts of micro sensors and micro actuators.
- To familiarize concepts of quantum mechanics and nano systems.

UNIT I OVERVIEW **9**

New trends in Engineering and Science: Micro and Nanoscale systems, Introduction to Design of MEMS and NEMS, MEMS and NEMS – Applications, Devices and structures. Materials for MEMS: Silicon, silicon compounds, polymers, metals.

UNIT II MEMS FABRICATION TECHNOLOGIES **9**

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

UNIT III MICRO SENSORS **9**

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

UNIT IV MICRO ACTUATORS **9**

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

UNIT V NANOSYSTEMS AND QUANTUM MECHANICS **9**

Atomic Structures and Quantum Mechanics, Molecular and Nanostructure Dynamics: Schrodinger Equation and Wavefunction Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular Wires and Molecular Circuits.

TOTAL: 45 PERIODS

OUTCOMES:

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

- Discuss micro sensors
- Explain micro actuators
- Outline nano systems and Quantum mechanics

REFERENCES:

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

AP5094 SIGNAL INTEGRITY FOR HIGH SPEED DESIGN L T P C
3 0 0 3

OBJECTIVES:

- To identify sources affecting the speed of digital circuits.
- To introduce methods to improve the signal transmission characteristics

UNIT I SIGNAL PROPAGATION ON TRANSMISSION LINES 9

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

UNIT II MULTI-CONDUCTOR TRANSMISSION LINES AND CROSS-TALK 9

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

UNIT III NON-IDEAL EFFECTS 9

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

UNIT IV POWER CONSIDERATIONS AND SYSTEM DESIGN 9

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

UNIT V CLOCK DISTRIBUTION AND CLOCK OSCILLATORS 9

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

TOTAL: 45 PERIODS

OUTCOMES:

- Ability to identify sources affecting the speed of digital circuits.
- Able to improve the signal transmission characteristics.

REFERENCES:

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

TOOLS REQUIRED

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

CU5073 VLSI FOR WIRELESS COMMUNICATION L T P C
3 0 0 3

OBJECTIVES:

- To understand the concepts of basic wireless communication concepts.
- To study the parameters in receiver and low noise amplifier design.
- To study the various types of mixers designed for wireless communication.
- To study and design PLL and VCO.
- To understand the concepts of 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

OUTCOMES:

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

- Design LNA and Mixers
- Evaluate frequency synthesizers
- Design and analyze power amplifiers

REFERENCES:

1. Bosco H Leung “VLSI for Wireless Communication”, Pearson Education, 2002.
2. Behzad Razavi, “Design of Analog CMOS Integrated Circuits” McGraw-Hill, 1999.
3. B.Razavi ,”RF Microelectronics” , Prentice-Hall ,1998.
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.

CU5071 DIGITAL COMMUNICATION RECEIVERS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basic principles of digital communication techniques.
- To gain knowledge about receivers for AWGN channel and Fading channels.
- To understand the concepts of synchronization and adaptive equalization techniques.

UNIT I REVIEW OF DIGITAL COMMUNICATION TECHNIQUES 9

Base band communication; signal space representation, linear and nonlinear modulation techniques, Error tracking and Spectral characteristics of digital modulation.

UNIT II OPTIMUM RECEIVERS FOR AWGN CHANNEL 9

Correlation demodulator, matched filter , maximum likelihood sequence detector, optimum receiver for CPM signals, optimum receivers for signals with random phase in AWGN channel, envelope detection of M-ary orthogonal signals and correlated binary signals.

UNIT III RECEIVERS FOR FADING CHANNELS 9

Characterization of fading multiple channels, statistical models, flat and frequency selective fading, diversity technique, parameter synchronization for flat fading channels, digital signaling over a frequency selective and slowly fading channel ,coded waveform for fading channel.

UNIT IV SYNCHRONIZATION TECHNIQUES 9

Carrier and signal synchronization, carrier phase estimation-PLL, Decision directed loops, symbol timing estimation, maximum likelihood and non-decision directed timing estimation, joint estimation.

UNIT V ADAPTIVE EQUALIZATION 9

Zero forcing algorithm, LMS algorithm, adaptive decision-feedback equalizer and Equalization of Trellis-coded signals. Kalman algorithm, blind equalizers and stochastic gradient algorithm.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Completion of the course, the students will be able to

- Apply basic principles of digital communication techniques.
- Discuss on receivers for AWGN & Fading channel
- Describe various synchronization techniques.
- Design adaptive equalization algorithms to satisfy the evolving demands in digital communication.

REFERENCES:

1. Heinrich Meyer, Mare Moeneclacy, Stefan.A.Fechtel, " Digital communication receivers ", Vol I & Vol II, John Wiley, New York, 1997.
2. H.Meyr & G.Ascheid, Synchronization in Digital Communications, John Wiley, 1990
3. John.G.Proakis, “Digital communication “4th Edition, McGraw-Hill, New York, 2001.
4. R.G. Gallager, "Principles of Digital Communication", Newyork, Cambridge University Press, 2008
5. Simon Marvin, “Digital communication over fading channel; An unified approach to performance Analysis ", John Wiley, New York, 2000.
6. U.Mengali & A.N.D’Andrea, Synchronization Techniques for Digital Receivers, Kluwer, 1997.

CU5292 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY L T P C
3 0 0 3

OBJECTIVES:

The basics of EMI.

- EMI sources.
- EMI problems.
- Solution methods in PCB.
- 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

OUTCOMES:

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

- Identify Standards
- Compare EMI test methods
- Discuss EMI mitigation techniques

REFERENCES:

1. Bemhard Keiser, “Principles of Electromagnetic Compatibility”, 3rd 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.

CU5072 DETECTION AND ESTIMATION THEORY L T P C
3 0 0 3

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.

UNIT I REVEIW OF 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, LeastSquares, 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

OUTCOMES:

- To be able to apply detection and estimation theory to solve communication problems.
- To apply probability and stochastic process concepts in detection and estimation.
- To design Wiener and Kalman filters to solve linear estimation problems.

REFERENCES:

1. Harry L. Van Trees, "Detection, Estimation and Modulation Theory", Part I John Wiley and Sons, New York, 2004.
2. Ludeman, Lonnie C. Random processes: filtering, estimation, and detection. John Wiley & Sons, Inc., 2003.
3. Steven M. Kay, "Fundamentals of Statistical Processing, Volume I: Estimation Theory", Prentice Hall Signal Processing Series, Prentice Hall, PTR, NewJersy, 1993.
4. Sergio Verdu " Multi User Detection" Cambridge University Press, 1998
5. Thomas Schonhoff, "Detection and Estimation Theory", Prentice Hall, New Jersy, 2007.

CU5091 ADVANCED SATELLITE COMMUNICATION AND NAVIGATION SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

The students should be made to be

- Learn M2M developments and satellite applications
- Understand Satellite Communication In Ipv6 Environment

UNIT I OVERVIEW OF SATELLITE COMMUNICATION 9

Overview of satellite communication and orbital mechanics Link budget Parameters, Link budget calculations, Auxiliary Equations, Performance Calculations.

UNIT II M2M DEVELOPMENTS AND SATELLITE APPLICATIONS 9

Overview of the Internet of Things and M2M- M2M Applications Examples and Satellite Support- Satellite Roles Context and Applications- Antennas for Satellite M2M Applications- M2M Market Opportunities for Satellite Operators- Ultra HD Video/TV and Satellite Implications- High Throughput Satellites (HTS) and Ka/Ku Spot Beam Technologies- Aeronautical, Maritime and other Mobility Services.

UNIT III SATELLITE COMMUNICATION IN IPV6 ENVIRONMENT 9

Overview 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

Over view 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

Introduction – 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-Telecom subsystem and Link performance. Mangalyaan Mission - Mission and space craft summary-Telecommunication subsystem overview- Ground Subsystem-Telecom subsystem and Link performance.

TOTAL : 45 PERIODS

OUTCOMES:

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

- Discuss satellite navigation and global positioning system
- Outline deep space networks and inter planetary missions

REFERENCES:

1. Adimurthy.V," Concept design and planning of India's first interplanetary mission" Current Science, VOL. 109, NO. 6, 1054 25 SEPTEMBER 2015.
2. Anil K. Maini, Varsha Agrawal, 'Satellite Technology: Principles and Applications', Third Edition, Wiley, 2014.
3. Daniel Minoli' "Innovations in Satellite Communication and Satellite Technology" Wiley, 2015
4. Daniel Minoli, "Satellite Systems Engineering in an IPv6 Environment", CRC Press, First Edition, 2009.
5. Hofmann-Wellenhof B., Lichtenegger H., and Elmar Wasle, "Global Navigational Satellite Systems" Springer-Verlag, 2008.
6. Jim Taylor, " Deep Space Communications" John Wiley & Sons, 2016.
7. Louis J. Ippolito, Jr. "Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance", Second Edition, 2017
8. http://www.isro.gov.in/pslv-c25-mars-orbiter-mission
9. https://en.wikipedia.org/wiki/Mars_Orbiter_Mission
10. https://en.wikipedia.org/wiki/Chandrayaan-1

NC5003 FUNDAMENTALS OF CLOUD COMPUTING L T P C
3 0 0 3

OBJECTIVES

- To Introduce the fundamentals of Cloud Computing and virtualization.
- To familiarize various standards related to cloud computing.

UNIT I INTRODUCTION TO CLOUD 9

Cloud Computing – History, Architecture, Storage, Advantages, Disadvantages, Services, Server Virtualization- Parallel Processing, Vector Processing, Symmetric Multiprocessing Systems and Massively Parallel Processing Systems.

UNIT II CLOUD BASED WEB SERVICES 9

Understanding Private and Public cloud environments – Communication as a Service (CaaS)- Infrastructure as a Service (IaaS) – On-demand, Amazon's Elastic, Amazon EC2, Mosso– Monitoring as a Service (MaaS) –Platform as a Service (PaaS) – On-Premises model, new cloud model – Software as a Service (SaaS) –implementation issues, characteristics, SaaS model.

UNIT III CLOUD COMPUTING FOR EVERYONE 9

Centralizing Email Communications – Collaborating on Schedules – Collaborating on To-Do Lists – Collaborating Contact Lists – Cloud Computing for the Community – Collaborating on Group Projects and Events – Cloud Computing for the Corporation

UNIT IV USING CLOUD SERVICES 9

Collaborating on Calendars, Schedules and Task Management – Exploring Online Scheduling Applications – Exploring Online Planning and Task Management – Collaborating on Event Management – Collaborating on Contact Management – Collaborating on Project Management – Collaborating on Word Processing - Collaborating on Databases – Storing and Sharing Files

UNIT V FUTURE DIRECTIONS TO CLOUD 9

Cloud Security – Software as a Service Security – Standards for application developers –Ajax, XML, JSON, LAMP, LAPP –Standards for Messaging –SMTP, POP, IMAP, HTTP, SIMPLE, XMPP – Standards for Security –SAML oAuth, OpenID, SSL/TLS, Collaborating via Blogs and Wikis – Mobile Platform Virtualization –KVM, VMWare

TOTAL:45 PERIODS

OUTCOMES:

- To be able to build custom made clouds.
- To be able to develop remote access applications, alert generation using cloud.
- To be able to work with commercial cloud packages.

REFERENCES:

1. Barrie Sosinsky, “Cloud Computing –Bible”, Wiley Indian Edition, 2011.
2. John W.Rittinghouse and James F.Ransome, “Cloud Computing – Implementation, Management and Security", CRC press, 2012.
3. Michael Miller, “Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online", Pearson, 2008.

DS5291 ADVANCED DIGITAL IMAGE PROCESSING L T P C
3 0 0 3

OBJECTIVES:

- To understand the image fundamentals.
- To understand the various image segmentation techniques.
- To extract features for image analysis.
- To introduce the concepts of image registration and image fusion.
- To illustrate 3D image visualization.

UNIT I FUNDAMENTALS OF DIGITAL IMAGE PROCESSING 9

Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, 2D image transforms-DFT, DCT, KLT,SVD. Image enhancement in spatial and frequency domain, Review of Morphological image processing.

UNIT II SEGMENTATION 9

Edge detection, Thresholding, Region growing, Fuzzy clustering, Watershed algorithm, Active contour models, Texture feature based segmentation, Graph based segmentation, Wavelet based Segmentation - Applications of image segmentation.

UNIT III FEATURE EXTRACTION 9

First and second order edge detection operators, Phase congruency, Localized feature extraction - detecting image curvature, shape features, Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co-occurrence features, Runlength features, Fractal model based features, Gabor filter, wavelet features.

UNIT IV REGISTRATION AND IMAGE FUSION 9

Registration - Preprocessing, Feature selection - points, lines, regions and templates Feature correspondence - Point pattern matching, Line matching, Region matching, Template matching. Transformation functions - Similarity transformation and Affine Transformation. Resampling – Nearest Neighbour and Cubic Splines. Image Fusion - Overview of image fusion, pixel fusion, wavelet based fusion -region based fusion.

UNIT V 3D IMAGE VISUALIZATION 9

Sources of 3D Data sets, Slicing the Data set, Arbitrary section planes, The use of color, Volumetric display, Stereo Viewing, Ray tracing, Reflection, Surfaces, Multiple connected surfaces, Image processing in 3D, Measurements on 3D images.

TOTAL: 45 PERIODS

OUTCOMES:

Upon Completion of the course, the students will be able to

- Explain the fundamentals digital image processing.
- Describe image various segmentation and feature extraction techniques for image analysis.
- Discuss the concepts of image registration and fusion.
- Explain 3D image visualization.

REFERENCES:

1. Ardeshir Goshtasby, " 2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications",John Wiley and Sons,2005.
2. Anil K. Jain, Fundamentals of Digital Image Processing', Pearson Education,Inc., 2002.
3. John C.Russ, "The Image Processing Handbook", CRC Press,2007.
4. Mark Nixon, Alberto Aguado, "Feature Extraction and Image Processing", Academic Press,2008.
5. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing', Pearson,Education, Inc.,Second Edition, 2004.
6. Rick S.Blum, Zheng Liu, "Multisensor image fusion and its Applications", Taylor& Francis,2006.

DS5292 RADAR SIGNAL PROCESSING L T P C

3 0 0 3

OBJECTIVES:

- To understand the basic concepts of Radar systems and Signal models.
- To illustrate the concepts of Sampling and Quantization of pulsed radar signals.
- To provide in-depth knowledge in Radar waveforms and Doppler processing.

UNIT I INTRODUCTION TO RADAR SYSTEMS 9

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-tonoise 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

OUTCOMES:

Upon completion of the course, students will be able to:

- Explain the principles of elements and functions involved in radar signal processing.
- Describe different types of radar waveforms.
- Discuss on Doppler processing and its issues

REFERENCES:

1. Francois Le Chevalier, "Principles of Radar and Sonar Signal Processing", Artech House
2. Fred E. Nathanson, "Radar Design Principles-Signal Processing and the Environment", PHI
3. Mark A. Richards, "Fundamentals of Radar Signal Processing", McGraw-Hill, New York, 2005
4. Michael O Kolawole, "Radar systems, Peak Detection and Tracking", Elsevier 2010.
5. Peyton Z. Peebles, "Radar Principles", Wiley India 2009
6. Skolnik,"Introduction To Radar Systems" 3rd Edition McGraw Hill.

NC5004 SPEECH PROCESSING AND SYNTHESIS L T P C

3 0 0 3

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.

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

OUTCOMES:

Students will be able to:

- Model speech production system and describe the fundamentals of speech.
- Extract and compare different speech parameters.
- Choose an appropriate statistical speech model for a given application.
- Design a speech recognition system.
- Use different text analysis and speech synthesis techniques.

REFERENCES:

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 Sons, 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.

CU5096 PATTERN RECOGNITION AND MACHINE LEARNING L T P C

3 0 0 3

OBJECTIVES:

- Study the fundamental of pattern classifier.
- To know about various clustering concepts.
- To originate the various structural pattern recognition and feature extraction.
- To understand the basic of concept learning and decision trees
- To explore recent advances in pattern recognition.

UNIT I PATTERN CLASSIFIER 9

Overview of Pattern recognition – Discriminant functions – Supervised learning –Parametric estimation – Maximum Likelihood Estimation – Bayesian parameter Estimation – Problems with Bayes approach– Pattern classification by distance functions –Minimum distance pattern classifier.

UNIT II CLUSTERING 9

Clustering for unsupervised learning and classification -Clustering concept – C-means algorithm – Hierarchical clustering procedures -Graph theoretic approach to pattern clustering -Validity of clusters.

UNIT III FEATURE EXTRACTION AND STRUCTURAL PATTERN RECOGNITION 9

KL Transforms – Feature selection through functional approximation – Binary selection -Elements of formal grammars - Syntactic description - Stochastic grammars –Structural representation.

UNIT IV INTRODUCTION, CONCEPT LEARNING AND DECISION TREES 9

Learning Problems – Designing Learning systems, Perspectives and Issues – Concept Learning – Version Spaces and Candidate Elimination Algorithm – Inductive bias – Decision Tree learning – Representation – Algorithm – Heuristic Space Search

UNIT V RECENT ADVANCES 9

Neural network structures for pattern recognition -Neural network based pattern associators – Unsupervised learning in neural pattern recognition -Self organizing networks -Fuzzy logic -Fuzzy pattern classifiers -Pattern classification using Genetic Algorithms.

TOTAL:45 PERIODS

OUTCOMES:

Upon Completion of the course, the students will be able to

- Classify the data and identify the patterns.
- Utilize the given data set to extract and select features for Pattern recognition.
- Describe the decision tree and concept learning.
- Discuss on recent advances in pattern recognition.

REFERENCES:

1. Duda R.O., and Hart.P.E., Pattern Classification and Scene Analysis, Wiley, New York, 1973.
2. Morton Nadier and Eric Smith P., Pattern Recognition Engineering, John Wiley & Sons, New York, 1993
3. Narasimha Murty M and Susheela Devi V, “Pattern Recognition – An Algorithmic Approach”, Springer, Universities Press, 2011
4. Robert J.Schalkoff, Pattern Recognition : Statistical, Structural and Neural Approaches, John Wiley &Sons Inc., New York, 2007.
5. Tom M. Mitchell, “Machine Learning”, McGraw-Hill Education (INDIAN EDITION), 2013.
6. Tou and Gonzalez, Pattern Recognition Principles, Wesley Publication Company, London, 1974.

CU5093 WAVELET TRANSFORMS AND ITS APPLICATIONS L T P C
3 0 0 3

OBJECTIVE:

- To introduce the fundamentals concepts of wavelet transforms.
- To study system design using Wavelets
- To learn the different wavelet families & their applications.

UNIT I INTRODUCTION TO WAVELETS 9

Introduction to Multirate signal processing- Decimation and Interpolation, Quadrature Mirror Filters, Subband coding, Limitations of Fourier transform, Short time Fourier transform and its drawbacks, Continuous Wavelet transform, Time frequency representation, Wavelet System and its characteristics, Orthogonal and Orthonormal functions and function space

UNIT II MULTIRESOLUTION CONCEPT AND DISCRETE WAVELET TRANSFORM 9

Multiresolution formulation of wavelet systems- signal spaces, scaling function, wavelet function and its properties, Multiresolution analysis, Haar scaling and wavelet function, Filter banks-Analysis and Synthesis, 1D and 2D Discrete wavelet transform, Wavelet Packets, Tree structured filter bank, Multichannel filter bank, Undecimated wavelet transform.

UNIT III WAVELET SYSTEM DESIGN 9

Refinement relation for orthogonal wavelet systems, Restrictions on filter coefficients, Design of Daubechies orthogonal wavelet system coefficients, Design of Coiflet and Symlet wavelets.

UNIT IV WAVELET FAMILIES 9

Continuous Wavelets- Properties of Mexican hat wavelet, Morlet, Gaussian and Meyer wavelets. Orthogonal wavelets- Properties of Haar wavelets, Daubechies wavelets, Symlets, Coiflets and Discrete Meyer wavelets. Properties of Biorthogonal wavelets, Applications of wavelet families.

UNIT V WAVELET APPLICATIONS 9

Denoising of Signals and Images, Image enhancement, Edge detection, Image Fusion, Image compression, Wavelet based feature extraction, Analysis of phonocardiogram signals, Analysis of EEG signals, Speech enhancement for hearing aids

TOTAL: 45 PERIODS

OUTCOMES:

The students will be able to apprehend the detailed knowledge about the Wavelet transforms & its applications.

REFERENCES:

1. C.Sidney Burrus, Ramesh Gopinath & Haito Guo, ‗Introduction to wavelets and wavelet transform', Prentice Hall, 1998.
2. G.Strang and T.Nguyen, ‗Wavelet and filter banks', Wesley and Cambridge Press.
3. Metin Akay, ‗Time frequency and wavelets in biomedical signal processing', Wiley-IEEE Press, October 1997
4. M.Vetterli and J. Kovacevic, ‗Wavelets and sub band coding', Prentice Hall, 1995.
5. P.P.Vaidyanathan, ‗Multi rate systems and filter banks', Prentice Hall 1993
6. Raguveer m Rao & Ajith S. Bopardikar, ‗Wavelet transforms – Introduction to theory and applications', Addison Wesley, 1998
7. S.Mallet, ‗A Wavelet tour of signal processing', Academic Press 1998

DS5191	DSP PROCESSOR ARCHITECTURE AND PROGRAMMING	L	T	P	C
		3	0	0	3

OBJECTIVES:

The objective of this course is to provide in-depth knowledge on

- Digital Signal Processor basics
- Third generation DSP Architecture and programming skills
- Advanced DSP architectures and some applications.

UNIT I FUNDAMENTALS OF PROGRAMMABLE DSPs 9

Multiplier and Multiplier accumulator – Modified Bus Structures and Memory access in PDSPs – Multiple access memory – Multi-port memory – VLIW architecture- Pipelining – Special Addressing modes in P-DSPs – On chip Peripherals.

UNIT II TMS320C5X PROCESSOR 9

Architecture – Assembly language syntax - Addressing modes – Assembly language Instructions - Pipeline structure, Operation – Block Diagram of DSP starter kit – Application Programs for processing real time signals.

UNIT III TMS320C6X PROCESSOR 9

Architecture of the C6x Processor - Instruction Set - DSP Development System: Introduction – DSP Starter Kit Support Tools- Code Composer Studio - Support Files - Programming Examples to Test the DSK Tools – Application Programs for processing real time signals.

UNIT IV ADSP PROCESSORS 9

Architecture of ADSP-21XX and ADSP-210XX series of DSP processors- Addressing modes and assembly language instructions – Application programs –Filter design, FFT calculation.

UNIT V ADVANCED PROCESSORS 9

Architecture of TMS320C54X: Pipe line operation, Code Composer studio – Architecture of TMS320C6X - Architecture of Motorola DSP563XX – Comparison of the features of DSP family processors.

TOTAL : 45 PERIODS

OUTCOMES:

Students should be able to:

- Become Digital Signal Processor specialized engineer
- DSP based System Developer

REFERENCES

1. Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSP Microprocessors with Examples from TMS320C54xx, cengage Learning India Private Limited, Delhi 2012
2. B.Venkataramani and M.Bhaskar, “Digital Signal Processors – Architecture, Programming and Applications” – Tata McGraw – Hill Publishing Company Limited. New Delhi, 2003.
3. RulphChassaing, Digital Signal Processing and Applications with the C6713 and C6416 Dsk, A John Wiley & Sons, Inc., Publication, 2005
4. User guides Texas Instrumentation, Analog Devices, Motorola.

CU5095 SPACE TIME WIRELESS COMMUNICATION L T P C
3 0 0 3

OBJECTIVES:

- To acquire the knowledge on various modulation and coding schemes for space-time
- wireless communications.
- To understand transmission and decoding techniques associated with wireless
- communications.
- To understand multiple-antenna systems such as multiple-input multiple-output (MIMO)
- and space-time codes.

UNIT I MULTIPLE ANTENNA PROPAGATION AND ST CHANNEL CHARACTERIZATION 9

Wireless channel, Scattering model in macrocells, Channel as a ST random field, Scattering functions, Polarization and field diverse channels, Antenna array topology, Degenerate channels, reciprocity and its implications, Channel definitions, Physical scattering model, Extended channel models, Channel measurements, sampled signal model, ST multiuser and ST interference channels, ST channel estimation.

UNIT II CAPACITY OF MULTIPLE ANTENNA CHANNELS 8

Capacity of frequency flat deterministic MIMO channel: Channel unknown to the transmitter, Channel known to the transmitter, capacity of random MIMO channels, Influence of ricean fading, fading correlation, XPD and degeneracy on MIMO capacity, Capacity of frequency selective MIMO channels.

UNIT III SPATIAL DIVERSITY 8

Diversity gain, Receive antenna diversity, Transmit antenna diversity, Diversity order and channel variability, Diversity performance in extended channels, Combined space and path diversity, Indirect transmit diversity, Diversity of a space-time- frequency selective fading channel.

UNIT IV MULTIPLE ANTENNA CODING AND RECEIVERS 10

Coding and interleaving architecture, ST coding for frequency flat channels, ST coding for frequency selective channels, Receivers(SISO,SIMO,MIMO),Iterative MIMO receivers, Exploiting channel knowledge at the transmitter: linear pre-filtering, optimal pre-filtering for maximum rate, optimal pre-filtering for error rate minimization, selection at the transmitter, Exploiting imperfect channel knowledge.

UNIT V ST OFDM, SPREAD SPECTRUM AND MIMO MULTIUSER DETECTION 10

SISO-OFDM modulation, MIMO-OFDM modulation, Signaling and receivers for MIMOOFDM,SISO-SS modulation, MIMO-SS modulation, Signaling and receivers for MIMO- SS. MIMOMAC, MIMO-BC, Outage performance for MIMO-MU, MIMO-MU with OFDM, CDMA and multiple antennas.

TOTAL : 45 PERIODS

OUTCOMES:

- To be able to design and evaluate receiver and transmitter diversity techniques.
- To be able to design and develop OFDM based MIMO systems.
- To be able to calculate capacity of MIMO systems.

REFERENCES:

1. A. Paulraj, Rohit Nabar, Dhananjay Gore., “Introduction to Space Time Wireless Communication Systems”, Cambridge University Press, 2003
2. Andre Viterbi “ Principles of Spread Spectrum Techniques” Addison Wesley 1995
3. Jafarkhani, Hamid. Space-time coding: theory and practice. Cambridge university press, 2005.
4. Sergio Verdu “ Multi User Detection” Cambridge University Press, 1998

NC5005	BROADBAND ACCESS TECHNOLOGIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give fundamental concepts related to broadband access technologies.
- 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 access networks.

UNIT I REVIEW OF ACCESS TECHNOLOGIES 5

Phone-Line modem, cable-access, ISDN, Emerging Broad band Technologies, Cable DSL, Fiber and Wireless, Standards for access network.

UNIT II DIGITAL SUBSCRIBER LINES 10

Asymmetric Digital subscriber lines (ADSL) – Rate Adaptive subscriber line (RADSL)-ISDN Digital subscriber line (IDSL) - High bit rate DSL (HDSL)-Single line DSL (SDSL) - very high bit rate DSL (VDSL) - Standards for XDSL & Comparison.

UNIT III CABLE MODEM 10

Cable Modem, DOCSIS – Physical Cabling, Dual Modem Operation, Hub Restriction, Upstream Operation – Downstream operation – Access control – framing Security sub layer – Data link layer – LLC & Higher layers – ATM centric VS IP – centric cable modem.

UNIT IV FIBER ACCESS TECHNOLOGIES 10

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 V BROAD BAND WIRELESS 10

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.**

TOTAL : 45 PERIODS

OUTCOMES:

- To able to design systems meeting out the requirements of the recent standards.
- To meet out the industry requirements for man power in next generation networks.
- To be able to contribute towards the enhancement of the existing wireless technologies.

REFERENCES:

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. Martin P. Clarke, “Wireless Access Network: Fixed Wireless Access and WLL Network Design and Operation”, John Wiley & Sons 2000.
5. Niel Ransom and Albert A. Azzam, “Broadband Access Technologies: ADSL, VDSL Cable Modem, Fiber and LMDS", McGraw Hill, 1999.

6. Sassan Ahmadi, “LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies”, Elsevier, 2014.
7. Walter J Woralski, “ADSL and DSL Technologies”, McGraw Hill Computer Communication Series, Second Edition Oct 2001.
8. William Webb, “Introduction to Wireless Local Loop Broadband and Narrow Band System”, Mobile Communication Series, Artech House Publishers, Second Edition 2000.

CU5094 SOFTWARE DEFINED RADIO L T P C
3 0 0 3

OBJECTIVES :
The students should be made to:
- Understand radio frequency implementation
- Learn multi rate signal processing and digital generation of signals

UNIT I INTRODUCTION & CASE STUDIES 9
Introduction to software Radio concepts: Need for software Radios, Definition of software Radio, Characteristics and Benefits. Design Principles. Case studies: SPEAK easy, JTRS, SDR-3000.

UNIT II RADIO FREQUENCY IMPLEMENTATION 9
The purpose of the RF Front End, Dynamic Range, RF receivers front end Topologies, Importance of the components to Overall performance, Transmitter Architecture, Noise and Distortion in the RF Chain, ADC and DAC Distortion, Flexible RF systems using MEMS.

UNIT III MULTI RATE SIGNAL PROCESSING AND DIGITAL GENERATION OF SIGNALS. 9
Sample rate conversion principles. Digital filter Banks. Timing recovery in Digital Receivers using Multi rate Digital filters. Approaches to Direct Digital Synthesis. Analysis of spurious signal Band pass signal generation, Generation of Random sequences.

UNIT IV DATA CONVERTERS AND SMART ANTENNAS 9
Parameters of Ideal and practical Data Converters, Techniques to Improve Data Converter performance, Common ADC and DAC Architectures. Smart Antennas- Hardware implementation of Smart Antennas.

UNIT V DIGITAL HARDWARE AND SOFTWARE CHOICES 9
DSP Processors, FPGA, ASIC s. Trade offs, Object oriented programming, Object Brokers, GNU Radio-USRP.

TOTAL : 45 PERIODS

OUTCOMES:
At the end of this course, the students should be able to:
- Design data converters
- Evaluate smart antennas
- Discuss digital hardware and software choices

REFERENCES:
1. Jeffrey H.Reed, "Software Radio: A Modern Approach to Radio Engineering", Printice Hall,2002.
2. Joseph Mitola, "Software Radio Architecture: Object oriented Approaches to Wireless System Engineering", Wiley-Inter Science; I Edition 2000,ISBN:0471384925
3. Radio, G. N. U. "The gnu software radio." available from world wide web: https://gnuradio. org 2007.
4. S.Shanmugavel, M.A.Bhagyaveni, R.Kalidoss, “Cognitive Radio-An Enabler for Internet of things”, River Publishers, 2017.

NC5071	NETWORK ROUTING ALGORITHMS	L	T	P	C
		3	0	0	3

OBJECTIVES:
- 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 INTRODUCTION 7

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 10

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 10

Classification of RWA algorithms, RWA algorithms, Fairness and Admission Control, Distributed Control Protocols, Permanent Routing and Wavelength Requirements, Wavelength Rerouting-Benefits and Issues, Lightpath 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

OUTCOMES:

Upon Completion of the course, the students will be able to

- Given the network and user requirements and the type of channel over which the network has to operate, the student would be in a position to apply his knowledge for identifying a suitable routing algorithm, implementing it and analyzing its performance.
- The student would also be able to design a new algorithm or modify an existing algorithm to satisfy the evolving demands in the network and by the user applications.

REFERENCES:

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", Addison – Wesley, 2001.
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. S. Keshav, "An engineering approach to computer networking", Addison Wesley 1999.
7. William Stallings, "High speed Networks TCP/IP and ATM Design Principles", Prentice Hall, New York, 1995.
8. William Stallings, "High speed networks and Internets Performance and Quality of Service", II Edition, Pearson Education Asia. Reprint India 2002.

CU5192 **OPTICAL NETWORKS** **L T P C**

3 0 0 3

OBJECTIVES:

The students should be made to understand:

- Optical system components like optical amplifiers, wavelength converters.
- Up-to-date survey of development in Optical Network Architectures.
- Packet switching.
- Network design perspectives.
- Different Optical Network management techniques and functions

UNIT I **9**

Introduction to Optical Networks: Telecommunications Networks Architecture, Services, circuit switching and packet switching, Optical Networks: Multiplexing Techniques, Second generation Optical Networks, Optical Packet Switching, Transmission Basics: Wavelength, frequencies, and channel spacing, Wavelength standards, Optical power and loss, Network Evolution, Nonlinear Effects: Self-phase Modulation, Cross-phase Modulation, Four Wave mixing, Solitons. Components: Couplers, Isolators and Circulators, Multiplexers and Filters, Optical Amplifiers, Transmitters, Detectors, Switches, Wavelength Converters.

UNIT II **9**

Transmission System Engineering: System Model, Power Penalty, Transmitter, Receiver, Optical Amplifiers, Crosstalk, Dispersion, Wavelength Stabilization, Overall Design Considerations. Optical Internets: Migration to IP optical networking, IP and Optical backbone, IP Routing table, MPLS and optical cross connect table, Protocol stack Alternatives, Internetworking SS7 and Legacy Transport, Internet transport network protocol stack.

UNIT III **9**

SONET, SDH and Optical Transport Networks (OTNs): SONET and SDH: SONET multiplexing hierarchy, Frame structure, Functional Component, problem detection, concatenation. Architecture of Optical Transport Networks (OTNs): Digital wrapper, in-band and out-ofband control signalling, Importance of Multiplexing and multiplexing hierarchies, SONET multiplexing hierarchies, SDH multiplexing hierarchies, New Optical Transport, OTN layered Model, Generic Framing Procedure (GFP) **.**

UNIT IV **9**

WDM, Network topologies, MPLS and Optical Networks: WDM: WDM operation, Dense Wavelength Division Multiplexing (DWDM), Erbium-doped Fiber (EDF), WDM amplifiers, Add-Drop Multiplexers, Wavelength Continuity Property, Higher dispersion for DWDM, Tunable DWDM Lasers.

UNIT V **9**

Network topologies and protection schemes: Robust networks, Line and path protection switching, Types of topology, Point to point topology, bi-directional line-switched ring (BLSR), meshed topology, Passive optical networks, Metro optical networks 28 MPLS and Optical Networks: IS label switching, Forwarding equivalence class (FEC), Types of MPLS nodes, Label distribution and binding, label swapping and traffic forwarding, MPLS support of Virtual Private Networks (VPN), MPLS traffic engineering, Multi protocol Lambda switching (MPIS).

TOTAL : 45 PERIODS

OUTCOMES:

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

- Design and Analyze Network Components
- Assess and Evaluate optical networks

REFERENCES:

1. Rajiv Ramaswami and Kumar Sivarajan, "Optical Networks Practical Perspective", 3rd Edition, , Morgan - Kaufmann Publishers.
2. Optical Networks, Third Generation Transport Systems, Uyless Black, Pearson.

MU5091	MULTIMEDIA COMPRESSION TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basic ideas of compression algorithms related to multimedia components – Text, speech, audio, image and Video.
- To understand the principles and standards and their applications with an emphasis on underlying technologies, algorithms, and performance.
- To appreciate the use of compression in multimedia processing applications
- To understand and implement compression standards in detail.

UNIT I FUNDAMENTALS OF COMPRESSION 9

Introduction To multimedia – Graphics, Image and Video representations – Fundamental concepts of video, digital audio – Storage requirements of multimedia applications – Need for compression – Taxonomy of compression Algorithms - Elements of Information Theory – Error Free Compression – Lossy Compression.

UNIT II TEXT COMPRESSION 9

Huffman coding – Adaptive Huffman coding – Arithmetic coding – Shannon-Fano coding – Dictionary techniques – LZW family algorithms.

UNIT III IMAGE COMPRESSION 9

Image Compression: Fundamentals –– Compression Standards – JPEG Standard – Sub-band coding – Wavelet Based compression – Implementation using Filters – EZW, SPIHT coders – JPEG 2000 standards – JBIG and JBIG2 standards.

UNIT IV AUDIO COMPRESSION 9

Audio compression Techniques – law, A-Law companding – Frequency domain and filtering – Basic sub-band coding – Application to speech coding – G.722 – MPEG audio – progressive encoding – Silence compression, Speech compression – Formant and CELP vocoders.

UNIT V VIDEO COMPRESSION 9

Video compression techniques and Standards – MPEG video coding: MPEG-1 and MPEG-2 video coding: MPEG-3 and MPEG-4 – Motion estimation and compensation techniques – H.261 Standard – DVI technology – DVI real time compression – Current Trends in Compression standards.

TOTAL : 45 PERIODS

OUTCOMES:

Upon Completion of the course, the students should be able to

- Implement basic compression algorithms with MATLAB and its equivalent open source environments.
- Design and implement some basic compression standards
- Critically analyze different approaches of compression algorithms in multimedia related mini projects.

REFERENCES:

1. David Solomon, “Data Compression – The Complete Reference”, Fourth Edition, Springer Verlog, New York, 2006.
2. Darrel Hankerson, Greg A Harris, Peter D Johnson, ‘Introduction to Information Theory and Data Compression’ Second Edition, Chapman and Hall ,CRC press, 2003
3. Khalid Sayood: Introduction to Data Compression”, Morgan Kauffman Harcourt India, Third Edition, 2010.
4. Mark S. Drew, Ze-Nian Li, “Fundamentals of Multimedia”, PHI, 2009.
5. Peter Symes : Digital Video Compression, McGraw Hill Pub., 2004.
6. Yun Q.Shi, Huifang Sun, “Image and Video Compression for Multimedia Engineering, Algorithms and Fundamentals”, CRC Press, 2003.

CU5074	ULTRA WIDEBAND COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give fundamental concepts related to Ultra wide band
- To understand the channel model and signal processing for UWB.
- To acquire knowledge about UWB antennas and regulations.

UNIT I INTRODUCTION TO UWB 9

History, Definition, FCC Mask, UWB features, UWB Interference: IEEE 802.11.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, 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

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

OUTCOMES:

- The student would be able to understand UWB technologies.
- Ability to assess the performance of UWB channels.
- The student would be able to design UWB antenna for various applications.

REFERENCES:

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 Siriwong pairat and K. J. Ray Liu, “Ultra-Wideband Communications Systems: Multiband OFDM approach” John Wiley and IEEE press, New York 2008.

NC5006	GAME THEORY FOR WIRELESS COMMUNICATION AND NETWORKING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give an overview of a broad range of models that is studied in game theory.
- To understand a range of mathematical models of Conflict and cooperation between two or more agents.
- To discuss the main concepts in the game theory and to explain the classes of games.
- To discuss the application of game theory in wireless communication and networking

UNIT I INTRODUCTION **9**

Introduction to theory of games- conflict, strategy, utility theory, games in extensive and normal forms, Examples: prisoners dilemma, battle of sexes,.

UNIT II CLASSIFICATION of GAMES **9**

NON CO-OPERATIVE GAMES : Basics of Non-Cooperative games, Non-Cooperative games in strategic form – Matrix games, Nash Equilibrium, Mixed Strategies. Dynamic Non-Cooperative games – Non-Cooperative game in extensive form, repeated games, and stochastic games. COOPERATIVE GAMES : Basics of Cooperative games, bargaining theory – Introduction, Nash bargaining solution, Coalition game theory – shapley value, Dynamic Coalition formation algorithms, Hedonic coalition

UNIT III BAYESIAN GAMES **9**

Overview of Bayesian Games, Bayesian Games in extensive form, Cournot duopoly model with incomplete information, Super-Modular games, Learning in games: Fictitious play, and Regret minimization, Vickrey-Clarke-Groves Auction, Optimal Auction

UNIT IV APPLICATIONS TO NETWORKING - I **9**

Cellular & Broadband wireless access networks – Routing & Resource allocation, Power allocation, Network selection in Multi-technology, WLAN – MAC Protocol design, Random Access Control, Rate Selection for VOIP services, throughput efficiency, competition and implication on network performance

UNIT V APPLICATIONS TO NETWORKING - II **9**

Game theoretic solutions for cooperation in ad hoc networks. Game theory for co-operative node selection for Cognitive network, Game theory for cooperative sensing in CR network, Gametheory for optimal power allocation for co-operative CR networks.

TOTAL: 45 PERIODS

OUTCOMES:

- To be able to design game theory based models.
- To be able to apply game theory to solve network related issues.

REFERENCES:

1. Allan MacKenzie, Luiz DaSilva, "Game Theory for Wireless Engineers, Synthesis Lectures on Communication", Morgan and Claypool Publishers, 2006.
2. Drew Fudenberg and Jean Tirole, "Game Theory", MIT Press, 1991.
3. Hao, Xiaolei, et al. "Hedonic coalition formation game for cooperative spectrum sensing and channel access in cognitive radio networks." IEEE Transactions on Wireless Communications 11.11 (2012): 3968-3979.
4. Khayatian, Hasan, Reza Saadat, and Jamshid Abouei. "Coalition-based approaches for joint power control and relay selection in cooperative networks." IEEE Transactions on Vehicular Technology 62.2 (2013): 835-842.

5. Martin J. Osborne, “An Introduction to Game Theory”, Oxford Press 2006.
6. Prajit K.Dutta, "Strategies and Games: Theory and Practice", MIT Press, 1999.
7. Vijay Krishna, "Auction Theory", Academic Press, 2010.
8. Zhu Han, Dusit Niyato, Walid Saad, Tamer Basar, Are Hjorungnes, “Game Theory in Wireless and Communication Networks: Theory, Models, and Applications”, University Press Cambridge, 1st Edition, 2012.

MP5092 SOFT COMPUTING TECHNIQUES

L	T	P	C
3	0	0	3

OBJECTIVES:

- To know the basics of artificial neural networks
- To provide adequate knowledge about feed forward /feedback neural networks
- To apply the concept of fuzzy logic in various systems.
- To have the idea about genetic algorithm
- To provide adequate knowledge about the applications of Soft Computing.
-

UNIT I ARTIFICIAL NEURAL NETWORK 9

Introduction-Basic concepts of Neural Network-Model of an Artificial Neuron-Characteristics of Neural Network-Learning Methods-Backpropagation Network Architecture-Backpropagation Learning-Counter Propagation Network-Hopfield/Recurrent Network-Adaptive Resonance Theory.

UNIT II FUZZY LOGIC 9

Basic concepts of Fuzzy Logic-Fuzzy Sets and Crisp Sets-Fuzzy Set Theory and Operations-Properties of Fuzzy Sets-Fuzzy and Crisp relations, Fuzzy to Crisp Conversion-Membership Functions-Interference in Fuzzy Logic-Fuzzy if-then Rules, Fuzzy implications and Fuzzy Algorithms,Fuzzification & Defuzzification-Fuzzy Controller.

UNIT III NEURO-FUZZY MODELLING 9

ANFIS Architecture-Classification and Regression Trees-Data Clustering algorithms-Rulebase Structure Identification.

UNIT IV GENETIC ALGORITHMS 9

Basic concepts-Working Principle-Inheritance Operators-Cross Over-Inversion & Deletion-Mutation Operator-Generation Cycle.

UNIT V APPLICATIONS OF SOFTCOMPUTING 9

Genetic Algorithm Application- Bagley and Adaptive Game-Playing Program- Greg Viols Fuzzy Cruise Controller-Air Conditioner Controller-Application of Back Propagation Neural Network.

TOTAL : 45 PERIODS

OUTCOMES:

- Knowledge on concepts of soft computational techniques.
- Able to apply soft computational techniques to solve various problems.
- Motivate to solve research oriented problems.

REFERENCES:

1. George J. Klir and Bo Yuan, 'Fuzzy Sets and Fuzzy Logic Theory and Applications', Printice Hall of India, 2002.
2. J.S.R.Jang,C.T.Sun and E.Mizutani,"Neuro-Fuzzy and Soft Computing",PHI,2004, Pearson Education 2004.
3. Laurene Fausett,"Fundamentals of Neural Networks: Architectures, Algorithms and Appli Pearson Education India, 2006.
4. S.Rajasekaran and G.A.V.Pai."Neural Networks, Fuzzy Logic and Genetic Algorithms",PHI,2010.
5. Timothy J Ross, "Fuzzy logic with Engineering Applications", John Wiley and Sons, 2009.
6. Zimmermann H.J."Fuzzy Set Theory and Its Application" Springer International Edition,2011.

NC5072	NETWORK PROCESSORS	L	T	P	C
		3	0	0	3

OBJECTIVES :

The students should be made to:

- Learn network processors
- Study commercial network processors
- Understand network processor architecture

UNIT I INTRODUCTION 9

Traditional protocol processing Systems – Network processing Hardware – Basic Packet Processing Algorithms and data Structures - Packet processing functions – Protocol Software – Hardware Architectures for Protocol processing – Classification and Forwarding – Switching Fabrics.

UNIT II NETWORK PROCESSOR TECHNOLOGY 9

Network Processors: Motivation and purpose - Complexity of Network Processor Design – Network Processor Architectures architectural variety, architectural characteristics Peripheral Chips supporting Network Processors: Storage processors, Classification Processors, Search Engines, Switch Fabrics, Traffic Managers.

UNIT III COMMERCIAL NETWORK PROCESSORS 9

Multi-Chip Pipeline, Augmented RISC processor, Embedded Processor plus Coprocessors,Pipelilne of Flomogeneous processors. Configurable Instruction set processors – Pipeline ofElectrogeneous processors – Extensive and Diverse processors – Flexible RISC plusCoprocessors – Scalability issues – Design Tradeoffs and consequences.

UNIT IV NETWORK PROCESSOR: ARCHITECTURE AND PROGRAMMING 9

Architecture: Intel Network Processor: Multiheaded Architecture Overview – Features-EmbeddedEISC processor - Packet Processor Hardware – Memory interfaces – System and ControlInterface Components – Bus Interface. Programming Software Development Kit-IXP Instructionset – register formats – Micro Engine Programming – Intra thread and Inter-thread communication– thread synchronization – developing sample applications – control plane – ARM programming.

UNIT V IOS TECHNOLOGIES 9

CISCO COS – Connectilvity and scalability – high availability – IP routing – IP services – IPV6 –Mobile IP – MPLS – IP Multicast 0 Manageability – QoS – Security – Switching – Layer VPN2.

TOTAL : 45 PERIODS

OUTCOMES:

At the end of this course, the students should be able to:

- Discuss network processor architecture
- Compare different programming
- Explain IOS technologies

REFERENCES:

1. Douglas E.Comer “Networks Systems Design using Network Processors” Prentice Hall JaN. 2003
2. Erik, J.Johnson and Aaron R.Kunze, “IXP2400/2806 Programming: The Microengine Coding Grade” Intel Press.
3. Hill Carlson, “Intel Internet Exchange Architecture & Applications a Practical Guide to Intel’s network Processors” Intel press. www.cisco.com.
4. Panas C. Lekkas, “Network Processors: Architectgures, Protocols and Paradigms Telecom Engineering)”, McGraw Hill, Professional, 2003.
5. Patrick Crowley, M aEranklin, H. Hadminglu, PZ Onfryk, “Network Processor Design, Issues and Practices Vol-1” Morgan Kaufman, 2002.
6. Patrick Crowley, M a Frankliln, H. Hadimioglyum PZ Onufryk, Network Processor Design, Issues and Prentices vol.II, Morgan Kaufman, 2003.
7. Ran Giladi, Network Processors: Architecture, Programming, and Implementation, Morgan Kauffmann, 2008.

NE5071 NETWORK MANAGEMENT L T P C

3 0 0 3

OBJECTIVES:

- To appreciate the need for interoperable network management as a typical distributed application
- To familiarize concepts and terminology associated with SNMP
- To be aware of current trends in network management technologies.

UINIT I OSI NETWORK MANAGEMENT 9

OSI Network management model - Organizational model - Information model, Communication model. Abstract Syntax Notation - Encoding Structure, Macros Functional Model CMIP/CMIS.

UINIT II BROADBAND NETWORK MANAGEMENT 9

Broadband networks and services, ATM Technology - VP, VC, ATM Packet, Integrated service, ATM LAN emulation, Virtual LAN, ATM Network Management - ATM Network reference model, Integrated local Management Interface. ATM Management Information base, Role of SNMP and ILMI in ATM Management, M1, M2, M3, M4 interface. ATM Digital Exchange Interface Management.

UNIT III SIMPLE NETWORK MANAGEMENT PROTOCOL 9

SNMPv1 Network Management: Communication and Functional Models. The SNMP Communication Model, Functional model. SNMP Management SNMPv2: Major Changes in SNMPv2, SNMPv2 System Architecture, SNMPv2 Structure of Management Information, The SNMPv2 Management Information Base,SNMPv2 Protocol, Compatibility With SNMPv1.Configuration management, Fault management, Performance management, Event Correlation Techniques 168 security management, Accounting management, Report Management, Policy Based Management, Services Level Management.

UNIT IV NETWORK MANAGEMENT SYSTEMS 9

Network Management Tools, Network Statistics Measurement Systems, History of Enterprise Management, Commercial Network management Systems, System Management and Enterprise Management Solutions.

UNIT V WEB-BASED MANAGEMENT 9

NMS with Web Interface and Web-Based Management, Web Interface to SNMP Management, Embedded Web-Based Management, Desktop management Interface, Web-Based Enterprise Management, WBEM: Windows Management Instrumentation, Java management Extensions, Management of a Storage Area Network.

TOTAL: 45 PERIODS

OUTCOMES:

After the completion of this course, students will be able to

- Diagnose problems and make minor repairs to computer networks using appropriate diagnostics software.
- Demonstrate how to correctly maintain LAN computer systems.
- Maintain the network by performing routine maintenance tasks.
- Apply network management tools.

REFERENCES:

1. Lakshmi G Raman, "Fundamentals of Telecommunication Network Management", Eastern Economy Edition IEEE Press, New Delhi, 1999.
2. Mani Subramanian, "Network Management - Principles and Practice", Pearson Education, Second edition, 2010.
3. Mani Subramanian, "Network Management Principles and Practice", Addison Wesley, Second edition, 2010.
4. Mark Burges, "Principles of Network System Administration", Wiley, 2000.
5. Salah Aiidarons and Thomas Plevayk, "Telecommunications Network Technologies and Implementations", Eastern Economy Edition IEEE press, New Delhi, 1998.
6. Stephen Morris, "Network Management, MIBs and MPLS - Principles, Design and Implementation", Pearson Education, 2003.

WEB REFERENCES

1. http://www.apps.ietf.org/rfc/rfc1095.html
2. ycchen.im.ncnu.edu.tw/nm/ch_5x.ppt
3. en.wikipedia.org/wiki/Systems_management

CU5097 WIRELESS ADHOC AND SENSOR NETWORKS

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OBJECTIVES:

- To understand the basics of Ad-hoc & Sensor Networks.
- To learn various fundamental and emerging protocols of all layers.
- To study about the issues pertaining to major obstacles in establishment and efficient management of Ad-hoc and sensor networks.
- To understand the nature and applications of Ad-hoc and sensor networks.
- To understand various security practices and protocols of Ad-hoc and Sensor Networks.

UNIT I MAC & TCP IN AD HOC NETWORKS 9

Fundamentals of WLANs – IEEE 802.11 Architecture - Self configuration and Auto configuration-Issues in Ad-Hoc Wireless Networks – MAC Protocols for Ad-Hoc Wireless Networks – Contention Based Protocols - TCP over Ad-Hoc networks-TCP protocol overview - TCP and MANETs – Solutions for TCP over Ad-Hoc Networks.

UNIT II ROUTING IN AD HOC NETWORKS 9

Routing in Ad-Hoc Networks- Introduction-Topology based versus Position based Approaches-Proactive, Reactive, Hybrid Routing Approach-Principles and issues – Location services - DREAM – Quorums based location service – Grid – Forwarding strategies – Greedy packet forwarding – Restricted directional flooding- Hierarchical Routing- **Issues and Challenges in providing QoS.**

UNIT III MAC, ROUTING & QOS IN WIRELESS SENSOR NETWORKS 9

Introduction – Architecture - Single node architecture – Sensor network design considerations – Energy Efficient Design principles for WSNs – Protocols for WSN – Physical Layer : Transceiver Design considerations – MAC Layer Protocols – IEEE 802.15.4 Zigbee – Link Layer and Error Control issues - Routing Protocols – Mobile Nodes and Mobile Robots - Data Centric & Contention Based Networking – Transport Protocols & QOS – Congestion Control issues – Application Layer support.

UNIT IV SENSOR MANAGEMENT 9

Sensor Management - Topology Control Protocols and Sensing Mode Selection Protocols - Time synchronization - Localization and positioning – Operating systems and Sensor Network programming – Sensor Network Simulators.

UNIT V SECURITY IN AD HOC AND SENSOR NETWORKS 9

Security in Ad-Hoc and Sensor networks – Key Distribution and Management – Software based Anti-tamper techniques – water marking techniques – Defense against routing attacks - Secure Adhoc routing protocols – Broadcast authentication WSN protocols – TESLA – Biba – Sensor Network Security Protocols – SPINS.

TOTAL : 45 PERIODS

OUTCOMES:

Upon Completion of the course, the students should be able to

- Identify different issues in wireless ad hoc and sensor networks.
- To analyze protocols developed for ad hoc and sensor networks.
- To identify and address the security threats in ad hoc and sensor networks.
- Establish a Sensor network environment for different type of applications.

REFERENCES:

1. Adrian Perrig, J. D. Tygar, "Secure Broadcast Communication: In Wired and Wireless Networks", Springer, 2006.
2. Carlos De Morais Cordeiro, Dharma Prakash Agrawal “Ad Hoc and Sensor Networks: Theory and Applications (2nd Edition), World Scientific Publishing, 2011.
3. C.Siva Ram Murthy and B.S.Manoj, “Ad Hoc Wireless Networks – Architectures and Protocols”, Pearson Education, 2004.
4. C.K.Toh, “Ad Hoc Mobile Wireless Networks”, Pearson Education, 2002.
5. Erdal Çayırcı , Chunming Rong, “Security in Wireless Ad Hoc and Sensor Networks”, John Wiley and Sons, 2009.
6. Holger Karl, Andreas willig, Protocols and Architectures for Wireless Sensor

Networks, John Wiley & Sons, Inc .2005.
7. Subir Kumar Sarkar, T G Basavaraju, C Puttamadappa, “Ad Hoc Mobile Wireless Networks”, Auerbach Publications, 2008.
8. Waltenegus Dargie, Christian Poellabauer, “Fundamentals of Wireless Sensor Networks Theory and Practice”, John Wiley and Sons, 2010.

NC5007 PARALLEL PROCESSING

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OBJECTIVES:

- To understand the architectures for parallel processing.
- To learn the concepts of pipelining and multithreading.

UNIT I THEORY OF PARALLELISM **9**

Parallel computer models- the state of computing, Multiprocessors and multi computers and multivectors and SIMD computers, PRAM and VLSI models, Architecture development tracks Program and network properties.

UNIT II PARALLEL PROCESSING APPLICATIONS **9**

Conditions of parallelism, Program partitioning and scheduling, Program flow mechanisms, system interconnect architectures. Principles of scalable performance, performance metrics and measures, Data Flow Machine Language- Architecture of Data Flow Machines.

UNIT III HARDWARE TECHNOLOGIES **9**

Processor and memory hierarchy- advanced processor technology, superscalar and vector processors, memory hierarchy technology, virtual memory technology, bus cache and shared memory, backplane bus systems, cache memory organizations, shared memory Organizations, sequential and weak consistency models.

UNIT IV INSTRUCTION LEVEL PARALLEL PROCESSING **9**

Pipelining in processing elements- delays in Pipeline execution- difficulties in Pipelining- Superscalar Processors- Vector Processor – Very Long Instruction Word Processor (VLIW)- Commercial Processor-Power PC 620 RISC Processor- Two Instruction Superscalar RISC Processor- Multithreaded Processors- Future Processor Architecture- Trace Processor, Multiscalar Processor, Super flow Architecture.

UNIT V PARALLEL ALGORITHMS **9**

Classification of Parallel Algorithms: Synchronized and Asynchronized parallel algorithms, Performance of Parallel algorithms- Elementary parallel algorithms: Searching, Sorting, Matrix Operations

TOTAL: 45 PERIODS

OUTCOMES:

- Apply the problem solving techniques in parallel computing.
- To be able to solve problems related to memory management.
- To be able to design efficient parallel algorithms.

REFERENCES:

1. Hwang.K.Briggs F.A., “Computer Architecture and Parallel Processing”, Tata McGraw Hill
2. Kai Hwang & Naresh Jotwani, “Advanced Computer Architecture”, Tata McGraw Hill, Second Edition.
3. Quinn M.J, “Designing Efficient Algorithm for Parallel Computers”, Mc Graw Hill, 2003.
4. V.Rajaraman, C.Siva Ram Murthy,”Parallel Computers” Architecture and Programming, Prentice Hall of India Private Limited, 2006.
5. William Stallings, “Computer Organization and Architecture”, Indian Edition, Pearson Education, 2010.