Sri SAI RAM ENGINEERING COLLEGE
An Autonomous Institution
West Tambaram, Chennai - 44
www.sairam.edu.in

Approved by AICTE, New Delhi
Affiliated to Anna University

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

M.E. COMMUNICATION SYSTEMS

AUTONOMOUS

REGULATIONS
2024

Academic Year 2024-25 onwards

PG CURRICULUM AND
SYLLABUS
I - IV
SEMESTERS

SRI SAIRAM ENGINEERING COLLEGE

VISION

To emerge as a "Centre of excellence " offering Technical Education and Research opportunities of very high standards to students, develop the total personality of the individual and instil high levels of discipline and strive to set global standards, making our students technologically superior and ethically stronger, who in turn shall contribute to the advancement of society and humankind.

MISSION

We dedicate and commit ourselves to achieve, sustain and foster unmatched excellence in Technical Education. To this end, we will pursue continuous development of infra-structure and enhance state-of-the-art equipment to provide our students a technologically up-to date and intellectually inspiring environment of learning, research, creativity, innovation and professional activity and inculcate in them ethical and moral values.

QUALITY POLICY

We at Sri Sai Ram Engineering College are committed to build a better Nation through Quality Education with team spirit. Our students are enabled to excel in all values of Life and become Good Citizens. We continually improve the System, Infrastructure and Service to satisfy the Students, Parents, Industry and Society.

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGG.

VISION

To emerge as a "centre of excellence" in the field of Electronics and Communication Engineering and to mould our students to become technically and ethically strong to meet the global challenges. The Students in turn contribute to the advancement and welfare of the society.

MISSION

Department of Electronics and Communication Engineering, SRI SAIRAM ENGINEERING COLLEGE is committed to

M1 Achieve, sustain and foster excellence in the field of Electronics and Communication Engineering.

M2 Adopt proper pedagogical methods to maximize the knowledge transfer.

M3 Enhance the understanding of theoretical concepts through professional society activities

M4 Improve the infrastructure and provide conducive environment of learning and research following ethical and moral values

AUTONOMOUS CURRICULA AND SYLLABI
Regulations 2024

SEMESTER I

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	24PCOMA103	Applied Mathematics for Communication Engineers	4	0	0	4	4
2	24PCOPC101	Advanced Radiation Systems	3	0	0	3	3
3	24PCOPC102	Advanced Digital Communication Techniques	3	0	0	3	3
4	24PCOPC103	Optical Networks	3	0	0	3	3
5	24PCOELXXX	Professional Elective - I	3	0	0	3	3
PRACTICAL							
6	24PCOPL101	Communication Systems Laboratory	0	0	3	3	1.5
VALUE ADDITIONS - I							
7	24PCOTE101	Innovative Design Project - I	0	0	4	4	2
TOTAL						**23**	**19.5**

SEMESTER II

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	24PCOPC201	Advanced Wireless Communication Systems	3	0	0	3	3
2	24PCOPC202	MIC and RF System Design	3	0	0	3	3
3	24PCOPC203	Electromagnetic Interference and Compatibility	3	0	0	3	3
4	24PCOPC204	Advanced Digital Signal Processing	3	0	0	3	3
5	24PCOELXXX	Professional Elective – II	3	0	0	3	3
PRACTICAL							
6	24PCOPL201	RF System Design Laboratory	3	0	0	3	1.5
VALUE ADDITIONS - II							
7	24PCOTE201	Innovative Design Project - II	0	0	4	4	2
TOTAL						**22**	**18.5**

SEMESTER III

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
THEORY							
1	24PCOPC301	Millimeter Wave Communication	3	0	0	3	3
2	24PCOELXXX	Professional Elective – III	3	0	0	3	3
3	24PCOELXXX	Professional Elective - IV	3	0	0	3	3
PRACTICAL							
4	24PCOPJ301	Project Work Phase - I	0	0	12	12	6
TOTAL						**21**	**15**

SEMESTER IV

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDITS
			L	T	P		
PRACTICAL							
1	24PCOPJ401	Project Work Phase - II	0	0	24	24	12
TOTAL						**24**	**12**

PROFESSIONAL ELECTIVES - I

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDIT
			L	T	P		
1	24PCOEL101	Communication Network Modeling and Simulation	3	0	0	3	3
2	24PCOEL102	Digital Communication Receivers	3	0	0	3	3
3	24PCOEL103	Detection and Estimation Theory	3	0	0	3	3
4	24PCOEL104	VLSI for Wireless Communication	3	0	0	3	3
5	24PCOEL105	Cognitive Radio Networks	3	0	0	3	3
6	24PCOEL106	Broadband Access Technologies	3	0	0	3	3
7	24PCOEL107	Space Time Wireless Communication	3	0	0	3	3

PROFESSIONAL ELECTIVES - II

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDIT
			L	T	P		
1	24PCOEL201	Advanced Satellite Communication and Navigation Systems	3	0	0	3	3
2	24PCOEL202	DSP Processor Architecture and Programming	3	0	0	3	3
3	24PCOEL203	Analog and Mixed Mode VLSI Design	3	0	0	3	3
4	24PCOEL204	Real Time Embedded Systems	3	0	0	3	3
5	24PCOEL205	MEMS and NEMS	3	0	0	3	3
6	24PCOEL206	Green Radio Communication Networks	3	0	0	3	3
7	24PCOEL207	Software Defined Radio	3	0	0	3	3

PROFESSIONAL ELECTIVES - III

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDIT
			L	T	P		
1	24PCOEL301	Advanced Antenna Design	3	0	0	3	3
2	24PCOEL302	Advanced Digital Image Processing	3	0	0	3	3
3	24PCOEL303	Radar Signal Processing	3	0	0	3	3
4	24PCOEL304	Speech Processing and Synthesis	3	0	0	3	3
5	24PCOEL305	Advanced Wireless Networks	3	0	0	3	3
6	24PCOEL306	Radio over Fiber Technologies	3	0	0	3	3
7	24PCOEL307	Pattern Recognition and Machine Learning	3	0	0	3	3

PROFESSIONAL ELECTIVES - IV

S. NO	COURSE CODE	COURSE TITLE	WEEK HOURS			TOTAL CONTACT HOURS	CREDIT
			L	T	P		
1	24PCOEL308	Soft Computing Techniques	3	0	0	3	3
2	24PCOEL309	Network Processors	3	0	0	3	3
3	24PCOEL310	Network Management	3	0	0	3	3
4	24PCOEL311	Communication Network Security	3	0	0	3	3
5	24PCOEL312	Internet of Things	3	0	0	3	3
6	24PCOEL313	Multimedia Compression Techniques	3	0	0	3	3
7	24PCOEL314	Ultra Wide Band Communication	3	0	0	3	3

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1 Acquire strong foundation in Engineering, Science and Technology for a successful career in Electronics and Communication Engineering.

PEO2 Apply their knowledge and skills acquired to solve the issues in real world Electronics and Communication sectors and to develop feasible and viable systems.

PEO3 Be receptive to new technologies and attain professional competence through professional society activities.

PEO4 Participate in lifelong learning, higher education efforts to emerge as expert researchers and technologists.

PEO5 Practice the profession with ethics, integrity, leadership and social responsibilities.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1 To inculcate the ability in graduates to design and analyze the subsystems such as RF, Signal Processing, Modern communication systems and networks.

PSO 2 To enhance problem solving skills in communication systems design using latest hardware and software tools and to apply communication engineering principles and practices for developing products for scientific and business applications.

PROGRAMME OUTCOMES(POs)

PO1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

PO2. 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.

PO3. 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.

PO4. Conduct investigations of complex problems: Use research-based knowledge andresearch methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. 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.

PO6. 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.

PO7. 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.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9. Individual and team work: Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. 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.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering 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.

PO12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

SEMESTER - I

24PCOMA103 SDG NO. 4	APPLIED MATHEMATICS FOR COMMUNICATION ENGINEERS	L	T	P	C
		4	0	0	4

OBJECTIVES:

- To introduce vector spaces and matrix decompositions for various applications in communication Engineering
- To introduce linear programming techniques for solving optimisation problems in Engineering
- To obtain the numerical solution of initial value and final value problems in ordinary Differential Equations
- To provide foundation on the theory of probability, one dimensional, two dimensional random variables and their statistical quantities
- To know about queueing systems for applications in computer networks

UNIT I LINEAR ALGEBRA 12

Vector spaces – Norms – Inner products – Eigen values 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 – Bayes' 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

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.

OUTCOMES:

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

1. Understand vector spaces and solve systems of linear equations using matrix decomposition methods.
2. Develop a linear model and apply linear programming techniques to optimize the model.
3. Compute the numerical solution of an ordinary differential equation using single step and multistep methods.
4. Understand one-dimensional and two-dimensional random variables and compute the coefficients of correlation and regression.
5. Model and analyse queueing systems in real world situations.

CO-PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	-	-	-	-	-	-	-	1
CO2	3	3	3	2	1	-	-	-	-	-	-	1
CO3	3	3	3	2	-	-	-	-	-	-	-	1
CO4	3	3	3	2	1	-	-	-	-	-	-	1
CO5	3	3	3	2	1	-	-	-	-	-	-	1

SEMESTER - I

24PCOPC101 SDG NO. 11 & 15	ADVANCED RADIATION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To acquire the knowledge of antenna radiation and its parameters
- To enhance the student's knowledge in the area of various antenna design
- To analyze the antenna arrays
- To identify the radiation mechanism and applications of microstrip dipole antennas
- To impart the knowledge about modern antennas

UNIT I ANTENNA FUNDAMENTALS 9

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

UNIT II RADIATION FROM APERTURES 9

Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture, distribution on an infinite ground plane; Slot antenna; Horn antenna; Reflector antenna, aperture blockage, design considerations.

UNIT III ARRAYS 9

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

UNIT IV MICRO STRIP ANTENNA 9

Radiation mechanism from patch; Excitation techniques; Microstrip dipole; Rectangular patch, Circular patch, and Ring antenna – radiation analysis from transmission line model, cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Applications of microstrip array antenna.

UNIT V SPECIAL ANTENNAS AND MEASUREMENTS 9

Mobile phone antenna, base station, handset antenna, UWB antenna, PIFA, Vivaldi antenna, Antenna for automobiles, Broadband antenna, antenna factor, Gain, impedance and radiation pattern measurements, test sites and anechoic chamber.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Balanis. A, "Antenna Theory Analysis and Design", John Wiley and Sons, New York, 1982.
2. Hubregt. J. Visser "Antenna Theory and Applications", 1st Edition, John Wiley & Sons Ltd, New York, 2012.

REFERENCES:

1. S. Drabowitch et. al., "Modern Antennas", 2nd Edition Springer science business Media,Inc.2005
2. Xavier Begaud, "Ultra Wide Band Antennas" , 1st Edition, ISTE Ltd and John Wiley & Sons Ltd, New York,2013.
3. Zhijun Zhang "Antenna Design for Mobile Devices", 1st Edition, John Wiley & Sons (Asia) Ltd, New York,2011.

ONLINE RESOURCES:

1. https://youtu.be/ZaXm6wau-jc
2. https://youtu.be/-F7KYLO4Bkg

OUTCOMES:

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

1. Understand the concept of antenna radiation pattern and fundamental concepts.
2. Design and analyze the various antennas.
3. Understand the concept of antenna arrays and beamforming techniques.
4. Design and analyze the microstrip dipole antenna with applications.
5. Acquire the knowledge of modern antenna design.

CO - PO, PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	2	-	-	-	-	2	2	2	1
CO2	3	2	3	2	1	2	-	-	-	-	2	2	2	1
CO3	3	2	3	2	-	2	-	-	-	-	2	2	2	1
CO4	3	2	3	2	3	2	-	-	-	-	2	2	2	1
CO5	3	2	3	2	3	2	-	-	-	-	2	2	2	1

SEMESTER - I

24PCOPC102 SDG NO. 4 & 9	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 non coherent receivers and its impact on different channel characteristics
- To understand the different equalizers
- To understand the different block coded and convolutional coded digital communication systems
- To understand the basics of multicarrier and multiuser communications

UNIT I COHERENT AND NON-COHERENT COMMUNICATION 9

Coherent receivers – Optimum receivers in AWGN – IQ modulation & demodulation – Non coherent 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; Bi orthogonal; Transorthogonal – Shannon's channel coding theorem; Channel capacity; Matched filter; Concepts of Spread spectrum communication – Coded BPSK and DPSK demodulators– Linear block codes; Hamming; Golay; Cyclic; BCH ; Reed – Solomon codes –Space time block codes.

UNIT IV CONVOLUTIONAL CODED DIGITAL COMMUNICATION 9

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

UNIT V MULTICARRIER AND MULTIUSER COMMUNICATIONS 9

Single Vs multicarrier modulation, Orthogonal Frequency Division Multiplexing (OFDM), Modulation and demodulation in an OFDM system, 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, sub optimum detectors, successive interference cancellation.

TOTAL: 45 PERIODS

REFERENCES:

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

WEB REFERENCES:

1. https://nptel.ac.in/courses/117/105/117105144/
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-02-introduction-to-eecs-ii-digital-communication-systems-fall-2012/lecture-videos/

ONLINE RESOURCES:

1. http://videolectures.net/ict07_mohorcic_docs/#

OUTCOMES:

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

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

CO – PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	2	-	-	-	-	2	2	3	2
CO2	3	2	3	2	2	2	-	-	-	-	2	2	3	2
CO3	3	2	3	2	3	2	-	-	-	-	2	2	3	2
CO4	3	2	3	2	3	2	-	-	-	-	2	2	3	2
CO5	3	2	3	2	2	2	-	-	-	-	2	2	3	2

SEMESTER - I

24PCOPC103 SDG NO. 11 & 15	OPTICAL NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand optical system components like optical amplifiers, wavelength converters
- To discuss transmission systems engineering & optical internets
- To get the Up-to-date survey of development in optical network architectures & OTNs
- To familiarize about WDM & DWDM technologies
- To know about optical switching networks

UNIT I INTRODUCTION TO OPTICAL NETWORKS AND COMPONENTS 9

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 TRANSMISSION SYSTEM ENGINEERING AND OPTICAL INTERNETS 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 SONET/SDH AND OPTICAL TRANSPORT NETWORKS (OTNs) 9

SONET/SDH: SONET multiplexing hierarchy, Frame structure, Functional Component, problem detection, concatenation. Architecture of Optical Transport Networks (OTNs): Digital wrapper, in-band and out-of band control signaling, Importance of Multiplexing and multiplexing hierarchies, SONET multiplexing hierarchies, SDH multiplexing hierarchies, New Optical

Transport, OTN layered Model, Generic Framing Procedure (GFP)

UNIT IV WDM AND DWDM NETWORK TECHNOLOGIES 9

WDM: WDM operation, Dense Wavelength Division Multiplexing (DWDM), Erbium-doped Fiber Amplifiers (EDFA), WDM amplifiers, Add-Drop Multiplexers, Wavelength Continuity Property, Higher dispersion for DWDM, Tunable DWDM Lasers.

UNIT V OPTICAL SWITCHING NETWORKS 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, MPLS 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 (MPlS).

TOTAL: 45 PERIODS

REFERENCES:

1. Rajiv Ramaswami and Kumar Sivarajan, "Optical Networks – Practical Perspective", 3rd Edition, Morgan – Kaufmann Publishers.
2. Uyless Black, "Optical Networks: Third Generation Transport Systems", Pearson Education.
3. C.Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks: Concept, Design and Algorithms", Prentice Hall ofIndia, 1st Edition,2002.
4. P.E. Green, Jr., "Fiber Optic Networks", PrenticeHall, NJ, 1993.
5. Biswanath Mukherjee, "Optical WDM Networks", Springer Series, 2006.

WEB REFERENCES:

1. https://www.fujitsu.com/global/about/resources/publications/fstj/archives/vol35-1.html
2. http://home.iitk.ac.in/~ynsingh/seminars/OptNets.pdf

OUTCOMES:

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

1. Analyze the functions of network components and transmission basis.
2. Assess and evaluate transmission system engineering and optical internets.
3. Discuss the development in optical network architectures & OTNs.
4. Understand & analyze the principles of WDM & DWDM Network technologies.

5. Compare the existing optical switching networks.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	2	-	-	-	-	2	2	2	1
CO2	3	2	3	2	1	2	-	-	-	-	2	2	2	1
CO3	3	2	3	2	-	2	-	-	-	-	2	2	2	1
CO4	3	2	3	2	3	2	-	-	-	-	2	2	2	1
CO5	3	2	3	2	3	2	-	-	-	-	2	2	2	1

SEMESTER - I

24PCOPL101 SDG NO. 11 & 15	COMMUNICATION SYSTEMS LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

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

LIST OF EXPERIMENTS :

USE NETWORK ANALYSER FOR THE FOLLOWING EXPERIMENTS:

1. Measurement of transmission line parameters.
2. S-parameter estimation of Microwave devices
3. Design and testing of a Microstrip coupler.
4. Characteristics of Microstrip patch antenna.

USE APPROPRIATE SIMULATION TOOLS FOR THE FOLLOWING EXPERIMENTS:

1. Generation & detection of binary digital modulation techniques.
2. Spread Spectrum communication system-Pseudo random binary sequence generation-Baseband DSSS.
3. Digital Filter Design
4. Performance evaluation of simulated CDMA system

5. Channel equalizer design (LMS,RLS)
6. Antenna Radiation Pattern measurement

TOTAL: 45 PERIODS

OUTCOMES:

On completion of this laboratory course, the student should be able to

1. Measure and analyze various transmission line parameters.
2. Design Microstrip patch antennas.
3. Implement the adaptive filtering algorithms.
4. To generate and detect digital communication signals of various modulation techniques using MATLAB.
5. Evaluate cellular mobile communication technology and propagation model.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	2	1	1	-	2	-	1	3	3	3
CO2	3	3	1	1	2	1	1	-	2	-	1	3	3	3
CO3	3	3	1	1	2	1	1	-	2	-	1	3	3	3
CO4	3	3	1	1	2	1	1	-	2	-	1	3	3	3
CO5	3	3	1	1	2	1	1	-	2	-	1	3	3	3

SEMESTER - I

24PCOTE101 SDG NO. 4 & 9	INNOVATIVE DESIGN PROJECT - I	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To encourage in identifying problems with social relevance
- To think of an innovative solution for the problem
- To design and conduct suitable experiment with modern tool
- To develop a cost effective prototype of the innovative design
- To understand the practical aspects and associated challenges in implementing the design

METHODOLOGY:

1. Student should do it individually.
2. Student should submit / present his/her ideas to the Faculty-in-Charge for approval.
3. Student should submit proposal with system/ technical details and cost implications.
4. Student should periodically demonstrate his/her progress.

EVALUATION:

Evaluation will be based on:

1. The social relevance of the work.
2. The utility of the system developed.
3. The Level of proof of concept.
4. Industry support if obtained.etc.

WEB REFERENCES:

1. https://www.mathworks.com/academia/books.html
2. http://www.mathcs.emory.edu/~cheung/Courses/455/Syllabus/A3-NS/Book/Introduction-to- Network-Simulator-NS2-2012.pdf

ONLINE REFERENCES

1. http://www.jgyan.com/ns2/
2. https://matlabacademy.mathworks.com/

OUTCOMES:

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

1. The student would be able to identify socially relevant issues and apply his/her knowledge to evolve feasible solutions.
2. The student would be able to comprehensively record and report the measured data, write reports, communicate research ideas and do oral presentations effectively.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	1	1	1	2	1	3	2	3	3
CO2	3	3	3	3	3	1	1	1	2	1	3	2	3	3

SEMESTER - II

24PCOPC201 SDG NO. 4 & 9	ADVANCED WIRELESS COMMUNICATIONS SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Understand concepts of MIMO diversity and spatial multiplexing
- Analyze Space time receivers and Diversity multiplexing trade - off
- Learn Massive MIMO system
- Know millimeter wave communication
- To gain knowledge in software defined radio and cognitive radio

UNIT I INFORMATION THEORETIC ASPECTS OF MIMO 9

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, Ergodic and outage capacity, capacity bounds and influence of channel properties on the capacity.

UNIT II MIMO DIVERSITY AND SPATIAL MULTIPLEXING 9

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, Massive MIMO technique, capacity of massive MIMO, Pilot Design for massive MIMO, Resource allocation and transceivers design, Baseband and RF implementation, Channel Models.

UNIT IV MILLIMETER WAVE COMMUNICATION 9

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

UNIT V SOFTWARE DEFINED RADIO AND COGNITIVE RADIO 9

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

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. Osseiran, Afif, Jose F. Monserrat, and Patrick Marsch, eds, "5G Mobile and Wireless Communication Technology", Cambridge University Press, 2016.
4. Lechowicz, Leszek, and Mieczyslaw M. Kokar, "Cognitive Radio Interoperability through Waveform Reconfiguration", ARTECH House, 2016.

WEB REFERENCES:

1. https://people.cs.nctu.edu.tw/~katelin/courses/wcs16/
2. https://doi.org/10.1155/2018/9693514

ONLINE RESOURCES:

1. http://wcsp.eng.usf.edu/MIMO_links.html
2. http://wcsp.eng.usf.edu/cognitive_radio_links.html

OUTCOMES:

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

1. Analyze MIMO system concept and MIMO system capacity.
2. Explain Space time receivers.
3. Familiarize with the millimeter wave communication.
4. Explain Space time receivers.
5. Illustrate software defined radio and cognitive radio.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	3	2	-	-	-	1	2	3	2
CO2	3	2	3	2	2	1	1	-	-	-	1	2	3	2
CO3	3	2	3	2	-	1	1	-	-	-	1	2	3	2
CO4	3	2	3	2	1	1	2	-	-	-	1	2	3	2
CO5	3	3	3	3	3	3	2	-	-	-	2	2	3	2

SEMESTER - II

24PCOPC202 SDG NO. 11 & 15	MIC AND RF SYSTEM DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

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

UNIT I CMOS PHYSICS, TRANSCEIVER SPECIFICATIONS AND ARCHITECTURES 9

CMOS: Introduction to MOSFET Physics, Noise: Thermal, shot, flicker, popcorn noise transceiver Specifications: Two port Noise theory, Noise Figure, THD, IP2, IP3, Sensitivity, SFDR, Phase noise. Transceiver Architectures: Receiver: Homodyne, Heterodyne, Image reject, Low IF Architectures, Transmitter: Direct up conversion, Two step up conversion schemes.

UNIT II IMPEDANCE MATCHING AND AMPLIFIERS 9

Review of S-parameters and Smith chart, Passive IC components, Impedance matching networks, Amplifiers: Common Gate, Common Source Amplifiers, OC Time constants in bandwidth estimation and enhancement, High frequency amplifier design, Low Noise Amplifiers: Power match and Noise match, Single ended and Differential schemes.

UNIT III FEEDBACK SYSTEMS AND POWER AMPLIFIERS 9

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

UNIT IV RF FILTERS, OSCILLATORS, MIXERS 9

Overview-basic resonator and filter configuration, special filter realizations, filter implementation. Basic oscillator model, high frequency oscillator configuration, basic characteristics of mixers, phase locked loops, RF directional couplers, hybrid couplers, detector and demodulator circuits.

UNIT V MIC COMPONENTS **9**

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

TOTAL: 45 PERIODS

TEXT BOOKS:

1. B.Razavi, "RF Microelectronics", Pearson Education, 1997.
2. T. Lee,"Design of CMOS RF Integrated Circuits", Cambridge, 2004.

REFERENCES:

1. Igor Minin, "Microwave and millimeter wave technologies modern UWB antennas and equipment", In-Tech publication, 2010.

WEB REFERENCES:

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-772-compound-semiconductor-devices-spring-2003/lecture-notes/Lecture10v2.pdf

ONLINE RESOURCES:

1. https://swayam.gov.in/nd1_noc20_ee25/

OUTCOMES:

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

1. Discuss the basic concepts of RF and MIC.
2. Understand the various components of RF systems.
3. Discuss the operation of RF circuits.
4. Understand the operation of Microwave components.
5. Discuss various MIC components.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	-	-	-	-	-	-	-	-	-	1	3	-
CO2	3	2	-	-	1	-	-	-	-	-	1	1	3	-
CO3	3	2	-	-	2	-	-	-	-	-	1	1	3	-
CO4	3	2	-	-	2	-	-	-	-	-	1	1	3	-
CO5	3	-	-	-	2	-	-	-	-	-	1	1	3	-

SEMESTER - II

24PCOPC203 SDG NO. 4	ELECTRO MAGNETIC INTERFERENCE AND COMPATIBILITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the basics of EMIC, it's sources and problems
- To acquire the knowledge about EMI coupling
- To understand the concepts of Filtering and Shielding
- To understand the need of various EMI standards and Regulations
- To understand the working of various test methods for Emission and Immunity

UNIT I BASIC THEORY **8**

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 **10**

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 **10**

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, Gasketing 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 STANDARDS AND REGULATION **8**

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. Electromagnetic 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.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Henry W. Ott, "Electromagnetic Compatibility Engineering", John Wiley & Sons Inc, Newyork, 2009.
2. V Prasad Kodali, "Engineering Electromagnetic Compatibility", IEEE Press, Newyork, 2001.
3. Bemhard Keiser, "Principles of Electromagnetic Compatibility", 3rd Ed, Artech house, Norwood, 1986.
4. Dr Kenneth L Kaiser, "The Electromagnetic Compatibility Handbook", CRC Press, 2005.
5. Clayton Paul, "Introduction to Electromagnetic Compatibility", Wiley Interscience, 2006.

REFERENCES:

1. Daryl Gerke and William Kimmel, "EDN‟s Designer‟s Guide to Electromagnetic Compatibility", Elsevier Science & Technology Books, 2002.
2. S Guide to Electromagnetic Compatibility", Elsevier Science & Technology Books, 2002.
3. Paul, C.R., "Introduction to Electromagnetic Compatibility", 2nd ed., Wiley (2010).
4. W Scott Bennett, "Control and Measurement of Unintentional Electromagnetic Radiation", John Wiley & Sons Inc., (Wiley Interscience Series) 1997.

WEB REFERENCES:

1. https://www.ee.iitb.ac.in/web/academics/courses/EE785
2. https://nptel.ac.in/courses/108106138/
3. https://www.classcentral.com/course/swayam-electromagnetic-compatibility-emc-12959

ONLINE RESOURCES:

1. http://www.montana.edu/tjkaiser/ee335/notes/EE335-29-EMI.pdf
2. https://www.getmynotes.com/electromagnetic-interference-and-compatibility-ec6011-notes/

OUTCOMES:

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

1. To identify the sources of EMI and its hazards.
2. To discuss the EMI coupling and transient sources.
3. To acquire knowledge about various mitigation techniques.
4. To acquire knowledge on various EMI standards and regulations.
5. To test and analyze EMI emissions.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	-	2	1	-	-	-	-	1	2	1
CO2	3	3	2	3	2	2	1	1	1	-	-	2	2	2
CO3	2	3	1	3	2	2	1	1	1	-	-	2	2	2
CO4	3	2	1	3	2	2	1	1	1	-	-	2	3	3
CO5	1	3	2	3	2	2	1	-	-	-	-	2	3	3

SEMESTER - II

24PCOPC204 SDG NO. 9	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the concepts of stationary and non-stationary random signals & characterization of discrete-time random processes
- To estimate power spectral density of random processes
- To introduce the principles of optimum filters such as Wiener and Kalman filters
- To introduce the principles of adaptive filters and their applications to communication engineering
- To analyze the concepts of multirate DSP

UNIT I DISCRETE RANDOM SIGNAL PROCESSING 9

Weiner Khinchine relation - Power spectral density – filtering random process, Spectral Factorization Theorem, special types of random process – Signal modeling-Least Squares method, Finite Data records, Stochastic Models.

UNIT II SPECTRUM ESTIMATION **9**

Non-Parametric methods - Periodogram estimator - Barlett spectrum estimation - Welch estimation - Model based approach - AR, MA, ARMA Signal modeling - Parameter estimation using Yule-Walker method.

UNIT III LINEAR ESTIMATION AND PREDICTION **9**

Maximum likelihood criterion - Efficiency of estimator - Least mean squared error criterion - Wiener filter - Discrete Wiener Hoff equations - Recursive estimators - Kalman filter - Linear prediction, Prediction error – Lattice realization, Levinson recursion algorithm for solving Toeplitz system of equations.

UNIT IV ADAPTIVE FILTERS **9**

FIR Adaptive filters - Newton's steepest descent method - Adaptive filters based on steepest descent method - Widrow Hoff LMS Adaptive algorithm - Adaptive channel equalization - Adaptive echo canceller - Adaptive noise cancellation - RLS Adaptive filters.

UNIT V MULTIRATE DIGITAL SIGNAL PROCESSING **9**

Mathematical description of change of sampling rate - Interpolation and Decimation - Continuous time model - Direct digital domain approach - Decimation by integer factor - Interpolation by an integer factor - Single and multistage realization - Poly phase realization - Applications to sub band coding.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Monson H. Hayes, "Statistical digital signal processing and modeling", John Wiley and Sons Inc. New York, Indian reprint 2008.
2. P. P. Vaidyanathan, "Multirate systems and filter banks", Prentice Hall Inc. 1993.

REFERENCES:

1. John G. Proakis & Dimitris G.Manolakis, “Digital Signal Processing – Principles, Algorithms & Applications”, 4th Edition, Pearson Education / Prentice Hall, 2007.
2. Sophoncles J. Orfanidis, “Optimum signal processing”, McGraw Hill, 2000.

WEB REFERENCES:

1. https://www.youtube.com/watch?v=kbjUCyHBJxQ
2. https://www.youtube.com/watch?v=CPP4NRVccJs
3. https://www.youtube.com/watch?v=5lHJYbkrH6o

ONLINE RESOURCES:

1. https://freevideolectures.com/course/2309/adaptive-signal-processing/29

OUTCOMES:

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

1. Articulate and apply the concepts of special random processes in practical applications.
2. Choose appropriate spectrum estimation techniques for a given random process.
3. Apply optimum filters appropriately for a given communication application.
4. Apply appropriate adaptive algorithm for processing non-stationary signals.
5. Design multirate DSP systems.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	1	1	-	-	-	-	2	3	-
CO2	3	3	3	3	3	1	1	-	-	-	-	2	3	-
CO3	3	3	3	3	3	1	1	-	-	-	-	2	3	-
CO4	3	3	3	3	3	1	1	-	-	-	-	2	3	-
CO5	3	3	3	3	3	1	1	-	-	-	-	2	3	3

SEMESTER - II

24PCOPL201 SDG NO. 4,11&15	RF SYSTEM DESIGN LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

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

LIST OF EXPERIMENTS :

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

1. Measurement of S parameters for a) Inductor b) Capacitor c) impedance matching circuits, filters using network analyzer.
2. Design of $\lambda/2, \lambda/4$ micro strip transmission line.
3. Design of microstrip inductor and capacitor.
4. Design of impedance matching network.
5. Design of low pass, high pass, band pass and band stop filter at RF.
6. Design and characterization of micro strip patch antennas.
7. Design and characterization of LNA.
8. Design and characterization of Mixer.
9. Design and characterization of VCO.

TOTAL: 45 PERIODS

LAB REQUIREMENT FOR A BATCH OF 30 STUDENTS / 2 STUDENTS PER EXPERIMENT:

1. Network analyzer Equipment - 1.5 GHz (Minimum) - 1 No
2. ADS/IE3D/HFSS or any similar / equivalent Electromagnetic Simulation tool for Design experiments - 10 User license
3. Desktop PC‟s for hosting Electromagnetic simulation tool – 10Numbers
4. Inductor, Capacitor, matching circuits, filters capable of operating at 500 MHz or above

OUTCOMES:

On completion of this laboratory course, the student should be able to:

1. Apply knowledge to identify a suitable architecture and systematically design an RF system.
2. Comprehensively record and report the measured data.
3. Analyze and interpret the experimentally measured data and produce meaningful conclusions.
4. Design RF components using microstrip technology.
5. Develop microstrip filters.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	2	2	2	3	3	3	3	3	3
CO2	3	3	3	3	3	2	2	2	3	3	3	3	3	3
CO3	3	3	3	3	3	2	2	2	3	3	3	3	3	3
CO4	3	3	3	3	3	2	2	2	3	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	3	3	3	3	3	3

SEMESTER - II

24PCOTE201 SDG NO. 4 & 9	INNOVATIVE DESIGN PROJECT - II	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To encourage in identifying problems with social relevance
- To think of an innovative solution for the problem
- To design and conduct suitable experiment with modern tool
- To develop a cost effective prototype of the innovative design
- To understand the practical aspects and associated challenges in implementing the design

METHODOLOGY:

1. Student should do it individually.
2. Student should submit / present his/her ideas to the Faculty-in-Charge for approval.
3. Student should submit proposal with system/ technical details and cost implications.
4. Student should periodically demonstrate his/her progress.

EVALUATION:

Evaluation will be based on:

1. The social relevance of the work.
2. The utility of the system developed.
3. The Level of proof of concept.
4. Industry support if obtained.etc.

WEB REFERENCES:

1. https://www.mathworks.com/academia/books.html
2. http://www.mathcs.emory.edu/~cheung/Courses/455/Syllabus/A3-NS/Book/Introduction-to- Network-Simulator-NS2-2012.pdf

ONLINE REFERENCES:

1. http://www.jgyan.com/ns2/
2. https://matlabacademy.mathworks.com/

OUTCOMES:

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

1. The student would be able to identify socially relevant issues and apply his/her knowledge to evolve feasible solutions.
2. The student would be able to comprehensively record and report the measured data, write reports, communicate research ideas and do oral presentations effectively.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	1	1	1	2	1	3	2	3	3
CO2	3	3	3	3	3	1	1	1	2	1	3	2	3	3

SEMESTER - III

24PCOPC301 SDG NO. 11 & 15	MILLIMETER WAVE COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the channel behavior in millimeter wave communication systems
- To understand the fundamentals of Millimeter wave devices and circuits
- To understand the various components of Millimeter wave Communication systems
- To know the antenna design at Millimeter wave frequencies

UNIT I INTRODUCTION TO MILLIMETER WAVES 9

Millimeter wave characteristics- millimeter wave wireless implementation challenges, Radio wave propagation for mm wave: Large scale propagation channel effects, small scale channel effects, Outdoor and Indoor channel models, Emerging applications of millimeter wave communications.

UNIT II MM WAVE DEVICES AND CIRCUITS 9

Millimeter wave generation and amplification: Peniotrons, Ubitrons, Gyrotrons and Free electron lasers, HEMT, models for mm wave Transistors, transistor configurations, Analog mm wave components: Amplifiers, Mixers, VCO, PLL, Metrics for analog mm wave devices, Consumption factor theory, Trends and architectures for MM wave wireless, ADC's and DAC's.

UNIT III MM WAVE COMMUNICATION SYSTEMS 9

Modulations for millimeter wave communications: OOK, PSK, FSK, QAM, OFDM, Millimeter wave link budget, Transceiver architecture, Transceiver without mixer, Receiver without Oscillator, Millimeter wave calibration, production and manufacture, Millimeter wave design considerations.

UNIT IV MM WAVE MIMO SYSTEMS 9

Massive MIMO Communications, Spatial diversity of Antenna Arrays, Multiple Antennas, Multiple Transceivers, Noise coupling in MIMO system, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation.

UNIT V ANTENNAS FOR MM WAVE SYSTEMS 9

Antenna beamwidth, polarization, advanced beam steering and beam forming, mm wave design consideration, On-chip and In package mm wave

antennas, Techniques to improve gain of on-chip antennas, Implementation for mm wave in adaptive antenna arrays, Device to Device communications over 5G systems, Design techniques of 5G mobile.

TOTAL: 45 PERIODS

REFERENCES:

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

OUTCOMES:

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

1. Develop channel models for millimeter wave systems.
2. Understand Millimeter devices and circuits.
3. Apply single carrier, multicarrier modulation techniques of millimeter wave communication.
4. Apply MIMO techniques in design of high data rate systems.
5. Understand the diversity and beamforming techniques and their use in millimeter wave systems.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	3	-	-	-	-	-	-	1	-	1	1
CO2	3	3	3	3	2	3	2	-	-	1	-	-	1	2
CO3	3	3	3	3	2	-	-	-	-	-	-	-	1	1
CO4	3	3	3	3	2	-	2	-	-	-	-	-	1	1
CO5	3	3	3	3	2	-	2	-	-	-	-	-	1	1

SEMESTER - III

24PCOPJ301 SDG NO. 4, 6, 7, 8, 9, 1,12,13, 17	PROJECT WORK PHASE - I	L	T	P	C
		0	0	12	6

OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same
- To train the students face reviews and viva voice examinations

GUIDELINES TO BE FOLLOWED:

A student should work under a project supervisor, a faculty member and prepare a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department. The Project Work Phase-I will follow the following Sequence:

I. Problem Identification

1. A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
2. List of possible solutions including alternatives and constraints
3. Cost benefit analysis
4. Timeline of activities

II. A report highlighting the design finalization [based on functional requirements and standards (if any)]

III. A presentation including the following:

1. Implementation Phase (Hardware / Software / both)
2. Testing and Validation of the developed system
3. Learning in the Project

IV. Consolidated report preparation

TOTAL: 90 PERIODS

OUTCOMES :

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

1. Conceptualize the societal needs and acquire exposure to product development.
2. Get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.

3. Get clear idea of their area of work and they will be in a position to carry out the remaining phase II work in a systematic way.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	2	2	2	3	2	2	3	3	3
CO2	3	3	3	2	3	3	2	2	3	3	3	3	3	3
CO3	2	2	2	1	2	1	1	1	3	2	3	3	3	2

SEMESTER - IV

24PCOPJ401 SDG NO. 4, 6, 7, 8, 9, 1,12,13, 17	PROJECT WORK PHASE - II	L	T	P	C
		0	0	24	12

OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same
- To train the students face reviews and viva voce examinations

GUIDELINES TO BE FOLLOWED:

A student should work under a project supervisor, a faculty member and prepare a comprehensive project report after completing the work to the satisfaction of the supervisor. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department. The Project Work Phase-II will follow the following Sequence:

I. Problem Identification

1. A statement of system / process specifications proposed to be developed (Block Diagram / Concept tree)
2. List of possible solutions including alternatives and constraints
3. Cost benefit analysis
4. Timeline of activities

II. A report highlighting the design finalization [based on functional requirements and standards (if any)]

III. A presentation including the following:

1. Implementation Phase (Hardware / Software / both)
2. Testing and Validation of the developed system
3. Learning in the Project

IV. Consolidated report preparation

TOTAL: 180 PERIODS

OUTCOMES :

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

1. Develop project related to societal needs and acquire knowledge regarding product development.
2. Get familiarized with respect to design standards, design calculations and analysis in designing any mechanical component or system.
3. Take up any challenging practical problem in the field of engineering design and find better solutions to it.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	2	3	3	3	3	3	3	3	3
CO2	2	2	3	1	3	3	3	3	3	3	3	3	3	3
CO3	3	1	-	-	3	-	2	3	3	3	1	3	3	3

PROFESSIONAL ELECTIVES - I

24PCOEL101 SDG NO. 9	COMMUNICATION NETWORK MODELLING AND SIMULATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn simulation and its different tools in modeling
- To understand Monte Carlo Simulation
- To learn the layered modeling of the Wireless System
- To study the channel modeling, mobility modeling and various network topologies

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, Semi-analytic 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, Queuing 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

TEXT BOOKS:

1. Irene Karzela, "Modeling and Simulating Communications Networks", Prentice Hall India, 1998.
2. William. H. Tranter, K. Sam Shanmugam, Theodore. S. Rappaport, Kurt L. Kosbar, "Principles of Communication Systems Simulation", Pearson Education (Singapore) Pvt. Ltd, 2004.

REFERENCES:

1. K. Wehrie Gunes, J. Gross, "Modeling and Tools for Network Simulation", Springer, 2010.
2. M. C. Jeruchim, P. Balaban and K. Sam Shanmugam, "Simulation of Communication Systems: Modeling, Methodology and Techniques", Plenum Press, New York, 2001.
3. Nejat, Bragg, Arnold, "Recent Advances in Modeling and Simulation Tools for Communication Networks and Services", Springer, 2007.

ONLINE RESOURCES:

1. http://ijarece.org/wp-content/uploads/2015/08/IJARECE-VOL-4-ISSUE-8-2256-2265.pdf
2. https://onlinelibrary.wiley.com/doi/abs/10.1002/047086799X

OUTCOMES:

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

1. Work with different simulation tools in various platforms.
2. Apply Monte Carlo Simulation in the communication system.
3. Implement the simulation tools for different layers of the communication models.
4. Analyse the performance of the channel and its mobility with different simulation models.

5. Implement and Compare the performance metrics of the network topology.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	3	-	3	-	-	2	1	1	2	3	3	3
CO2	2	2	3	3	2	1	-	2	2	1	2	2	3	1
CO3	3	-	1	1	1	1	-	3	1	-	2	1	3	2
CO4	1	-	2	2	1	2	-	2	1	-	2	2	3	1
CO5	1	1	1	3	3	2	-	3	2	2	2	1	3	3

PROFESSIONAL ELECTIVES - I

24PCOEL102 SDG NO. 4 & 9	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

Baseband 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

REFERENCES:

1. Heinrich Meyer, Marc Moeneclacy, Stefan.A.Fechtel, "Digital Communication Receivers", Vol I & Vol II, John Wiley, New York, 1997.
2. H.Meyer & G K 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.

WEB REFERENCES:

1. https://nptel.ac.in/courses/117/105/117105144/
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-02-introduction-to-eecs-ii-digital-communication-systems-fall-2012/lecture-videos/

ONLINE RESOURCES:

1. http://videolectures.net/ict07_mohorcic_docs/#

OUTCOMES:

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

1. Apply basic principles of digital communication techniques.

2. Discuss on receivers for AWGN channel.
3. Discuss on receivers for Fading channel.
4. Describe various synchronization techniques.
5. Design adaptive equalization algorithms to satisfy the evolving demands in digital communication.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	2	-	-	-	-	2	2	3	2
CO2	3	2	3	2	2	2	-	-	-	-	2	2	3	2
CO3	3	2	3	2	3	2	-	-	-	-	2	2	3	2
CO4	3	2	2	2	-	2	-	-	-	-	2	2	3	2
CO5	3	2	3	2	2	2	-	-	-	-	2	2	3	2

PROFESSIONAL ELECTIVES - I

24PCOEL103 SDG NO. 4, 8 & 9	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 REVIEW 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, Optimum Digital Detector in Additive Gaussian Noise, Performance of Binary Receivers in AWGN.

UNIT III FUNDAMENTALS OF ESTIMATION THEORY 9

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

UNIT IV WIENER AND KALMAN FILTERS 9

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

UNIT V APPLICATIONS 9

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

TOTAL: 45 PERIODS

REFERENCES:

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

WEB REFERENCES:

1. https://nptel.ac.in/courses/117103018/
2. https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/108105059/lec1.pdf
3. https://www.ece.uic.edu/~devroye/courses/ECE531/lectures/intro.pdf

ONLINE RESOURCES:

1. https://www.youtube.com/watch?v=4prlftiKpUY
2. https://www.youtube.com/watch?v=CaCcOwJPytQ
3. https://nptel.ac.in/courses/111105043/
4. https://www.youtube.com/watch?v=bdXJmYwSLE0&list=PLGI7M8vwfrFM08D4s2vUGIKRHw7W1rMvG&index=11

OUTCOMES:

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

1. Apply detection and estimation theory to solve communication problems.
2. Apply probability and stochastic process concepts in detection and estimation.
3. Design Wiener and Kalman filters to solve linear estimation problems.
4. Analyse the fundamentals of estimation theory.
5. Gain the knowledge to apply in various applications.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	2	-	1	1	2	1	2	3	1
CO2	2	2	2	2	3	2	-	1	1	1	1	2	2	1
CO3	2	3	3	2	2	2	-	1	1	2	1	3	2	1
CO4	3	2	2	3	2	2	-	1	1	2	1	2	2	1
CO5	3	3	2	3	2	2	-	1	1	2	1	3	3	1

PROFESSIONAL ELECTIVES - I

24PCOEL104 SDG NO. 4	VLSI FOR WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the concepts of basic wireless communication
- To study the parameters in receiver and low noise amplifier design
- To study 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

TEXT BOOK:

1. Bosco H Leung "VLSI for Wireless Communication", Pearson Education, 2002.

REFERENCES:

1. B.Razavi ,"RF Microelectronics" , Prentice-Hall,1998.
2. Behzad Razavi, "Design of Analog CMOS Integrated Circuits" McGraw-Hill, 1999.
3. Emad N Farag and Mohamed I Elmasry, "Mixed Signal VLSI wireless design – Circuits & Systems", Kluwer Academic Publishers, 2000.
4. J. Crols and M. Steyaert, "CMOS Wireless Transceiver Design," Boston, Kluwer Academic Pub., 1997.
5. Thomas H.Lee, "The Design of CMOS Radio – Frequency Integrated Circuits", Cambridge University Press, 2003.

WEB REFERENCES:

1. https://www.electronic-engineering.ch/study/phd/General_MIMO_Poster.pdf.
2. https://archive.org/stream/Bosco_Leung_VLSI_for_Wireless_Communication/Bosco_Leung VLSI_for_Wireless_Communication_djvu.txt.

ONLINE RESOURCES:

1. https://pdfs.semanticscholar.org/19e2/81a115c4023e915e0f416bae74475b8f1c43.pdf.
2. http://www.ece.iisc.ernet.in/~banerjee/course_E3237/Upload_files/E3%20237_L1.pdf.

OUTCOMES:

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

1. Describe the basic concepts of wireless communication.
2. Design Receiving architecture and LNA.
3. Design and analyze the working of Mixers.
4. Evaluate frequency synthesizers.
5. Design and analyze power amplifiers.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	-	-	-	-	-	2	2	3	2
CO2	3	2	2	2	1	-	-	-	-	-	2	2	3	2
CO3	3	2	2	2	3	-	-	-	-	-	2	2	3	2
CO4	3	3	2	1	3	-	-	-	-	-	2	2	3	3
CO5	3	3	3	3	3	-	-	-	-	-	2	2	3	2

PROFESSIONAL ELECTIVES - I

24PCOEL105 SDG NO. 9	COGNITIVE RADIO NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the evolving software defined radio and cognitive radio techniques and their essential functionalities
- To study the basic architecture and standard for cognitive radio
- To learn spectrum sensing and dynamic spectrum access
- To understand the physical, MAC and Network layer design of cognitive radio
- To expose the student to evolving applications and advanced features of cognitive radio

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 TVbands.

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 - KullbackLeibler 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

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. Kwang-Cheng Chen, Ramjee Prasad, "Cognitive Radio Networks", John Wiley and Sons, 2009.
4. HuseyinArslan (Ed.), "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems", Springer, 2007.
5. S.Shanmugavel, M.A.Bhagyaveni, R.Kalidoss, "Cognitive Radio-An Enabler for Internet of things", River Publishers, 2017.

WEB REFERENCES:

1. https://www.classcentral.com/course/swayam-basics-of-software-defined-radios-and-practical-applications-10088
2. https://nptel.ac.in/courses/108107107/
3. https://www.ofcom.org.uk/research-and-data/technology/general/emerging-tech/cognitive-radio

ONLINE RESOURCES:

1. https://link.springer.com/chapter/10.1007/978-981-10-4280-5_68
2. https://www.sciencedirect.com/topics/computer-science/cognitive-radio-network

OUTCOMES:

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

1. Illustrate the evolution of software Defined Radio.
2. Interpret the basics and architecture of Software Defined Radio.
3. Outline the basics of Cognitive networks.
4. Compare MAC and network layer design for cognitive radio.
5. Discuss cognitive radio for Internet of Things and M2M technologies.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	2	1	0	0	0	0	1	3	3	-
CO2	3	2	3	3	1	1	0	0	0	0	1	3	2	-
CO3	3	2	2	3	1	1	0	0	0	0	1	2	3	3
CO4	3	2	3	3	2	1	0	0	0	0	1	2	-	3
CO5	3	3	3	3	1	1	0	0	0	0	1	2	-	3

PROFESSIONAL ELECTIVES - I

24PCOEL106 SDG NO. 4 & 9	BROADBAND ACCESS TECHNOLOGIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the fundamental concepts of wireless access technologies and their standards
- To understand the current and emerging wired and wireless access technologies
- To acquire knowledge on cable modems for wireless access and control
- To understand fiber access technologies and their architectures
- 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 Broadband 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 BROADBAND WIRELESS 10

Fixed Wireless, Direct Broadcast Satellite (DBS), Multichannel 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

REFERENCES:

1. Niel Ransom and Albert A. Azzam, "Broadband Access Technologies: ADSL, VDSL Cable Modem, Fiber and LMDS", McGraw Hill, 1999.
2. Walter J Woralski, "ADSL and DSL Technologies", McGraw Hill Computer Communication Series, Second Edition Oct 2001
3. 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..
4. Gilbert Held, "Next Generation Modems: A Professional Guide to DSL and Cable Modems", John Wiley & Sons, 2000.
5. Leonid G. Kazovsky, Ning Cheng, Wei-Tao Shaw, David Gutierrez, Shing-Wa Wong, "Broadband Optical Access Networks", John Wiley and Sons, New Jersey, 2011.
6. Martin P. Clarke, "Wireless Access Network: Fixed Wireless Access and WLL Network Design and Operation", John Wiley & Sons 2000.
7. Sassan Ahmadi, "LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies", Elsevier, 2014.
8. William Webb, "Introduction to Wireless Local Loop Broadband and Narrow Band System", Mobile Communication Series, Artech House Publishers, Second Edition 2000.

WEB REFERENCES:

1. https://www.fcc.gov/general/types-broadband-connections
2. https://nptel.ac.in/courses/117101050/
3. https://www.3gpp.org/technologies/keywords-acronyms/98-lte

ONLINE RESOURCES:

1. https://www.electronics-notes.com/

OUTCOMES:

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

1. Outline the types of broadband wireless technologies and their characteristics.
2. Design and Differentiate various wired and wireless broadband technology systems.
3. Illustrate the aspects of transport on copper wire networks and flavors of DSL.
4. Summarize the fiber access technologies and their architectures.
5. Contribute towards the enhancement of the existing wireless technologies.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	3	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	3	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	-	-	-	1	2	3	-	3	3
CO5	3	3	2	2	1	-	-	-	1	2	2	-	3	3

PROFESSIONAL ELECTIVES - I

24PCOEL107 SDG NO. 4 & 9	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 macro cells, 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 9

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 9

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 9

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, Massive MIMO.

UNIT V ST OFDM, SPREAD SPECTRUM AND MIMO MULTIUSER DETECTION **9**

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

TOTAL: 45 PERIODS

REFERENCES:

1. Andre Viterbi " Principles of Spread Spectrum Techniques", Addison Wesley 1995.
2. Jafarkhani, Hamid. Space-time coding: Theory and Practice. Cambridge University Press, 2005.
3. Paulraj, RohitNabar, Dhananjay Gore., "Introduction to Space Time Wireless Communication Systems", Cambridge University Press, 2003.
4. Sergio Verdu " Multi User Detection" Cambridge University Press,1998

WEB REFERENCES:

1. https://nptel.ac.in/courses/117/104/117104126/
2. https://nptel.ac.in/courses/117/104/117104118/
3. https://nptel.ac.in/courses/117/104/117104115/
4. https://nptel.ac.in/courses/117/105/117105132/
5. https://www.coursera.org/lecture/wireless-communications/4-5-wqXDF

ONLINE RESOURCES:

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-452-principles-of-wireless-communications-spring-2006/

OUTCOMES:

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

1. Understand the different channel models and the related parameters.
2. Calculate capacity of MIMO systems.
3. Design and evaluate receiver and transmitter diversity techniques.
4. Understand the Space time coding techniques in the MIMO systems.
5. Design and develop OFDM based MIMO systems.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	3	-	-	-	-	-	-	-	3	3
CO2	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	2	2	2	2	2	2	-	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO5	3	3	3	3	3	2	2	2	2	2	2	-	3	3

PROFESSIONAL ELECTIVES - II

24PCOEL201 SDG NO. 11 & 15	ADVANCED SATELLITE COMMUNICATION AND NAVIGATION SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basics of Satellite Communication
- To learn M2M developments
- To understand Satellite Communication in IPv6 Environment
- To describe various Satellite applications

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 Suppor t-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

Overview 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 INTERPLANETARY MISSIONS 9

Introduction - Functional description - Design procedure and performance criterion - Mars exploration Rover- Mission and spacecraft summary - Telecommunication subsystem overview-Ground Subsystem - Telecom subsystem and Link performance Telecom subsystem Hardware and software Chandrayaan-1 Mission - Mission and spacecraft summary - Telecommunication subsystem overview - Ground Subsystem-Telecom subsystem and Link performance. Mangalyaan Mission - Mission and spacecraft summary - Telecommunication subsystem overview - Ground Subsystem - Telecom subsystem and Link performance.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Anil K. Maini, Varsha Agrawal, "Satellite Technology: Principles and Applications", Third Edition, Wiley, 2014.
2. Daniel Minoli "Innovations in Satellite Communication and Satellite Technology" Wiley, 2015.
3. Daniel Minoli, "Satellite Systems Engineering in an IPv6 Environment", CRC Press, First Edition, 2009.
4. Hofmann-Wellenhof B., Lichtenegger H., and ElmarWasle, "Global Navigational Satellite Systems" Springer-Verlag, 2008
5. Jim Taylor, " Deep Space Communications" John Wiley & Sons, 2016.

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. Louis J. Ippolito, Jr. "Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance", Second Edition, 2017.

WEB REFERENCES:

1. http://www.isro.gov.in/pslv-c25-mars-orbiter-mission
2. https://en.wikipedia.org/wiki/Mars_Orbiter_Mission
3. https://en.wikipedia.org/wiki/Chandrayaan-1

OUTCOMES:

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

1. Discuss the basic concepts of Satellite Communication.
2. Identify applications of Satellite Communication.
3. Describe various applications of Satellite.
4. Describe Satellites for Navigation and GPS.
5. Understand Satellites for deep space networks and interplanetary missions.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	-	2	2	-	-	-	-	1	2	3	-
CO2	3	-	-	-	-	2	-	-	-	-	1	2	1	-
CO3	3	-	-	-	-	1	-	-	-	-	1	2	1	-
CO4	3	-	-	-	-	-	-	-	-	-	1	2	1	-
CO5	3	-	-	-	-	-	-	-	-	-	1	2	1	-

PROFESSIONAL ELECTIVES - II

24PCOEL202 SDG NO. 4	DSP PROCESSOR ARCHITECTURE AND PROGRAMMING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the basics on Digital Signal Processors
- To design the Programmable DSP's Architecture, On –chip Peripherals and Instruction set
- To design Third generation DSP Architecture and programming skills
- To learn and design and Advanced DSP architecture and some applications
- To design and compare the features of different family Processors

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 signs.

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: Pipeline operation, Code Composer studio – Architecture of TMS320C6X – Architecture of Motorola DSP563XX – Comparison of the features of DSP family processors.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. B. Venkataramani and M. Bhaskar, "Digital Signal Processors – Architecture, Programming and Application", Tata McGraw Hill Publishing Company Limited, New Delhi, 2003.

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. Rulph Chassaing, "Digital Signal Processing and Applications with the C6713 and C6416, DSK", A John Wiley & Sons, INC., Publication, 2005.
3. User guides Texas Instrumentation, Analog Devices, and Motorola.

WEB REFERENCES:

1. https://www.ti.com.
2. https://www.analog.com/media/en/technical –documentation.

ONLINE RESOURCES:

1. https://www.academia.edu/38043202/Architecture_of_TMS320C50_DSP_Processor.
2. http://www.ti.com/general/docs/gencontent.tsp?contentId=46898.

OUTCOMES:

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

1. Design and analyze the concept of Digital Signal Processor.
2. Demonstrate their ability to Program the DSP Processor for signal processing applications.
3. Demonstrate the On –chip Peripherals and Instruction set.
4. To become a Digital Signal Processor specialized engineer.
5. Design and analyze the DSP based System Developer.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	–	–	–	1	–	2	2	1
CO2	3	3	2	2	3	–	–	–	–	2	–	2	2	1
CO3	3	3	2	1	3	–	–	–	–	2	–	2	2	2
CO4	3	3	1	2	3	–	–	–	–	2	–	2	2	1
CO5	3	3	2	1	3	–	–	–	–	1	–	2	2	1

PROFESSIONAL ELECTIVES - II

24PCOEL203 SDG NO. 4 & 9	ANALOG AND MIXED MODE VLSI DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the concepts of MOS large signal model and small signal model
- To study the concepts of circuit design in submicron scale
- To understand the concepts of D/A conversion methods and their architectures

- To learn filters for ADC and DAC
- To study about the switched capacitor circuits

UNIT I INTRODUCTION AND BASIC MOS DEVICES 9

Challenges in analog design-Mixed signal layout issues- MOS FET structures and characteristics- large signal and small signal model of single stage Amplifier-Source follower- Common gate stage – Cascode Stage – large and small signal analysis of differential amplifier with active load, pole-zero estimation, zero value time constant method, frequency response of CS, cascade and cascade amplifiers.

UNIT II SUBMICRON CIRCUIT DESIGN 9

Submicron CMOS process flow, Capacitors and resistors, Current mirrors, Digital Circuit Design, Delay Elements – Adders- OP Amp parameters and Design.

UNIT III DATA CONVERTERS 9

Static and dynamic errors in DAC and ADC – Architectures & Characteristics of Sample and Hold- Digital to Analog Converters- DAC- R-2R, weighted DAC, multiplying DAC, segmented DAC and sigma delta DAC. ADC – Flash ADC, pipelined ADC, successive approximation ADC, sigma delta ADC.

UNIT IV SNR IN DATA CONVERTERS 9

Overview of SNR of Data Converters- Clock Jitters- Improving Using Averaging – Decimating Filters for ADC- Band pass and High Pass Sinc Filters- Interpolating Filters for DAC.

UNIT V SWITCHED CAPACITOR CIRCUITS 9

Resistors, First order low pass Circuit, Switched capacitor Amplifier, Switched Capacitor Integrator – Design of flip around sample and hold circuit – pipelined ADC.

TOTAL: 45 PERIODS

REFERENCES:

1. J. Jacob Wikner, Mikael Gustavsson, Nianxiong Tan "CMOS DataConverters for Communications" Springer, 2000.
2. Van de Plassche, Rudy J "CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters" Springer, 2003.

WEB REFERENCES:

1. https://www.slideshare.net/athiulla/analog-mixed-vlsi-notes

2. https://www.youtube.com/playlist?list=PL_uaeekrhGzIDoH9oXE_xiG2k0rpioWlN

ONLINE RESOURCES:

1. https://nptel.ac.in/courses/117106030

OUTCOMES:

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

1. Describe the basic MOS devices, types and properties.
2. Discuss submicron circuit design for resistors, capacitors and basic digital circuits.
3. Demonstrate different types of A/D and D/A conversion methods.
4. Design and analyze the different filters for ADC and DAC.
5. Design and analyze switched capacitor circuits.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	1	-	-	-	-	-	2	3	2
CO2	3	2	2	3	3	1	-	-	-	-	-	2	3	2
CO3	3	2	1	3	3	1	-	-	-	-	-	2	2	1
CO4	3	2	1	2	2	2	-	-	-	-	-	2	2	1
CO5	3	2	1	3	3	2	2	-	-	-	-	2	3	2

PROFESSIONAL ELECTIVES - II

24PCOEL204 SDG NO. 4 & 9	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 PROCESSORS 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

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", Palgrave Publisher, 2004.

5. Wayne Wolf, "Computers as Components - Principles of Embedded Computer System Design", Morgan Kaufmann Publisher, 2006.
6. Arnold.S.berger, "Embedded System Design: An Introduction to processes Tools, & Techniques", CRC Press, 2017.

WEB REFERENCES:

1. https://developer.arm.com/ip-products/processors/classic-processors
2. https://spin.atomicobject.com/2015/08/19/learn-embedded-systems-programming/
3. https://www.ocfreaks.com/tag/lpc2148/
4. https://www.freertos.org/about-RTOS.html

ONLINE RESOURCES:

1. https://swayam.gov.in/nd1_noc20_cs15/preview
2. https://swayam.gov.in/nd1_noc20_cs16/preview

COURSE OUTCOMES:

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

1. Describe the architecture and programming of ARM processor.
2. Illustrate computing platform and design analysis.
3. Demonstrate multiple tasks and multiple processes.
4. Discuss hardware and software co-design.
5. Model real-time applications using embedded-system concepts.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	-	-	-	-	-	-	3	1	3
CO2	3	2	1	-	-	-	-	-	-	-	-	2	1	3
CO3	2	2	3	-	-	-	-	-	-	-	-	-	3	3
CO4	3	3	-	-	-	-	-	-	-	-	-	-	1	3
CO5	2	2	1	-	-	-	-	-	-	-	-	-	1	3

PROFESSIONAL ELECTIVES - II

24PCOEL205 SDG NO. 4 & 9	MEMS AND NEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the concepts of micro electro mechanical devices
- To understand the fabrication process of Microsystems
- To know the design concepts of micro sensors
- To learn the design concept of 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– 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 Piezoresistive Pressure sensors- engineering mechanics behind these Micro sensors. 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 NANO SYSTEMS AND QUANTUM MECHANICS **9**

Atomic Structures and Quantum Mechanics, Molecular and Nanostructure

Dynamics: Schrodinger Equation and Wave function Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular Wires and Molecular Circuits.

TOTAL: 45 PERIODS

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.

WEB REFERENCES:

https://nptel.ac.in/courses/117/105/117105082

ONLINE RESOURCES:

https://freevideolectures.com/course/2323/mems-and-microsystems

OUTCOMES:

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

1. Interpret the basics of Micro/Nano electromechanical systems including their applications and advantages.
2. Illustrate the use of materials in micro fabrication and describe the fabrication processes, including surface micromachining, bulk micromachining and LIGA.
3. Analyze the key performance aspects of electromechanical transducers including sensors.
4. Design and analyze the performance of actuators.
5. Describe the theoretical foundations of quantum mechanics and the Nano system.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	-	-	-	-	-	-	2	3	1
CO2	3	2	2	2	-	-	-	-	-	-	-	2	3	1
CO3	3	2	2	2	-	-	-	-	-	-	-	2	3	1
CO4	3	2	2	2	-	-	-	-	-	-	-	2	3	1
CO5	3	2	2	2	-	-	-	-	-	-	-	2	3	1

PROFESSIONAL ELECTIVES - II

24PCOEL206 SDG NO. 11 & 15	GREEN RADIO COMMUNICATION NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand green communication concepts
- To understand model architectures and algorithms
- To understand power consumption methodology
- To understand carbon emission impact on the environment
- To understand model test-beds

UNIT I COMMUNICATION ARCHITECTURES AND MODEL 9

Fundamental trade-offs on the design of green radio networks-Introduction, Insight from Shannon's capacity formula-SE-EE trade-off, BW-PW trade-off, DL-PW trade-off & DE-EE trade-off, Impact of practical constraints. Algorithms for energy harvesting Wireless networks-Technologies, Point to point channel, MAC policies and multi-hop networks, Introduction to physical layer design.

UNIT II PHYSICAL COMMUNICATIONS TECHNIQUES 9

Green modulation and coding schemes in energy constrained wireless networks-Introduction, System model and assumptions, Energy consumption of uncoded scheme, Energy consumption analysis of LT coded modulation, Energy efficiency metrics for wireless networks, Energy efficient cooperative networks.

UNIT III BASE STATION POWER MANAGEMENT TECHNIQUES 9

Opportunistic spectrum and load management concepts, Assessment of power saving potential, Energy saving techniques-Energy consumption model of RBS, EE metric, RBS energy saving methods, Power management for a wireless base station, Power consumption model of a base station, Optimization of power management.

UNIT IV GREEN COMMUNICATIONS FOR CARBON EMISSION REDUCTIONS 9

Architectures and Standards: Introduction, Network Architectures and Technologies to Reduce Carbon Emissions - Networks and Protocols, Integrated Optical-Wireless Access, Test beds -Green star, SAVI, NetVirt, Carbon Standards for Communications Technologies- Power and Performance Measurement Challenges- Network and System Operation Challenges.

UNIT V GREEN RADIO TEST- BED AND STANDARDS 9

Introduction, Energy efficiency evaluation framework(E3F),Power model, Traffic model, Case study : Energy efficiency of LTE, Green metrics, Fundamental challenges and future potential, Standardization fora –ETSI,3GPP,TIA and 3GPP2,ATIS.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Ekram Hossain, Vijay K.Bhargava, Gerhard P.Fettweis, "Green Radio Communication Networks " Cambridge University Press, 2012.
2. Jinsong Wu Sundeep Rangan, Honggang Zhang, "Green Communications Theoretical fundamentals, Algorithms and Applications " CRC press, 2013.

REFERENCES:

1. Richard Yu F, Zhang Xi and Victor Leung C M, "Green Communications and Networking", 1 st Edition, CRC press, 2012.
2. Mazin Al Noor, "Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access", GRINVerlag, 2012.
3. Mohammad Obaidat S, AlaganAnpalagan and Isaac Woungang, "Handbook of Green Information and Communication Systems", 1st Edition, Academic Press, 2012.
4. Ramjee Prasad, Shingo Ohmori and Dina Simunic, "Towards Green ICT", River Publishers, 2010.

WEB REFERENCES:

1. http://www.comsoc.org/webcasts/view/wireless
2. http://www.comsoc.org/webcasts/view/wireless
3. http://www.comsoc.org/webcasts/view/wireless

ONLINE RESOURCES:

1. https://youtu.be/d4-uWmash04

OUTCOMES:

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

1. Understand Green Communication Concepts and related architectures.
2. Understand Different modulation and coding schemes.
3. Analyze the power consumption models.
4. Explore Architectures and Technologies to Reduce Carbon Emissions.
5. Explore test-beds and standards.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	2	-	-	-	-	2	2	3	2
CO2	3	2	3	1	-	1	-	-	-	-	1	2	3	2
CO3	3	2	3	1	-	2	-	-	-	1	2	2	3	2
CO4	3	2	2	1	3	1	-	-	-	-	2	2	3	2
CO5	3	2	2	1	3	2	-	-	2	3	2	2	3	2

PROFESSIONAL ELECTIVES - II

24PCOEL207 SDG NO. 4,8,9&15	SOFTWARE DEFINED RADIO	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To Understand Software Defined radio Architectures and design principles
- To Learn radio frequency implementation components, functions and capabilities.
- To Discuss multi rate signal processing and digital generation of signals
- To Acquire knowledge on Data converters and Smart Antennas in SDR

- To Learn the digital Hardware and Software methods for SDR.

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 MULTIRATE 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

REFERENCES:

1. Jeffrey H.Reed, "Software Radio: A Modern Approach to Radio Engineering, Prentice Hall,2002.
2. Joseph Mitola, "Software Radio Architecture: Object Oriented Approaches to Wireless System Engineering", Wiley-Inter science; I Edition 2000, ISBN:0471384925.
3. Tony J Rouphael, "RF and DSP for SDR," Elsevier Newnes Press, 2008.
4. S.Shanmugavel, M.A.Bhagyaveni, R.Kalidoss, "Cognitive Radio-An Enabler for Internet of things", River Publishers,2017, Modems", John Wiley & Sons, 2000.
5. Paul Burns, "Software Defined Radio for 3G," Artech House, 2002.

6. P. Kenington, "RF and Baseband Techniques for Software Defined Radio," Artech House, 2005.

WEB REFERENCES:

1. https://www.gnuradio.org/index.php/Tutorials
2. https://www.digimat.in/nptel/courses/video/108107107/L03.html

ONLINE REFERENCES:

1. https://www.classcentral.com/course/swayam-basics-of-software-defined-radios-and-practical-applications-10088

OUTCOMES:

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

1. Demonstrate the understanding of software defined radio architecture and design principles.
2. Design and demonstrate on Radio frequency implementation issues.
3. Implement smart antennas in SDR.
4. Analyze complex problems critically in the domain of SDR using Smart antenna techniques.
5. Apply appropriate hardware and software techniques for the development of scientific and technological knowledge in designing software defined radios and their usage.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	-	-	-	1	1	2	3	3	2
CO2	3	3	3	2	2	-	-	-	1	1	2	3	3	2
CO3	3	3	3	2	2	-	-	-	1	1	2	3	3	2
CO4	3	3	3	2	1	-	-	-	1	1	2	3	3	2
CO5	3	3	3	2	3	-	-	-	1	2	2	3	3	2

PROFESSIONAL ELECTIVES - III

24PCOEL301 SDG NO. 4,8,9&15	ADVANCED ANTENNA DESIGN	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the radiation characteristics and antenna arrays in detail
- To know the mathematics of arrays and Smart Antennas
- To enhance the knowledge of Numerical Methods in Antenna Analysis
- To design antennas for various practical applications
- To understand and design modern antennas

UNIT I ANTENNA FUNDAMENTALS 9

Introduction-Solution to Maxwell's Equations, Ideal Dipole, Fundamental Parameters-Radiation Pattern, Directivity and Gain, Antenna Impedance, Efficiency, Polarization, Radar Cross Section (RCS), Microstrip Patch Antenna-Cavity and Transmission Line Model- Feeding Methods and Design Considerations.

UNIT II ANTENNA ARRAYS & SMART ANTENNAS 9

Introduction, Array Factor, 2D and 3D arrays, Background of Smart Antennas, Switched Beams-Adaptive antennas-Smart Antenna Network Implementation, Smart Antenna Algorithms-Adaptive Beam forming-Direction finding methods-Smart Antenna Advantages-implementation issues, Vivaldi Arrays.

UNIT III ANTENNA MODELING AND ANALYSIS TECHNIQUES 9

Numerical Methods in Antenna Modeling- Time Domain Modeling-Finite Difference Time Domain (FDTD)-Finite Element Time Domain (FETD) methods, Frequency Domain Modeling-Finite Element Method (FEM), Integral Equations and Method of Moments (MoM), Genetic Algorithms and Neural Networks in Antennas Modeling.

UNIT IV ADVANCED ANTENNA CONCEPTS 9

Microstrip reflect arrays, Reconfigurability, Frequency, pattern and Polarization Reconfiguration, Wearable Antennas for Body Area Networks (BAN)-Fabric Antennas, Ultra Wide Band (UWB) Antennas, Multiple Antenna Techniques-Diversity and MIMO Systems. Millimeter Technology & THz Antennas.

UNIT V SPECIAL ANTENNAS FOR APPLICATIONS 9

Antennas in Medical Therapy and Diagnostics-SAR analysis and Link Budget Analysis-Implanted and Embedded Antennas-Antennas for Sensing and Imaging, Plasma Antennas-Fundamentals-Windowing-Plasma FSS, RFID and NFC Antennas. ESM and ECM Antennas, Automotive Antennas.

TOTAL: 45 PERIODS

REFERENCES:

1. Constantine A. Balanis, "Antenna Theory Analysis and Design", 3rd Edition, John Wiley & Sons Ltd., New York, 1982.
2. Warren L. Stutzman & Gary A. Thiele, "Antenna Theory and Design", 3rd Edition, John Wiley & Sons Ltd., New York, 2013.
3. Thomas F. Eibert & John L. Volakis, "Antenna Engineering Handbook", 4th Edition, McGraw-Hill Companies, 2004.
4. Zhijun Zhang, "Antenna Design for Mobile Devices", 1st Edition, John Wiley & Sons Ltd, Newyork, 2011.
5. Constantine A. Balanis, "Modern Antenna Handbook", 1st Edition, John Wiley & Sons Ltd, 2008.
6. Frank B. Gross, "Frontiers in Antennas: Next Generation Design & Engineering", 1st Edition, The McGraw-Hill Companies, 2011.

WEB REFERENCES:

1. http://www.antenna-theory.com
2. https://nptel.ac.in/courses/117107035/
3. https://www.mwrf.com/technologies/systems/article/21848994

ONLINE RESOURCES:

1. http://www.antennadesign.com/
2. https://www.microwaves101.com/encyclopedias/antenna-design

OUTCOMES:

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

1. To understand basic theory behind antenna and arrays.
2. To understand numerical techniques in antenna analysis.
3. To design and assess the performance of various antennas.
4. To understand and design of Smart antenna arrays.
5. To design antennas for various industrial, medical and sensor applications.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	-	3	2
CO2	3	3	3	3	3	-	-	-	-	-	-	-	3	2
CO3	3	3	3	3	3	-	-	-	-	-	-	3	3	2
CO4	3	3	3	3	3	-	-	-	-	-	3	3	3	2
CO5	3	3	3	3	3	-	-	-	-	-	3	3	3	2

PROFESSIONAL ELECTIVES - III

24PCOEL302 SDG NO. 9	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

Image 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

TEXT BOOKS:

1. Anil K. Jain, “Fundamentals of Digital Image Processing”, Pearson Education, Inc., 2002.
2. Rafael C. Gonzalez, Richard E. Woods, “Digital Image Processing”, Pearson, Education, Inc.,Second Edition, 2004.

REFERENCES:

1. Kenneth R. Castleman, “Digital Image Processing”, Pearson, 2006.
2. William K. Pratt, “Digital Image Processing”, John Wiley, New York, 4th dition, 2007.
3. Milan Sonka, Vaclav Hlavac& Roger Boyle, "Image processing, Analysis and Machine Vision", Thomson Asia Prt. Ltd, 4th Edition, 2015.
4. Sid Ahmed M.A., "Image Processing - Theory, Algorithm and Architecture", McGraw Hill, 2009.
5. John C.Russ, “The Image Processing Handbook”, CRC Press, 2007.
6. Mark Nixon, Alberto Aguado, “Feature Extraction and Image Processing”, Academic Press, 2008.
7. Ardeshir Goshtasby, “ 2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications”, John Wiley and Sons, 2005.

WEB REFERENCES:

1. Teaching material: http://www.ee.uta.edu/dip/
2. Digital Image Fundamentals :http://www.ph.tn.tudelft.nl/Courses/FIP/Frames/fip.html
3. DIAL-Digital Image Analysis Laboratory http://www.ece.arizona.edu/~dial/

ONLINE RESOURCES:

1. https://www.tutorialspoint.com/dip/image_processing_introduction.htm
2. https://sisu.ut.ee/imageprocessing/book/1

OUTCOMES:

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

1. Explain the fundamentals of digital image processing.
2. Describe various image segmentation techniques.
3. Utilize to represent image in the form of features.
4. Illustrate the concepts of image registration and fusion.
5. Elaborate 3D image visualization.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	2	3	2	-	-	-	-	-	2	2	2	1
CO3	2	2	2	2	2	-	-	-	-	-	2	2	2	1
CO4	2	2	2	3	2	-	-	-	-	-	2	2	2	1
CO5	3	2	2	2	2	-	-	-	-	-	3	2	2	1

PROFESSIONAL ELECTIVES - III

24PCOEL303 SDG NO. 11 & 15	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-to noise ratio - Jamming, Frequency models: the doppler shift, spatial models, spectral model.

UNIT III SAMPLING AND QUANTIZATION OF PULSED RADAR SIGNALS 9

Domains and criteria for sampling radar signals - Sampling in the fast time dimension - Sampling in slow time: selecting the pulse repetition interval - Sampling the doppler spectrum - Sampling in the spatial and angle dimension – Quantization - I/Q Imbalance and Digital I/Q.

UNIT IV RADAR WAVEFORMS **9**

Introduction - The waveform matched filter - Matched filtering of moving targets - The ambiguity function - The pulse burst waveform - Frequency-modulated pulse compression waveforms - Range side lobe control for FM waveforms - The stepped frequency waveform - Phase-modulated pulse compression waveforms - COSTAS Frequency codes.

UNIT V DOPPLER PROCESSING **9**

Alternate forms of the Doppler spectrum - Moving target indication (MTI) - Pulse Doppler processing, Dwell-to-Dwell stagger - Pulse pair processing - Additional Doppler processing issues - Clutter mapping and the moving target detector - MTI for moving platforms: adaptive displaced phase center antenna processing.

TOTAL: 45 PERIODS

REFERENCES:

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

WEB REFERENCES:

1. https://swayam.gov.in/nd1_noc19_ee58/preview
2. https://nptel.ac.in/courses/108105154/

ONLINE RESOURCES:

1. https://freevideolectures.com/course/5299/introduction-radar-systems

OUTCOMES:

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

1. Explain the principles of elements and functions involved in radar signal processing.
2. Understand Radar signal Models.
3. Understand Pulse Radar signals.
4. Describe different types of radar waveforms.
5. Discuss on Doppler processing and Issues.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	-	-	-	-	-	-	-	-	3	3	1
CO2	2	2	3	1	2	-	-	-	-	-	-	2	3	2
CO3	3	3	3	1	2	2	-	1	3	-	3	2	3	2
CO4	3	3	2	2	1	2	-	1	-	-	2	2	3	2
CO5	2	3	3	1	1	2	-	1	-	-	2	2	3	2

PROFESSIONAL ELECTIVES - III

24PCOEL304 SDG NO. 4,7 & 9	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
- To get information about 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

TEXT BOOKS:

1. Ben Gold and Nelson Morgan, "Speech and Audio Signal Processing, Processing and Perception of Speech and Music", Wiley- India Edition, 2006.
2. Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition", Pearson Education, 2003.

REFERENCES:

1. Claudio Becchetti and LucioPrinaRicotti, "Speech Recognition", John Wiley and Sons,1999.
2. Daniel Jurafsky and James H Martin, "Speech and Language Processing – An Introduction to Natural Language Processing, Computational

Linguistics, and Speech Recognition", Pearson Education, 2002.
3. Frederick Jelinek, "Statistical Methods of Speech Recognition", MIT Press,1997.
4. Steven W. Smith, "The Scientist and Engineer"s Guide to Digital Signal Processing", California Technical Publishing, 1997.
5. Thomas F Quatieri, "Discrete-Time Speech Signal Processing – Principles and Practice", Pearson Education,2004.

WEB REFERENCES:

1. https://nlp.stanford.edu/courses/lsa352/
2. https://www.cse.iitb.ac.in/~pjyothi/cs753/index.html
3. https://www.udemy.com/course/speech-processing-face-detection-with-raspberry-pi-iot/
4. https://nptel.ac.in/courses/117105145/

ONLINE RESOURCES:

1. http://eemedia.ee.unsw.edu.au/contents/elec9344/LectureNotes/
2. https://www.ece.ucsb.edu/Faculty/Rabiner/ece259/speech%20course.html

OUTCOMES:

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

1. Model speech production system and describe the fundamentals of speech.
2. Extract and compare different speech parameters.
3. Design a speech recognition system.
4. Choose an appropriate text analysis technique for a given application.
5. Use different text analysis and speech synthesis techniques.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	1	2	2	-	-	-	-	2	2	3	2
CO2	3	1	3	1	3	2	-	-	-	-	2	2	3	2
CO3	3	1	3	2	3	2	-	-	-	1	2	2	3	2
CO4	3	1	3	2	3	2	-	-	2	2	2	2	3	2
CO5	3	1	3	2	3	2	-	-	2	2	2	2	3	2

PROFESSIONAL ELECTIVES - III

24PCOEL305 SDG NO. 4,9 & 11	ADVANCED WIRELESS NETWORKS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study about advanced wireless network, LTE, 4G and evolution of LTE
- To gain knowledge on wireless IP architecture, Packet Data Protocol and LTE network architecture
- To learn about adaptive link layer, hybrid ARQ and routing protocol
- To study about mobility management, cellular network, and micro cellular networks
- To know about QoS challenges and attributes in various advanced wireless 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 Bearers and QoS in LTE networks.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Savo Glisic, "Advanced Wireless Networks-Technology and Business Models", Third Edition, John Wiley & Sons Ltd, 2016.

REFERENCES:

1. Ayman El Nashar, 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. Savo Glisic,"Advanced Wireless Networks-4G Technologies", John Wiley & Sons Ltd, 2006.
6. Stefania Sesia, Issam Toufik and Matthew Baker, "LTE – The UMTS Long Term Evolution From Theory to Practice", John Wiley & Sons Inc. Publication, Second Edition, 2011.

WEB REFERENCES:

1. https://people.cs.nctu.edu.tw/~jcc/book/ch2-2in1.pdf
2. https://mm.aueb.gr/publications/2007-RLC-Mobimedia.pdf
3. https://iith.ac.in/~tbr/teaching/docs/LTE-Tutorial.pdf

ONLINE RESOURCES:

1. https://youtu.be/E7GnlmxGhXc
2. https://www.cse.wustl.edu/~jain/cse574-06/ftp/wireless_qos/index.html

OUTCOMES:

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

1. Familiarize with the latest 4G networks and LTE.

2. Explain the wireless IP architecture and LTE network architecture.
3. Illustrate the adaptive link layer and network layer graphs and routing protocols.
4. Describe the mobility management and cellular network.
5. Define QoS challenges and attributes of various advanced wireless networks.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	3	2	-	-	-	1	2	3	2
CO2	3	2	3	2	2	1	1	-	-	-	1	2	3	2
CO3	3	2	3	2	-	1	1	-	-	-	1	2	3	2
CO4	3	2	3	2	1	1	2	-	-	-	1	2	3	2
CO5	3	3	3	3	3	3	2	-	-	-	2	2	3	2

PROFESSIONAL ELECTIVES - III

24PCOEL306 SDG NO. 11 & 15	RADIO OVER FIBER TECHNOLOGIES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand Radio over Fiber link types
- To understand Analog Fiber optic transmission
- To understand Components of RoF
- To understand RoF technologies
- To understand Different Radio highway networks

UNIT I INTRODUCTION TO RADIO OVER FIBER (ROF) 9

Radio Over Fiber – applications, advantages, limitations, Microwave properties of optical links, Direct modulated optical links, Direct modulated optical links, external modulators, types, modulation transfer in microwave fiber optic links.

UNIT II ANALOG FIBER OPTIC 9

Sub carrier Optical fiber transmission systems, Fiber optic transmission of 64-

QAM, 256-QAM signals, Capacity of coaxial and fiber optic links, LASER diode and Photodiode nonlinearities.

UNIT III COMPONENTS FOR ROF SYSTEMS 9

Analog modulation of LASER diode, LASER diode fundamentals, Rate equation analysis, Intensity modulation, Frequency modulation Low cost LASER diode driver, LASER diode noise and their influence on link performance.

UNIT IV ROF TECHNOLOGY FOR THE CELLULAR APPLICATIONS 9

3G cellular systems, cellular architecture, UMTS architecture, WCDMA ROF systems, Micro diversity, Macro diversity, Traffic estimation, Spectral efficiency, power level, multiple user interference, ROF for Hiper-LAN2, Micro cellular communication networks.

UNIT V FIBER OPTIC RADIO NETWORKS 9

Introduction to radio highway – types of radio highway, Photonic TDMA Highway –Natural sampling of photonic TDMA, Photonic CDMA – Conventional CDMA, DOS-CDMA, Photonic chirp multiple access – architecture and performance, chirp multiplexing transform.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Hameed Al-Raweshidy, Shozo Komaki, “Radio Over fiber technologies for mobile communication networks”, Artech House publications, London, 2002.
2. William S.C.Chang, “RF Photonic technology in optical fiber links”, Cambridge university press. 2002.

REFERENCES:

1. Charles H. Cox, III, "Analog optical Links,Theory and Practice", Cambridge University Press, 2004.
2. Igor Minin, "Microwave and millimeter wave technologies modern UWB antennas and equipment", In-Tech publication, 2010.

WEB REFERENCES:

1. https://www.fiberoptics4sale.com/blogs/archive-posts/95043078-what-is-radio-over-fiber
2. https://www.researchgate.net/publication/319738806_A_Review_on_Radio_over_Fiber_communication System

ONLINE RESOURCES:

1. https://swayam.gov.in/nd1_noc19_ee67/

OUTCOMES:

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

1. Discuss the basic concepts of radio over fiber systems and their applications in real time.
2. Identify the noise measures and distortions measures.
3. Discuss radio over fiber link design and tradeoffs link parameter and amplifier.
4. Describe the techniques for transporting RF signals over optical fibre
5. Identify the cellular and UMTS architecture and also illustrate Micro and Macro diversity.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	1	1	-	-	1	-	-	-	1	-	-
CO2	1	1	2	-	-	-	-	-	-	-	-	-	-	-
CO3	-	1	-	-	2	-	-	-	-	-	-	-	1	-
CO4	2	1	-	-	1	-	-	-	-	-	-	-	1	-
CO5	2	-	-	-	1	1	-	-	-	1	1	-	1	-

PROFESSIONAL ELECTIVES - III

24PCOEL307 SDG NO. 4 & 9	PATTERN RECOGNITION AND MACHINE LEARNING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To 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

TEXT BOOKS:

1. Tom M. Mitchell, "Machine Learning", McGraw-Hill Education (Indian Edition), 2013.
2. Tou and Gonzalez, "Pattern Recognition Principles", Wesley Publication Company, London, 1974.

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.

WEB REFERENCES:

1. https://nptel.ac.in/courses/117108048/
2. https://cedar.buffalo.edu/~srihari/CSE555/
3. https://sites.cs.ucsb.edu/~yfwang/courses/cs290i_prann/lecture.html
4. https://freevideolectures.com/course/3530/pattern-recognition-i
5. https://cse.buffalo.edu/~jcorso/t/CSE555/files/lecture_introduction.pdf

ONLINE RESOURCES:

1. https://freevideolectures.com/course/3194/pattern-recognition
2. https://www.classcentral.com/course/swayam-pattern-recognition-and-application-14228
3. http://www.engr.mun.ca/~charlesr/9881/index.html

OUTCOMES:

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

1. Understand the principles of pattern recognition.
2. Understand the algorithm to classify the data and identify the patterns.
3. Utilize the given data set to extract and select features for Pattern recognition.
4. Describe the decision tree and concept learning.
5. Discuss on recent advances in pattern recognition

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	2	2	-	-	-	2	2	3	2
CO2	3	2	2	2	2	2	2	-	-	-	2	2	3	2
CO3	3	3	3	3	3	3	3	-	-	-	2	2	3	3
CO4	3	3	3	3	3	3	3	-	-	-	2	2	3	3
CO5	3	2	2	2	2	2	2	-	2	3	2	2	3	3

PROFESSIONAL ELECTIVES - IV

24PCOEL308 SDG NO. 4 & 9	SOFT COMPUTING TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To obtain knowledge on various Soft computing techniques
- To get insight of genetic algorithm
- To provide adequate knowledge about feed forward /feedback neural networks
- To apply the concept of fuzzy logic in various systems
- To provide adequate knowledge about the applications of Soft Computing

UNIT I INTRODUCTION TO SOFT COMPUTING AND NEURAL NETWORKS **9**

Evolution of Computing - Soft Computing Constituents – From Conventional AI to Computational Intelligence - Machine Learning Basics

UNIT II GENETIC ALGORITHMS **9**

Introduction to Genetic Algorithms (GA) – Basic concepts-Working Principle-Inheritance operators-Cross Over-Inversion & Deletion- Mutation Operator-Generation Cycle. Applications of GA in Machine Learning - Machine Learning Approach to Knowledge Acquisition.

UNIT III NEURAL NETWORKS **9**

Machine Learning Using Neural Network, Adaptive Networks – Feed forward Networks – Supervised Learning Neural Networks – Radial Basis Function Networks - Reinforcement Learning – Unsupervised Learning Neural Networks – Adaptive Resonance architectures – Advances in Neural networks, Applications

UNIT IV FUZZY LOGIC **9**

Fuzzy Sets – Operations on Fuzzy Sets – Fuzzy Relations – Membership Functions- Fuzzy Rules and Fuzzy Reasoning – Fuzzy Inference Systems – Fuzzy Expert Systems – Fuzzy Decision Making, Applications

UNIT V NEURO-FUZZY MODELING **9**

Adaptive Neuro-Fuzzy Inference Systems – Coactive Neuro-Fuzzy Modelling – Classification and Regression Trees – Data Clustering Algorithms – Rule base Structure Identification – Neuro-Fuzzy Control – Case studies.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, "Neuro-Fuzzy and Soft Computing", Prentice-Hall of India, 2003.
2. George J. Klir and Bo Yuan, "Fuzzy Sets and Fuzzy Logic-Theory and Applications", Prentice Hall, 1995.
3. James A. Freeman and David M. Skapura, "Neural Networks Algorithms, Application and programming Techniques", Pearson Edition., 2003.

REFERENCES:

1. Klir.G and Yuan. B B "Fuzzy sets and Fuzzy Logic", Prentice Hall of India private limited, 1997.
2. Laurene Fausett, "Fundamentals of Neural Networks", Prentice hall, 1992
3. S.Rajasekaran and G.A.V.Pai."Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI, 2010.
4. Timothy J Ross, "Fuzzy logic with Engineering Applications", John Wiley and Sons, 2009.
5. Zimmermann H.J."Fuzzy Set Theory and Its Application" Springer International Edition, 2011.

WEB REFERENCES:

1. https://swayam.gov.in/nd1_noc20_cs17/preview
2. https://nptel.ac.in/courses/106105173/
3. https://www.slideshare.net/sajidqaxi/fuzzy-logic-and-neural-networks
4. https://nptel.ac.in/courses/127105006/
5. https://www.youtube.com/watch?v=7C19X6pJEuU

ONLINE RESOURCES:

1. https://youtu.be/IZWTduVCrf8
2. https://www.iitg.ac.in/rkbc/CE602/CE602/Genetic%20Algorithms.pdf
3. http://www.cs.cmu.edu/~02317/slides/lec_8.pdf

OUTCOMES:

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

1. Understand the principles behind Soft computing techniques.
2. Understand fuzzy logic and Genetic algorithm concepts.
3. Apply and analyze the clustering and Neuro fuzzy techniques.
4. Apply ANN models and Fuzzy logic principles for industrial and societal application.
5. Create hybrid soft computing techniques.

CO – PO, PSO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	2	2	2	1	-	-	-	2	2	3	2
CO2	3	2	3	2	1	2	1	-	-	-	2	2	3	2
CO3	3	3	3	3	2	3	-	-	-	-	2	2	3	3
CO4	3	3	3	2	3	2	1	-	-	-	2	2	3	3
CO5	3	3	3	2	3	2	2	-	2	3	2	2	3	3

PROFESSIONAL ELECTIVES - IV

24PCOEL309 SDG NO. 4,8,9&15	NETWORK PROCESSORS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Learn network processors.
- Study commercial network processor
- 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, Pipeline of Homogeneous processors. Configurable Instruction set processors – Pipeline of Electrogeneous processors – Extensive and

Diverse processors – Flexible RISC plus Coprocessors – Scalability issues – Design Tradeoffs and consequences.

UNIT IV NETWORK PROCESSOR: ARCHITECTURE AND PROGRAMMING 9

Architecture: Intel Network Processor: Multi headed Architecture Overview – Features- Embedded EISC processor - Packet Processor Hardware – Memory interfaces – System and Control Interface Components – Bus Interface. Programming Software Development Kit-IXP Instruction set – 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 – Connectivity and scalability – high availability – IP routing – IP services –IPV6 –Mobile IP – MPLS – IP Multicast 0 Manageability – QoS – Security – Switching –Layer VPN2.

TOTAL: 45 PERIODS

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: Architectures, Protocols and Paradigms Telecom Engineering)", McGraw Hill, Professional, 2003.
5. Patrick Crowley, M A Eranklin, H. Hadmioglum and PZ Onufryk, "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.

WEB REFERENCES:

1. https://www.embedded.com/the-basics-of-network-processors/
2. https://en.wikipedia.org/wiki/Network_processor
3. https://www.embedded.com/network-processor-programming/
4. https://intellipaat.com/blog/tutorial/ios-tutorial/ios-technologies

ONLINE REFERENCES:

1. https://nptel.ac.in/courses/106/103/106103183/

OUTCOMES:

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

1. Understand the basics of traditional protocol processing systems and hardware architectures for protocol processing.
2. Analyze the technologies in the network processor.
3. Examine the behavior of commercial Network Processor.
4. Compare different programming in network processor.
5. Explain IOS technologies.

CO - PO - PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	1	2	1	-	-	-	-	2	2	3	2
CO2	3	1	1	1	2	1	-	-	-	-	2	2	3	2
CO3	3	2	2	2	3	1	-	-	-	-	2	2	3	2
CO4	3	2	2	2	3	1	-	-	-	-	2	2	3	2
CO5	3	1	1	1	3	2	-	-	-	-	2	2	3	2

PROFESSIONAL ELECTIVES - IV

24PCOEL310 SDG NO. 4,8 &9	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

UNIT 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.

UNIT 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

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. Mark Burges, "Principles of Network System Administration", Wiley, 2000.
4. Salah Aiidarons and Thomas Plevayk, "Telecommunications Network Technologies and Implementations", Eastern Economy Edition, IEEE press, New Delhi, 1998.

5. 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
4. www.rivier.edu/faculty/vriabov/NWM_ch_14.ppt 169
5. https://www2.rivier.edu/faculty/vriabov/cs685_notes.htm

ONLINE RESOURCES:

1. https://freevideolectures.com/course/2276/computer-networks/37
2. https://www.youtube.com/watch?v=RD8hnhGCFcY
3. https://www.youtube.com/watch?v=JtpYdefMHkg&list=PL041D7B835EA04014

OUTCOMES:

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

1. Diagnose problems and make minor repairs to computer networks using appropriate diagnostics software.
2. Demonstrate how to correctly maintain LAN computer systems.
3. Maintain the network by performing routine maintenance tasks.
4. Apply network management tools.
5. Apply the concept of web-based management.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	2	2	-	-	1	2	-	1	2	3	1
CO2	2	1	1	1	2	-	-	1	1	-	1	2	2	1
CO3	1	1	1	2	2	-	-	1	2	-	1	2	2	1
CO4	2	1	1	12	2	-	-	1	1	-	1	2	2	1
CO5	2	2	1	2	2	-	-	1	2	-	1	2	3	1

PROFESSIONAL ELECTIVES - IV

24PCOEL311 SDG NO. 4,8,9&15	COMMUNICATION NETWORK SECURITY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- 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 CRYPTO SYSTEMS 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

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.

WEB REFERENCES:

1. http://www.vssut.ac.in/lecture_notes/lecture1428550736.pdf
2. http://www.cse.iitm.ac.in/~chester/courses/16e_cns/slides/01_Introduction.pdf
3. http://pubs.sciepub.com/iteces/3/1/1/index.html

ONLINE REFERENCES:

1. https://www.classcentral.com/course/swayam-cryptography-and-network-security-9896

OUTCOMES:

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

1. Understand cryptography its need and goals.
2. Explain different types of crypto system Algorithms.
3. Explain digital signature standards.
4. Discuss authentication.
5. Explain security at different layers.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	1	-	-	-	-	1	1	3	2
CO2	3	3	3	3	3	1	-	-	-	-	1	1	3	2
CO3	3	3	2	2	3	2	-	-	-	-	2	2	3	2
CO4	3	3	3	2	3	2	-	-	-	-	2	2	3	2
CO5	3	3	3	2	3	2	-	-	-	-	2	2	3	2

PROFESSIONAL ELECTIVES - IV

24PCOEL312 SDG NO. 9,11 &15	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
- To understand the real world applications of Internet of Things

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 RASPBERRY 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

REFERENCES:

1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, 2015.
2. Dieter Uckelmann and 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 Holler Vlasios Tsiatsis Catherine Mulligan Stamatis Karnouskos 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.

WEB REFERENCES:

1. https://swayam.gov.in/nd1_noc19_cs65/preview
2. https://www.classcentral.com/course/swayam-introduction-to-internet-of-things-10093
3. https://www.iitm.ac.in/content/nptel-open-online-course-noc-0
4. https://nptel.ac.in/courses/106/105/106105166/
5. https://online.stanford.edu/courses/xee100-introduction-internet-things

ONLINE RESOURCES:

1. https://freevideolectures.com/course/4628/nptel-design-internet-things
2. https://www.udemy.com/topic/internet-of-things/
3. https://builtin.com/internet-things

OUTCOMES:

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

1. Analyze various protocols for IoT.
2. Develop web services to access/control IoT devices.
3. Design a portable IoT using Raspberry Pi.
4. Deploy an IoT application and connect to the cloud.
5. Analyze applications of IoT in real time scenarios.

CO – PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	-	-	-	-	-	1	2	3	2
CO2	3	2	2	2	2	1	-	-	-	-	2	2	3	2
CO3	3	2	3	2	3	-	-	-	-	-	3	2	3	2
CO4	3	2	3	2	3	-	-	-	1	2	2	2	3	2
CO5	3	2	2	2	3	2	2	2	2	2	3	2	3	2

PROFESSIONAL ELECTIVES - IV

24PCOEL313 SDG NO. 4,9 &11	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 – μ-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

TEXT BOOKS:

1. Khalid Sayood, "Introduction to Data Compression", Morgan Kauffman Harcourt India, Third Edition, 2010.
2. David Solomon, "Data Compression – The Complete Reference", Fourth Edition, Springer Verlog, New York, 2006.

REFERENCES:

1. Darrel Hankerson, Greg A Harris and Peter D Johnson, "Introduction to Information Theory and Data Compression" Second Edition, Chapman and Hall, CRC press, 2003.
2. Mark S. Drew, Ze-Nian Li, "Fundamentals of Multimedia", PHI, 2009.
3. Peter Symes, "Digital Video Compression", McGraw Hill Publications, 2004.
4. Yun Q.Shi, Huifang Sun, "Image and Video Compression for Multimedia Engineering, Algorithms and Fundamentals", CRC Press, 2003.

WEB REFERENCES:

1. https://pdfs.semanticscholar.org/6a25/d08e1697dcd97e8f86ffdfe7cf0e23b0f7f1.pdf

2. https://eclass.uoa.gr/modules/document/file.php/D246/Lectures/compression.pdf
3. https://www.pearsonhighered.com/assets/samplechapter/0/1/3/2/0132106426.pdf

ONLINE RESOURCES:

1. https://nptel.ac.in/courses/117105083/
2. https://nptel.ac.in/courses/117105081/

OUTCOMES:

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

1. Define the needs of Multimedia Compression in modern communication systems and the relevant techniques used.
2. Implement basic compression algorithms with MATLAB and its equivalent open source environments.
3. Explain various image compression standards.
4. Design and implement some basic compression standards and vocoders.
5. Illustrate real time and modern video compression techniques.

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	2	3	2	-	-	-	1	2	3	2
CO2	3	2	3	2	2	3	2	-	-	-	1	2	3	2
CO3	3	2	3	2	2	3	2	-	-	-	1	2	3	2
CO4	3	2	3	2	2	3	2	-	-	-	1	2	3	2
CO5	3	3	3	3	3	3	3	-	-	-	2	2	3	2

PROFESSIONAL ELECTIVES - IV

24PCOEL314 SDG NO. 4&9	ULTRA WIDE BAND COMMUNICATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To give fundamental concepts related to Ultra wideband
- 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 Locating Methods, Time of Arrival Estimation, NLOS Location Error, and Locationing with OFDM.

UNIT IV UWB ANTENNAS **9**

Antenna Requirements, Radiation Mechanism of the UWB Antennas, Types of Broadband 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

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 and Feng Zheng, "Ultra Wideband Systems with MIMO", 1st Edition, John Wiley & Sons Ltd, New York, 2010.

WEB REFERENCES:

1. https://nptel.ac.in/courses/117/104/117104126/
2. https://nptel.ac.in/courses/117/104/117104118/
3. https://nptel.ac.in/courses/117/104/117104115/
4. https://nptel.ac.in/courses/117/105/117105132/
5. https://www.coursera.org/lecture/wireless-communications/4-5-wqXDF

ONLINE RESOURCES:

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-452-principles-of-wireless-communications-spring-2006/

OUTCOMES:

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

1. Understand UWB technologies.
2. Understand the different channel models.
3. Understand the different signal processing techniques and the metrics.
4. Design UWB antenna for various applications.
5. Summarize the different regulations and standards in the design.

CO - PO, PSO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	3	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	3	2	-	-	-	-	-	-	-	3	3
CO3	3	3	3	3	3	-	-	-	-	-	-	-	3	3
CO4	3	3	3	3	3	3	3	3	1	2	3	-	3	3
CO5	3	3	2	2	1	3	2	2	1	2	2	-	3	3

Imagine the Future and

Make it happen!

Together let's build a better world where there is NO POVERTY and ZERO HUNGER.

We have GOOD HEALTH AND WELL BEING QUALITY EDUCATION and full GENDER EQUALITY everywhere.

There is CLEAN WATER AND SANITATION for everyone. AFFORDABLE AND CLEAN ENERGY

which will help to create DECENT WORK AND ECONOMIC GROWTH. Our prosperity shall be fuelled

by investments in INDUSTRY, INNOVATION AND INFRASTRUCTURE that will help us to

REDUCE INEQUALITIES by all means. We will live in SUSTAINABLE CITIES AND COMMUNITIES.

RESPONSIBLE CONSUMPTION AND PRODUCTION will help in healing our planet.

CLIMATE ACTION will reduce global warming and we will have abundant,

flourishing LIFE BELOW WATER, rich and diverse LIFE ON LAND.

We will enjoy PEACE AND JUSTICE through STRONG INSTITUTIONS

and will build long term PARTNERSHIPS FOR THE GOALS.

For the goals to be reached, everyone needs to do their part: governments, the private sector, civil society and **People like you.**

Together we can...

Sai Prakash Leo Muthu

CEO – Sairam Institutions

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through Quality education.

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