ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS 2023

M.E. WIRELESS TECHNOLOGIES

CHOICE BASED CREDIT SYSTEM

VISION OF DEPARTMENT OF ELECTRONICS ENGINEERING

The Department of Electronics Engineering is committed to produce globally competitive and socially sensitized graduates in Electronics & Communication Engineering. We seek to instillthe spirit of creativity and leadership skills enabling the students to make a global impacttowards the availability of technology to mankind from all walks of life.

MISSION OF DEPARTMENT OF ELECTRONICS ENGINEERING

- To impart high quality technical education to students from socially and economicallydiverse backgrounds
- Give solid foundation on Mathematical skills and allied fields of Electronics and Communication
- To produce students with technical competence to design sophisticated systems in Electronics & Communication
- To make high quality research contribution in the field of Electronics, Communication, Networking , VLSI & Signal Processing
- To collaborate with industries in Electronics & Communication in the indigenous product development
- To inculcate qualities of leadership and entrepreneurship in students
- To facilitate adequate exposure to the faculty enabling them to be synchronized with the Cutting edge technology

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M.E. WIRELESS TECHNOLOGIES

CHOICE BASED CREDIT SYSTEM

I. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. Provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve problems in Signal Processing, Wireless Communication and Networking.

II. Serve in research establishments and contribute towards the development of sophisticated Wireless Technologies systems.

III. Prepare students to excel in research or to succeed in Wireless Communication and Networking domain through global, rigorous post graduate education.

IV. Become entrepreneurs and contribute towards indigenous product development to compete in global market.

II. PROGRAMME OUTCOMES (POs):

PO#	GRADUATE ATTRIBUTE	PROGRAMME OUTCOME
1.	Research aptitude	An ability to independently carry out research /investigation and development work to solve practical problems
2.	Technical Documentation	An ability to write and present a substantial technical report/document
3.	Technical Competence	Students should be able to demonstrate mastery over the area as per the specialization of the program.
4.	Engineering Design	An ability to apply various advanced tools and techniques to develop efficient solutions for signal processing, wireless communication and networking systems
5.	The Engineer and Society	Apply technical knowledge towards the development of socially relevant products to meet the practical issues
6.	Environment and Sustainability	Ensure the developmentof cost effective and eco-friendly indigenous products.

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III. PROGRAMME SPECIFIC OUTCOMES (PSOs):

I. Foundation of wireless communication systems: Ability to understand the basics principles involved in the operation of wireless communication systems and thereby provide solutions due to channel impairments in real time implementation.

II. Foundation of networking systems: Ability to understand the various technologies behind the recent wireless communication standards and work towards to providing improved solutions.

III. Foundations of Mathematical concepts: Ability to apply mathematical knowledge to develop new protocols, algorithms, interfaces to address networking issues and to develop new protocols, and algorithms for cyber security issues.

IV. Applications of Communication and networking and Research ability: Ability to use knowledge in various domains to identify research gaps and provide innovative solutions.

IV. PEO/PO Mapping:

PEOs	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
I.	3	1	3	2	2	2
II.	2	2	3	3	2	2
III.	2	1	2	3	3	3
IV.	1	1	2	2	3	3

V. MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOME

SEM	COURSE	PROGRAM OUTCOMES					
		PO1	PO2	PO3	PO4	PO5	PO6
I	Applied Mathematics for Network Engineers	3	1.4	2	1.8	1	1
	Research Methodology and IPR	2.2	1.8	1	3	2	1.2
	Wireless Broadband Networks	2.8	2.8	2	1	1	1.4
	Wireless Communication Techniques	2.4	1	2.2	1.6	1.2	1.2
	RF Engineering	3	1	3	2.2	1.6	1.6
	Wireless Sensor Networks	3	3	3	3	3	3
	RF System Design Laboratory	3	1	3	3	1.2	1.4
II	Access Technologies	2.8	1	3	1.8	2.2	1.2
	Free Space Optical Communication	2.8	1	2.8	2.8	2.8	2.8
	Advanced Antenna Systems	3	1	3	2.2	3	1.8
	Adaptive Signal Processing Techniques	3	1	2	2	1	1.4
	Professional Elective I						
	Professional Elective II						
	Wireless Technology Laboratory	3	2	2.6	2	1.4	1
III	Professional Elective III						
	Professional Elective IV						
	Professional Elective V						
	Project Work I	3	3	3	3	3	3
IV	Project Work II	3	3	3	3	3	3

PROGRAM ELECTIVE COURSES

PROGRAM ELECTIVE COURSES	PROGRAM OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
Principles of Network Security	3	3	1.8	2.2	2.2	2.2
Optical and Wireline Technology	2.8	1	2.8	2.8	2.8	2.8
Satellite Communication Systems	2.4	1	2.4	2.6	2.4	2.4
Modeling and Simulation of Wireless Communication Systems	1.6	1	2.4	2.6	1.6	1
Network Routing Protocols	3	1	2	1.6	1.6	1.2
Multimedia Compression Techniques	3	1	2	1.4	1	1
Micro Electro Mechanical System for Wireless Communication	1.4	1.4	2	1.4	1.8	2.2
Global Positioning Systems	2.4	1	2.4	2.6	2.8	1.6
Multirate Signal Processing for Communication	3	1	3	3	2	1
Signal Integrity for High Speed Electronic Systems	3	1	1.6	1.8	1	1

IoT and Applications	3	1	3	1.6	1.6	1.2
Real Time Systems	1.8	2.6	3	1.8	1.8	1
Game Theory for Communication and Networking	3	1	3	2.8	2.8	2.2
Wireless Personal Area Communication Networks	3	3	1.4	1.6	1.6	1.6
Cognitive Radio Communication and Networks	3	1	2	1.6	2.4	2.4
Pattern Recognition and machine learning	2	1.4	1.4	2	2.4	2.4
Wireless Transceiver Design	3	1	3	2.2	1.6	1.4
VLSI Design Techniques	3	1	2	1.6	1.6	1.2
Antenna for 5G and 6G Communication	3	1	3	1.6	2.2	1.4
Computational Intelligence	3	2	3	1.6	2	2
Electromagnetic Interference and Electromagnetic Compatibility	2.8	1	2.8	2.8	2.8	2.8
Ultra Wideband Communication	3	1	3	2.2	2.2	1.4
Advanced Wireless Communication Techniques	2.4	1	2	1.8	1.2	1.4
RF IC design	3	1	3	2	2	1
Radio over Fiber for 5G Networks	3	1	3	2.2	2.2	1.8
Information Theory and Coding	3	1	2.6	1.6	1.6	1.8
Spread Spectrum Techniques and Applications	2.2	1	2	2	1.8	1.2
Space Time Wireless Communication	2.6	1	2.4	2.6	1.8	1.8
Software Defined Network	3	1	3	2.4	2.4	2

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UNIVERSITY DEPARTMENTS
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REGULATIONS – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULA AND SYLLABI
SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3157	Applied Mathematics for Network Engineers	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	WT3151	Wireless Broadband Networks	PCC	3	0	0	3	3
4.	WT3101	Wireless Communication Techniques	PCC	3	0	0	3	3
5.	NE3152	RF Engineering	PCC	3	0	0	3	3
6.	WT3102	Wireless Sensor Networks Design	PCC	3	0	4	7	5
PRACTICALS								
7.	NE3161	RF System Design Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**1**	**8**	**27**	**23**

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	WT3201	Access Technologies	PCC	3	0	0	3	3
2.	WT3251	Free Space Optical Communication	PCC	3	0	0	3	3
3.	WT3202	Advanced Antenna Systems	PCC	3	0	4	7	5
4.	NE3251	Adaptive signal Processing Techniques	PCC	3	0	0	3	3
5.		Professional Elective I	PEC	3	0	0	3	3
6.		Professional Elective II	PEC	3	0	0	3	3
PRACTICALS								
7.	WT3261	Wireless Technology Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**0**	**8**	**26**	**22**

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective III	PEC	3	0	0	3	3
2.		Professional Elective IV	PEC	3	0	0	3	3
3.		Professional Elective V	PEC	3	0	0	3	3
PRACTICALS								
4.	WT3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	WT3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL: 72 CREDITS

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	MA3157	Applied Mathematics for Network Engineers	4	0	0	4	I

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	WT3151	Wireless Broadband Networks	3	0	0	3	I
2.	WT3101	Wireless Communication Techniques	3	0	0	3	I
3.	NE3152	RF Engineering	3	0	0	3	I
4.	WT3102	Wireless Sensor Networks	3	0	4	5	I
5.	NE3161	RF System Design Laboratory	4	0	4	2	I
6.	WT3201	Access Technologies	3	0	0	3	II
7.	WT3251	Free Space Optical Communication	3	0	0	3	II
8.	NE3251	Adaptive signal Processing Techniques	3	0	0	3	II
9.	WT3202	Advanced Antenna Systems	3	0	4	5	II
10	WT3261	Wireless Technology Laboratory	4	0	4	2	II
		TOTAL CREDITS				**32**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

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

PROFESSIONAL ELECTIVES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	WT3001	Principles of Network Security	PEC	3	0	0	3	3
2	WT3002	Optical and Wireline Technology	PEC	3	0	0	3	3
3	WT3003	Satellite Communication Systems	PEC	3	0	0	3	3
4	WT3004	Modeling and Simulation of Wireless Communication Systems	PEC	3	0	0	3	3
5	WT3052	Network Routing Protocols	PEC	3	0	0	3	3
6	WT3005	Multimedia Compression Techniques	PEC	3	0	0	3	3
7	WT3006	Micro Electro Mechanical System for Wireless Communication	PEC	3	0	0	3	3
8	WT3007	Global Positioning Systems	PEC	3	0	0	3	3
9	WT3008	Multirate Signal Processing for Communication	PEC	3	0	0	3	3
10	WT3058	Signal Integrity for High Speed Electronic Systems	PEC	3	0	0	3	3
11	NE3057	IoT and Applications	PEC	3	0	0	3	3
12	VE3051	Real Time Systems	PEC	3	0	0	3	3
13	NE3055	Game Theory for Communication and Networking	PEC	3	0	0	3	3
14	NE3059	Wireless Personal Area Communication Networks	PEC	3	0	0	3	3
15	NE3151	Cognitive Radio Communication and Networks	PEC	3	0	0	3	3
16	WT3053	Pattern Recognition and Machine Learning	PEC	3	0	0	3	3
17	WT3060	Wireless Transceiver Design	PEC	3	0	0	3	3
18	WT3009	VLSI Design Techniques	PEC	3	0	0	3	3
19	NE3051	Antenna for 5G and 6G Communication	PEC	3	0	0	3	3
20	NE3052	Computational Intelligence	PEC	3	0	0	3	3
21	NE3054	Electromagnetic Interference and	PEC	3	0	0	3	3

		Electromagnetic Compatibility						
22	WT3057	Ultra Wideband Communication	PEC	3	0	0	3	3
23	WT3051	Advanced Wireless Communication Techniques	PEC	3	0	0	3	3
24	WT3055	RF IC Design	PEC	3	0	0	3	3
25	WT3054	Radio Over Fiber for 5G Networks	PEC	3	0	0	3	3
26	NE3056	Information Theory and Coding	PEC	3	0	0	3	3
27	WT3056	Spread Spectrum Techniques and Applications	PEC	3	0	0	3	3
28	WT3059	Space Time Wireless Communication	PEC	3	0	0	3	3
29	NE3058	Software Defined Network	PEC	3	0	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			L	T	P		
1.	WT3311	Project Work I	0	0	12	6	I
2.	WT3411	Project Work II	0	0	24	12	II
					TOTAL CREDITS	18	

SUMMARY

	Name of the Programme: M.E WIRELESS TECHNOLOGIES					
	Subject Area	Credits Per Semester				Credits Total
		I	II	III	IV	
1.	FC	4	-	-	-	4
2.	PCC	16	16	-	-	32
3.	PEC		6	9	-	15
4.	RMC	3	-	-	-	3
5.	EEC	-	-	6	12	18
6.	**TOTAL CREDIT**	**23**	**22**	**15**	**12**	**72**

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MA3157 APPLIED MATHEMATICS FOR NETWORK ENGINEERS L T P C
4 0 0 4

UNIT I LINEAR ALGEBRA 12

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

UNIT II SPECIAL FUNCTIONS 12

Bessel's equation – Bessel function – Recurrence relations - Generating function and orthogonal property for Bessel functions of first kind – Fourier-Bessel expansion.

UNIT III GRAPH ALGORITHMS 12

Graphs – Sub graphs – Complements – Graph isomorphism – Eulerian graphs –Hamiltonian graphs - Planar graphs– Kruskals algorithm – Dijkstras shortest path algorithm, Prims algorithm– Transport Networks.

UNIT IV ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system — Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method.

UNIT V RANDOM PROCESSES 12

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

TOTAL: 60 PERIODS

COURSE OUTCOME:

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

CO1: Work with vector spaces and linear transformations and their applications.
CO2: Use the ideas of Special Functions in solving special types of problems.
CO3: Apply Graph Theory algorithms in networks.
CO4: Use various methods of solving systems of Algebraic Equations and eigen value problems.
CO5: Apply the ideas of random processes

REFERENCES:

1. Glyn James, “Advanced Modern Engineering Mathematics”, Pearson/Prentice Hall, Horlow, 5th Edition, 2018.
2. Peter V.O'Neil, “Advanced Engineering Mathematics”, Cengage Learning, Singapore, 8th Edition,2017
3. Oliver C. Ibe, “Fundamentals of Applied Probability and Random Processes”, Academic Press, (Animprint of Elsevier), Boston, 2014.
4. Richard Bronson and Gabriel B. Costa, “Linear Algebra”, Academic Press, Amsterdam, 3rd Edition,2013.
5. Balakrishnan R., Ranganathan K., “A textbook of Graph theory”, Springer, New York, 2nd Edition,2012.
6. Richard Bronson, “Matrix Operation”, Schaum’s outline series, McGraw Hill, New York, 2nd Edition,2011
7. Erwin Kreyszig. “Advanced Engineering Mathematics”, John Wiley & Sons, New York, 10th

Edition,2010..
8. Ralph P. Grimaldi, "Discrete and combinatorial Mathematics", Pearson Education, New Jersey, 5thEdition, 2004.

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

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

UNIT I RESEARCH PROBLEM FORMULATION 9

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

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

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

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

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

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

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

UNIT V PATENTS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:

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

WT3151 WIRELESS BROADBAND NETWORKS L T P C
3 0 0 3

UNIT I WIRELESS PROTOCOLS 9

Mobile network layer- Fundamentals of Mobile IP, data forwarding procedures in mobile IP, IPv4,IPv6, IP mobility management, IP addressing - DHCP, Mobile transport layer-Traditional TCP, congestion control, slow start, fast recovery/fast retransmission, classical TCP improvements Indirect TCP, snooping TCP, Mobile TCP.

UNIT II 3G EVOLUTION 9

IMT-2000 - W-CDMA, CDMA 2000 - radio & network components, network structure, packet-data transport process flow, Channel Allocation, core network, interference-mitigation techniques, UMTS-services, air interface, network architecture of 3GPP, UTRAN – architecture, High speed packet data-HSUPA.

UNIT III 4G EVOLUTION 9

Introduction to LTE-A – Requirements and Challenges, network architectures – EPC, E- UTRAN architecture - mobility management, resource management, services, channel -logical and transport channel mapping, MAC control element, PDU packet formats, scheduling services, random access procedure.

UNIT IV LAYER-LEVEL FUNCTIONS 9

Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme-frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, interference cancellation – CoMP, Carrier aggregation.

UNIT V 5G AND 6G EVOLUTION 9

5G Roadmap - Pillars of 5G - 5G Architecture, The 5G internet - IoT and context awareness - Networking reconfiguration and virtualization support - Mobility QoS control - emerging approach for resource over provisioning, Small cells for 5G mobile networks - Mobile data demand, Demand Vs Capacity, Small cell challenges, Conclusion and future directions; Introduction to 6G.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Design and implement the various protocols in wireless networks.

CO2: Analyze the architecture of 3G network standards.
CO3: Analyze the difference of LTE-A network design from 4G standard.
CO4: Design the interconnecting network functionalities by layer level functions.
CO5: Explore the current generation (5G) network architecture.

REFERENCES:

1. Erik Dahlman, Stefan Parkvall and Johan Skold ,"5G NR: The Next Generation Wireless Access Technology"Academic Press, 2020.
2. Jonathan Rodriguez, "Fundamentals of 5G Mobile networks", John Wiley, 2015.
3. Sassan Ahmadi, "LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies", Elsevier, 2014.
4. Abd-Elhamid M. Taha and Hossam S. Hassanein, Najah Abu Ali ,"LTE, LTE-Advanced and WiMAX", John Wiley, 2012
5. Vijay K.Garg, "Wireless Network Evolution - 2G & 3G". Prentice Hall; August 2011,
6. Clint Smith,P.E, Dannel Collins, "3G Wireless Networks" Tata McGrawHill, 2nd Edition, 2011.
7. Kareh Pahalavan, "Principles of Wireless Networks" Prentice-Hall of India, 2008.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	1	2
CO2	3	3	2	1	1	2
CO3	3	3	2	1	1	1
CO4	3	3	2	1	1	1
CO5	2	2	2	1	1	1
AVG	2.8	2.8	2	1	1	1.4

WT3101 WIRELESS COMMUNICATION TECHNIQUES L T P C
3 0 0 3

UNIT I CELLULAR CONCEPTS 9

Frequency Reuse – Channel Assignment Strategies – Hand off Strategies – Interference and system capacity- Co-Channel Interference- Adjacent Channel Interference – Trunking and Grade of service – Improving coverage & capacity in cellular systems-Cell Splitting- Sectoring-Repeaters for Range Extension-Microcell Zone Concept.

UNIT II THE WIRELESS CHANNEL 9

Overview of wireless systems – Physical modeling for wireless channels – Time and Frequency coherence – Statistical channel models – Capacity of wireless Channel- Capacity of Flat Fading Channel – Channel Side Information at Receiver – Channel Side Information at Transmitter and Receiver –Capacity comparisons – Capacity of Frequency Selective Fading channels.

UNIT III PERFORMANCE OF DIGITAL MODULATION OVER WIRELESS CHANNELS 9

Performance of flat fading and frequency selective fading – Impact on digital modulation techniques - Outage Probability– Average Probability of Error –– Combined Outage and Average Error Probability – Doppler Spread – Inter symbol Interference.

UNIT IV DIVERSITY TECHNIQUES 9

Realization of Independent Fading Paths – Receiver Diversity – Selection Combing – Threshold Combing – Maximal-Ratio Combing – Equal - Gain Combing – Capacity with Receiver diversity – Transmitter Diversity – Channel known at Transmitter – Channel unknown at Transmitter – The

Alamouti Scheme– Transmit & Receive Diversity-MIMO Systems.

UNIT V MULTICARRIER MODULATION 9

Data Transmission using Multiple Carriers – Multicarrier Modulation with Overlapping Sub channels – Mitigation of Subcarrier Fading – Discrete Implementation of Multicarrier Modulation – Peak to average Power Ratio- Frequency and Timing offset.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Design solutions for cellular communication.
CO2: Compute the capacity of wireless channels.
CO3: Analyze the performance of the digital modulation techniques in fading channels.
CO4: Diversity techniques in wireless communication.
CO5: Multicarrier systems in wireless communication.

REFERENCES:

1. Andreas F. Molisch, " Wireless Communications", Second Edition, An Indian Adaptation, Wiley India, 2021.
2. Aditya K. Jagannatham, “Principles of Modern Wireless Communication Systems Theory and Practice”, McGraw Hill Education, 2017.
3. Keith Q. T. Zhang, “Wireless Communications: Principles, Theory and Methodology” John Wiley & Sons, 1st Edition, 2016.
4. Theodore.S. Rappaport, “Wireless Communications: Principles and Practice", 2nd Edition, Pearson Education, India, 2009.
5. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005.
6. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Wiley Series in Telecommunications, Cambridge University Press, 2005.
7. Ramjee Prasad, "OFDM for Wireless Communication Systems", Artech House,2004.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	1	1	2
CO2	2	1	2	1	1	1
CO3	3	1	3	2	2	1
CO4	3	1	2	2	1	1
CO5	2	1	2	2	1	1
AVG	2.4	1	2.2	1.6	1.2	1.2

NE3152 RF ENGINEERING L T P C
3 0 0 3

UNIT I NETWORKS AND MATRICES 9

Scattering and chain scattering matrices, Generalized scattering matrix, Analysis of two port networks, Interconnection of networks. Positive real concepts, scattering matrix, representation of microwave components (directional coupler, circulators, hybrids and isolators).

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UNIT II HIGH FREQUENCY CIRCUIT DESIGN 9

Tuned Circuits, Filter design- Butterworth filter, Chebyshev filter, impedance matching. High frequency amplifier, BJT and FET amplifier, Broadband Amplifiers RF Oscillators, Colpitts, Hartley Oscillators, PLL. High Frequency Integrated Circuits.

UNIT III MICROWAVE AMPLIFIER DESIGN 9

Types of amplifiers, Power gain equations. Introduction to narrow band amplifiers basic concepts, IMD3, IIP3 and SFDR, Maximum gain design, Low noise design. High power design, Negative resistance, reflection amplifiers – various kinds – stability considerations, Microwave transistor amplifier design – input and output matching networks – constant noise figure circuits, IC based Microwave amplifier design.

UNIT IV MICROWAVE OSCILLATOR DESIGN 9

One port and two port negative resistance oscillators. Oscillator configurations, Oscillator design using large signal measurements, Introduction to Microwave CAD packages, Microwave integrated circuits, MIC design for lumped elements, IC based Oscillator Design.

UNIT V RF AND MICROWAVE ANTENNAS 9

Radiation from surface current and line current distribution, Basic Antenna parameters, Feeding structure-Patch Antenna, Ring Antenna, Micro strip dipole, Micro strip arrays, Traveling wave Antenna, Antenna System for Mobile Radio-Antenna Measurements and Instrumentation. Propagation characteristics of RF and Microwave signals, Introduction to EBG structures, Antenna for 5G/6G Mobile Networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Apply scattering parameters in RF circuit and systems
CO2: Develop filters for high frequency applications
CO3: Design amplifiers for RF transceivers
CO4: Understand the RF oscillator design techniques
CO5: Develop antennas for high frequency applications.

REFERENCES:

1. Charles E. Free, Colin S. Aitchison, “RF and Microwave Circuit Design: Theory and Applications” John Wiley & Sons Ltd, 2021.
2. Kraus.J.D, Marhefka.R.J. Khan.A.S. “Antennas and Wave Propagation”, Tata Mc Graw Hill, New Delhi, 5 th Edition, 2017
3. Reinhold Ludwig and Gene Bogdanov, "RF Circuit Design – Theory and Applications", Pearson, 2 nd Edition, 2012.
4. David.M.Pozar, "Microwave Engineering", John Wiley and Sons, 4 th Edition, 2012.
5. E.da Silva, "High Frequency and Microwave Engineering", Butterworth Heinmann Publications, Oxford, 2001.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	3
CO2	3	1	3	1	1	2
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1
AVG	3	1	3	2.2	1.6	1.6

WT3102 WIRELESS SENSOR NETWORKS DESIGN L T P C
3 0 4 5

UNIT I INTRODUCTION 9

Overview of personal area networks - Principles of Wireless Sensor Network (WSN) - design principles, Node Architecture, Network Architecture, physical layer of sensor network, transceiver design considerations.

UNIT II DATA LINK LAYER AND NETWORK LAYER PROTOCOLS 9

MAC protocols – fundamentals, low duty cycle protocol and wakeup concepts of MAC protocol, contention based protocols. Routing protocols — Requirements,Classification -SPIN, Directed Diffusion, and COUGAR. LEACH, PEGASIS

UNIT III 6LoWPAN 9

6LoWPAN Architecture - protocol stack, Adaptation Layer, Link layers – Addressing. Routing - Mesh-Under - Route-Over, Header Compression - Stateless header compression. Fragmentation and Reassembly.

UNIT IV 6LoWPAN APPLICATION LAYER 9

Design Issues, Protocol Paradigms -End-to-end, Real-time streaming and sessions, Publish/subscribe, Web service paradigms, Common Protocols -Web service protocols, MQ telemetry transport for sensor networks (MQTT-S), ZigBee compact application protocol (CAP),Service discovery. , Industry- Specific protocols.

UNIT V IoT NODES 9

LoRA Transmission range, LoRA communication, LoRA devices, LoRAWAN communication, gateway, and service provider, gateway, end devices. TTN -The Things Network Infrastructure, LoRAWAN gateway- Heltec HT-M00 dual channel, Dragino LPs8. LoRA Transceivers -micro chip RN 2483, LoRAWAN nodes --commercial end devices, Boards, NIC of networks - IEEE 802.3, IEEE 802.15.4, LoRAWAN.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

1. Program and verify the data reading of LDR, temperature sensor and pressure sensor data
2. Measure the performance of mesh network topology based WSN edge nodes
3. Point to point UDP & Mesh networking based Server Client Communication
4. Configuration of Wireless Sensor Network and measurement of minimum and maximum transmission range in the point to point wireless communication range.
5. Implementing Point-to-Point UDP Server-Client Wireless Communication using 6LowPAN based Edge Nodes
6. Perform client data transfer to server by fetching the sensor data in 1 edge node and RPL border router to publishing the sensor data to the server.
7. Performance measurement of MQTT protocol using broker and wifi technologies under
8. MQTT broker setup to establish MQTT client and server communication
9. Publish and subscribe to read data to the WSN environment using multiple edge node and 3 RPL router.
10. Create an account with ubidots cloud source and store the sensor data using RPL border router.

TOTAL:60 PERIODS

Attested

COURSE OUTCOMES:

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

CO1: Understand the WSN MAC , Routing Protocol

CO2: Acquire knowledge on 6lowpan protocols.

CO3: Design WSN using open source tool contiki OS

CO4: Implement a program on contiki OS for testing a UDP server and client communication of 6LowPAN

CO5: Measure the performance of power levels of 6lowpan nodes and its communication with cloud servers

CO6: Measure the performance of 6lowpan routing protocol

REFERENCES:

1. Dr. Claus Kuhel, "Devlop and Operate LoRAWAN IoT nodes" Elektor Publication, Elektor International Media B.V. Printed in the Netherlands by Ipskamp Printing, 2022.
2. Anna Forster, “Introduction to Wireless Sensor Networks”, Wiley, 2017.
3. Zach Shelby Sensinode and Carsten Bormann, “ 6LoWPAN: The Wireless Embedded Internet” John Wiley and Sons, Ltd, Publication, 2009.
4. Holger Karl , Andreas willig, “Protocol and Architecture for Wireless Sensor Networks”, John Wiley Publication, 2006.
5. Philip Levis, “TinyOS Programming”, 2006 – www.tinyos.net. The Contiki Operating System. http://www.sics.se/contiki.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	3	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
CO6	3	3	3	3	3	3
AVG	**3**	**3**	**3**	**3**	**3**	**3**

NE3161 **RF SYSTEM DESIGN LABORATORY** **L T P C**
0 0 4 2

LIST OF EXPERIMENTS

1. Measurement of transmission line parameters using network analyzer
   (a) Reflection coefficient (b) VSWR
2. Design of Microstrip transmission line
   (a) λ/2 line (b) λ/4 line (c) λ/8 line
3. Design and characterization of RF filters
4. Design of impedance matching network
5. Measurement of RF signals and their spectrum at 5G sub-GHz band
6. Design and characterization of antennas
7. Design and Characterization of antenna for 5G/6G mobile networks
8. Design and characterization of LNA
9. Design and characterization of Mixer
10. Design and characterization of VCO

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Measure the RF network parameters

CO2: Design and develop RF filters

CO3: Design and develop antennas for RF applications

CO4: Construct new circuit and systems for high frequency applications

CO5: Test RF components and systems

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	1	2
CO2	3	1	3	3	2	1
CO3	3	1	3	3	1	2
CO4	3	1	3	3	1	1
CO5	3	1	3	3	1	1
AVG	3	1	3	3	1.2	1.4

WT3201 ACCESS TECHNOLOGIES L T P C

3 0 0 3

UNIT I REVIEW OF ACCESS TECHNOLOGIES 9

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

UNIT II DIGITAL SUBSCRIBER LINES 9

DSL Transmission Techniques -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 9

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 9

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

UNIT V WIRELESS ACCESS NETWORK 9

Fixed Wireless, Direct Broadcast Satellite (DBS), Multi channel multi point distribution services (MMDS), Local multi point distribution services (LMDS), and Wideband integrated Digital Interactive Services (WIDIS) OFDM , RAN ,WIMAX,WLAN.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Explore the fundamental concepts and emerging broadband technologies

CO2: Design the systems meeting out the requirements of the recent standards.

CO3: Design the cable modem in next generation Access technologies.

CO4: Analyze the systems standards for next generation access technologies.

CO5: Explore the various services of wireless broadband technologies.

REFERENCES:

1. Upena Dalal, “Wireless Communication”, Oxford University Press, 2015.
2. Steven Gorshe, Arvind Raghavan, Thomas Starr, Stefano Galli, "Broadband Access: Wireline and Wireless - Alternatives for Internet Services", John Wiley & Sons, 2014.
3. Glen Carty, "Broadband Networking",Mc Graw Hill,2002.
4. Walter J Woralski, “ADSL and DSL Technologies”, McGraw Hill Computer Communication Series, Second Edition Oct 2001.
5. Gilbert Held, “Next Generation Modems: A Professional Guide to DSL and Cable Modems”, John Wiley & Sons, 2000.
6. Niel Ransom and Albert A. Azzam, “Broadband Access Technologies: ADSL, VDSL Cable Modem, Fiber and LMDS", McGraw Hill, 1999.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	3	1	1	2
CO2	3	1	3	1	1	1
CO3	3	1	3	2	3	1
CO4	3	1	3	3	3	1
CO5	3	1	3	2	3	1
AVG	2.8	1	3	1.8	2.2	1.2

WT3251 FREE SPACE OPTICAL COMMUNICATION L T P C
3 0 0 3

UNIT I FUNDAMENTALS OF FSO TECHNOLOGY 9

Introduction - History of Optical Telecommunications - Maxwell's Equations - Electromagnetic wave propagation in an isotropic, linear homogenous medium - Propagation of a wave in a non-homogenous medium - Coherent and incoherent communication - Indoor and Out door FSO links, FSO versus RF and optical fiber.

UNIT II OPTICAL COMPONENTS AND SUBSYSTEMS 9

Radiometry : basic concepts - Optical spectral windows, materials and eye-safety - Transmitters - LED - Laser Diodes - Modulation Schemes - Receivers - Types of Detectors - Receiver Configuration - Optical Post and Preamplifiers - Link Design Trade-off - Acquisition, Tracking and Pointing

UNIT III FREE SPACE OPTICAL CHANNEL 9

Atmospheric Channel - Losses - Absorption and Scattering Losses - Free Space Loss - Beam Divergence Loss - Pointing Loss - Loss due to Weather Conditions - Atmospheric Turbulence - Atmospheric Turbulent Channel Model - Techniques for Turbulence Mitigation - Visibility - Atmospheric attenuation - Meteorological disturbances - channel - Modeling

UNIT IV FSO LINK PERFORMANCE 9

FSO Link budget, case studies, Additional power requiredto reach a given bit error rate - Optical noise - BER performance of FSO System - Link Performance Improvement Techniques - Concept of quality of service and availability - Regulation of FSO equipment

UNIT V INTEGRATION OF FSO IN OPTICAL NETWORKS 9

Revolution of Optical Networking - Next Generation Optical Networking - Classifying the Global

Optical Network - Driving FSO from the EDGE - FSO in Metropolitan Optical Networks - FSO Market - Installation of Free space Optical Systems - Regulation of FSO equipment Free space optics and Laser safety.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: Design and analyze the free space optical communication systems.
CO2: Identify and select suitable components for building a FSO system
CO3: Understand FSO channels with their mathematical representation models.
CO4: Understand the beam propagation mechanism. FSO link performance
CO5: Understand the networking principles aspects of FSO technology

REFERENCES:

1. Hemani Kaushal, V.K Jain, Subrat Kar, "Free Space Optical Communication", Springer (India) Pvt. Ltd., 2017.
2. Hamid Hemmati," Near earth laser communications" CRC press, Boca Raton,FL,2009.
3. Arun K. Majumdar, Jennifer C. Ricklin, "Free-Space Laser Communications : Principles and Advances", Springer Science + Business Media, LLC, 2008.
4. Olivier Bouchet, Herve Sizun, Christian Boisrobert, Frederique de Fornel, Pierre-Noel Favennec, "Free-Space Optics : Propagation and Communication", ISTE Ltd, 2006.
5. Heinz Willebrand, Baksheesh S. Ghuman, "Free-Space Optics : Enabling Optical Connectivity in Today's Networks", Sams Publishing, 2002.
6. Morris Katzman, "Laser Satellite Communication", Prentice Hall Inc, Newyork, 1991.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	2	2	2
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	**2.8**	**1**	**2.8**	**2.8**	**2.8**	**2.8**

WT3202 ADVANCED ANTENNA SYSTEMS **L T P C**
3 0 4 5

UNIT I ANTENNA FUNDAMENTALS **9**

Introduction –Types of Antennas – Radiation Mechanism – Current distribution on wire antennas – Maxwell's equations - Antenna fundamental parameters - Radiation integrals - Radiation from surface and line current distributions – dipole, monopole, loop antenna; Mobile phone antennabase station, hand set antenna; Image; Induction, reciprocity theorem, Balance to unbalance transformer, Review of Antenna Measurements.

UNIT II ANTENNA ARRAYS **9**

One Dimensional Arrays: Linear array –uniform array, end fire and broad side array, gain, beam width, side lobe level; Linear array synthesis techniques – Binomial and Chebyshev distributions; Two dimensional uniform arrays;smartantennas,switched beam and adaptive arrays, Mutual Coupling in Finite Arrays.

UNIT III RADIATION FROM APERTURES 9

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

UNIT IV MICROSTRIP ANTENNA 9

Radiation Mechanism and Excitation techniques : Microstrip dipole; Patch, Rectangular patch, Circular patch, and Ring antenna – radiation analysis from cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Reconfiguration Mechanisms; Computer Aided Design of Microstrip Antennas, Microstrip Reflectarray Antennas, Microstrip antenna for 5G mobile networks.

UNIT V MODERN ANTENNAS 9

PIFA – Vivaldi Antennas - UWB Antennas - Antennas in Medicine – Leaky Wave Antennas – Plasma Antennas – Wearable Antennas – RFID Antennas - Automotive antennas, Reconfigurable antennas - Meta materials.

TOTAL: 45 PERIODS

LIST OF EXPERIMENTS

1. Measurement of return loss of different antenna using network analyzer
2. Design and development of Yagi antenna
3. Design and development of microstrip patch antenna for 5G applications
4. Characteristics of Horn antenna
5. Radiation pattern and gain measurement of antenna
6. Design and characterization of reflector antenna
7. Design and development of wire antenna
8. Design and characterization of WiFi and Cell phone antenna
9. Design and characterization of EMC antennas
10. Mini Project

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the basic antenna theory
CO2: Identify the concepts of antenna arrays
CO3: Apply the theory of aperture for antenna design
CO4: Design microstrip antennas
CO5: Develop antennas for various applications

REFERENCES:

1. Krauss.J.D, Ronald J Marhefka and Ahmed S khan, “Antennas and Wave Propagation”, Fifth edition, Tata Mc Graw Hill, New Delhi, 2017.
2. Balanis.A, “Antenna Theory Analysis and Design”, John Wiley and Sons, New Jersey, 4th Edition, 2016.
3. W.L.Stutzman and G.A.Thiele, “Antenna Theory and Design”, John Wiley & Sons Inc., 3rd Edition, 2013
4. Frank B. Gross, “Frontiers in Antennas- Next Generation Design and Engineering”, Mc Graw Hill, 2011.
5. S. Drabowitch, A. Papiernik, H.D.Griffiths, J.Encinas, B.L.Smith, “Modern Antennas”, Springer Publications, 2nd Edition, 2007.

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	3	3
CO2	3	1	3	1	3	3
CO3	3	1	3	3	3	1
CO4	3	1	3	3	3	1
CO5	3	1	3	3	3	1
AVG	3	1	3	2.2	3	1.8

NE3251 ADAPTIVE SIGNAL PROCESSING TECHNIQUES L T P C
3 0 0 3

UNIT I DISCRETE RANDOM SIGNAL PROCESSING 9

Discrete Random Processes, Random variables, Parseval's theorem, Wiener-Khintchine relation, Power Spectral Density, Spectral factorization, Filtering Random Processes, Special types of Random Processes.

UNIT II SPECTRAL ESTIMATION 9

Introduction, Nonparametric methods – Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods – ARMA, AR and MA model based spectral estimation, Solution using Levinson-Durbin algorithm.

UNIT III WEINER AND ADAPTIVE FILTERS 9

Weiner Filter: FIR wiener filter, IIR wiener filter, Adaptive Filter: FIR adaptive filters – Steepest descent method- LMS algorithm, RLS adaptive algorithm, Applications.

UNIT IV DETECTION AND ESTIMATION 9

Bayes detection techniques, MAP, ML – detection of M-ary signals, Neyman Peason, minimax decision criteria. Kalman filter- Discrete Kalman filter, The Extended kalman filter, Application.

UNIT V SYNCHRONIZATION 9

Signal parameter estimation, carrier phase estimation, symbol timing estimator, joint estimation of carrier phase and symbol timing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Analyze the basic principles of discrete random signal processing.
CO2: Analyze the principles of spectral estimation.
CO3: Analyze and design the Weiner and adaptive filters.
CO4: Analyze the different signal detection and estimation methods.
CO5: Design the synchronization methods for proper functioning of the system.

REFERENCES:

1. John G. Proakis., "Digital Communication", (2014), McGraw Hill Publication, 5th edition.
2. Simon Haykin, “Adaptive Filter Theory”, (2013), Pearson Education, 5th edition.
3. Paulo S. R. Diniz, “Adaptive Filtering Algorithms and Practical Implementation”, (2013), Springer,4th edition.
4. Monson H. Hayes, “Statistical Digital Signal Processing and Modeling”, (2009) John Wiley andSons, Inc, Singapore.

5. Kay Steven M, “Fundamentals of Statistical Processing: Estimation Theory Volume 1 and 2 (Estimation & detection Theory”, (1993) Pearson.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	2	1	1
CO2	3	1	2	2	1	1
CO3	3	1	2	2	1	1
CO4	3	1	2	2	1	2
CO5	3	1	2	2	1	2
AVG	3	1	2	2	1	1.4

WT3261 **WIRELESS TECHNOLOGY LABORATORY** **L T P C**
0 0 4 2

LIST OF EXPERIMENTS

1. Configure wireless router and wireless devices and create a wireless network. environment to verify transmission of data between device to wireless network.
2. Protocol analysis on the created wireless network (IEEE 802.11).
3. Packet analysis on the deployed wireless network (IEEE 802.11).
4. Network analysis of (IEEE 802.11) wireless network and observe hacking and attack information from the wireless network protocols.
5. Perform and measure the interactions between client and server communication on deployed network.
6. Validation of two server and two device configuration and communication under two different network.
7. Setting up a network and its configurations to measure a network service such as voice service over network.
8. Perform MITM attack to wireless network and observation of users information from an compromised user.
9. Create a hacking platform of an user OS and find possible attacks.
10. Hacking of an web page by an OS platform and observation of an compromised user details.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the functioning of various protocols in wireless environment.
CO2: Perform real-time experimentation using the existing infrastructure.
CO3: Get exposed to open source networking tools.
CO4: Gain knowledge in constructing WLAN, and VLAN
CO5: Design a network and verify new service

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	3	2	1	1
CO2	3	2	3	2	2	1
CO3	3	2	3	2	1	1
CO4	3	2	2	2	1	1

CO5	3	2	2	2	2	1
AVG	3	2	2.6	2	1.4	1

WT3001 PRINCIPLES OF NETWORK SECURITY L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Security Services and Mechanism, Mathematics of cryptography - integer arithmetic, modular arithmetic, Matrices, Linear congruence, algebraic structures ,GF(2^n), primes - Euler's phi & totient functions, Fermat's and Euler's theorem, primality testing, factorization, CRT, quadratic congruence, exponentiation and logarithm.

UNIT II SYMMETRIC KEY CRYPTOGRAPHY 9

Classical Cryptographic Techniques – Substitution Ciphers - Transposition Ciphers. Symmetric Encryption Principles- Feistel Cipher Structure. Block cipher: DES,AES. Stream cipher: RC4.Cipher Block Modes of Operation.

UNIT III ASYMMETRIC KEY CRYPTOGRAPHY 9

Asymmetric ciphers - RSA, ElGamal, rabin. Message Integrity, EntityAuthentication - Passwords, Challenge Response. Digital Signatures- RSA, ELGamal. Other Security Services - Message Integrity, EntityAuthentication - Passwords, Challenge Response.

Digital Signatures- RSA, ELGamal. User Authentication: Remote User-Authentication Principles, Remote User-Authentication Using Symmetric Encryption, Kerberos Systems, Remote User Authentication Using Asymmetric Encryption.

UNIT IV SYSTEM SECURITY 9

Firewalls and Intrusion Detection Systems: Intrusion Detection Password Management, Firewall Characteristics Types of Firewalls, Firewall Basing, Firewall Location and Configurations. Malicious Software: Viruses, Worms, System Corruption, Attack Agents, Information Theft - Keyloggers, Phishing, Spyware Payload Stealthing, Backdoors, Rootkits, Wireless Network Security: Mobile Device Security, IEEE 802.11i, Wireless LAN Security.

UNIT V SECURITY PROTOCOLS 9

Security Protocols: Security at the Application Layer- PGP and S/MIME, Security at Transport Layer- SSL and TLS, Security at Network Layer-IPSec. Advance - Blockchains, Cloud Security and IoT security. **TOTAL: 45 PERIODS**

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: To be able to learn the mathematics behind cryptographic Techniques.

CO2: To be able to understand the security mechanisms and security algorithms using symmetric key and asymmetric key.

CO3: To study the fundamental security protocols involved in network security.

CO4: To understand the system security with various security protection systems namely firewall and IDS.

CO5: To be able to analyze the various threats and vulnerabilities on internet

Attested

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REFERENCES:

1. The Network Security Test Lab: A Step-By-Step Guide, Michael Gregg, Dreamtech Press, 2015, ISBN-10:8126558148, ISBN-13: 978-8126558148.
2. Cryptography and Network Security: Principles and Practice, 6th Edition, William Stallings, 2014, Pearson, ISBN13:9780133354690.
3. Network Security, Firewalls And VPNs, J. Michael Stewart, Jones & Bartlett Learning, 2013, ISBN-10: 1284031675, ISBN-13: 978-1284031676.
4. Linux Firewalls, by Michael Rash, No Starch Press, October 2007, ISBN: 978-1-59327-141-1.
5. Linux iptables Pocket Reference, Gregor N. Purdy, O'Reilly, 2004, ISBN-13: 978-0596005696.
6. Network Security: Private Communications in a Public World, M. Speciner, R. Perlman, C. Kaufman, Prentice Hall, 2002.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	1	3	3	3
CO2	3	3	3	3	3	3
CO3	3	3	3	3	3	3
CO4	3	3	1	1	1	1
CO5	3	3	1	1	1	1
AVG	3	3	1.8	2.2	2.2	2.2

WT3002 OPTICAL AND WIRELINE TECHNOLOGY L T P C
3 0 0 3

UNIT I REVIEW OF OPTICAL FIBERS 9

Fibre Optic Guides, Light wave generation systems, systems components, optical fibers, SI, GI fibre, modes, Dispersion in fibers limitations due to dispersions, fibre loss, non-liner effects.

UNIT II OPTICAL TRANSMITTERS & RECEIVERS 9

Optical Transmitters, Basic concepts, spectral distribution, semiconductor lasers, gain coefficients, modes. Transmitter design, Receiver PIN and APD diodes, SNR. Optical Switches, Coherent, homodyne and Hetro dyne keying formats, BER in synchronous and Asynchronous schemes.

UNIT III COMPENSATION TECHNIQUES 9

Amplifiers, Basic concepts, Semiconductor laser amplifiers Raman and Brillouin-fibre amplifiers, Erbium doped-fibre and amplifiers, pumping phenomenon, Dispersion Compensation, Limitations, post and pre-compensation techniques, equalizing filters.

UNIT IV OPTICAL NETWORKS: ARCHITECTURES ANDPROTOCOLS 9

SONET/SDH PON Architectures, Network Dimensioning and operation, Power Budget, FTTx , Broadband PON: architecture, protocol and Service, Bandwidth allocation. Gigabit-Capable PON. Burst switching, Ethernet PON Architecture, 10GEPON PMD Architecture.

UNIT V WIRE LINE TECHNIQUES 9

Wire line Narrowband, XDSL, Wire line broad band, Very High Bit Rate Digital Subscriber Line (VDSL), Cable MODEM Home Networks, & VDSL Transmission Protocols. DOCSIS-Standards.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand optical transmission characteristics
CO2: Design optical transmitters and receivers
CO3: Use appropriate compensation techniques in a optical fiber link
CO4: Identify the architectures and protocols in PON
CO5:Apply wireline techniques in network design

REFERENCES:

1. G. P. Agarwal, “Fiber optic communication system”, John Wiley & sons, New York, 5th Edition, 2021.
2. G Keiser, “Optical fiber communication, system”, Tata McGraw Hill, New Delhi, 5th Edition,2013.
3. Franz and Jain, “Optical communication system”, Narosa Publications, New Delhi, 2013.
4. Dave Hood, Elmar Trojer, “Gigabit capable passive optic network”, John Wiley & sons,New Jersy 2012.
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.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	2	2	2
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	2.8	1	2.8	2.8	2.8	2.8

WT3003 SATELLITE COMMUNICATION SYSTEMS L T P C
3 0 0 3

UNIT I BASIC PRINCIPLES 9

General features- frequency allocation for satellite services- properties of satellite communication systems- Kepler's laws- orbital dynamics- orbital characteristics- satellite spacing and orbital capacity- GSO & LEO Satellites – Launch Vehicle Technology-GSLV.

UNIT II SATELLITE SUBSYSTEMS AND SATELLITE LINKS 9

Attitude and orbit control system- telemetry, tracking and command- power systems communication subsystems- antenna subsystem- equipment reliability and space qualification. Free space loss- Atmospheric effects- Ionospheric scintillation-link design- Power Budget Calculation -system noise temperature — Modulation for satellite communication

UNIT III MOBILE SATELLITE NETWORK 9

GSM signaling and S-PCN signaling protocol architecture, Mobility management-cell location, location management, handover management. Resource Management- Resource allocation strategies, Network operation and procedures

UNIT IV ANTENNAS AND MOBILE TERMINALS 9

Antennas for MSS, Architecture of Hand held, Vehicle mounted, Ship borne, Aeronautical terminals, CODECS for Mobile Satellite Communication.

UNIT V APPLICATIONS 9

GPS, Mobile satellite system for UMTS, GSM/EDGE, MOBILE IP, WLAN, Global Broadband services, ATM, GEO and Non GEO Mobile satellite systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the principles of satellite system
CO2: Design satellite subsystems and satellite link.
CO3: Design mobile satellite network
CO4: Design new antenna architecture for satellite system
CO5: Develop new applications in the field of mobile satellite

REFERENCES:

1. Wilbur L Pritchard, Henri G Suyderhoud, “Satellite Communication Systems Engineering”, 2nd Edition, Pearson 2013.
2. Tri T.Ha “Digital Satellite Communications”, Tata McGraw Hill, 1st Reprint, 2nd Edition, 2012.
3. Timothy Pratt, Chareless Bostian, “Satellite Communications”, Wiley, 2nd Edition, 2010.
4. Dennis Roddy “Satellite Communication”, Tata McGraw-Hill, 4th Edition, 2009.
5. Ray E. Sheriff and Y. Fun Hu, “Mobile Satellite communication Networks,” John Wiley & Sons, 2008.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	3	2	2
CO2	2	1	3	3	2	2
CO3	3	1	2	2	3	3
CO4	3	1	3	3	2	2
CO5	2	1	2	2	3	3
AVG	2.4	1	2.4	2.6	2.4	2.4

WT3004 MODELING AND SIMULATION OF WIRELESS COMMUNICATION SYSTEMS

L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Role of Simulation: Examples of complexity- multi disciplinary aspects of simulation - models - deterministic and stochastic simulations; simulation sampling frequency-low pass simulation models for band pass — low pass complex envelope for band pass signals -linear band pass systems- multi carrier signals-non linear and time - varying systems.

UNIT II GENERATING AND PROCESSING RANDOM SIGNALS 9

Stationary and Ergodic Processes: Uniform random number generators - mapping uniform RVs to an arbitrary PDF - generating uncorrelated Gaussian random numbers - generating correlated Gaussian random numbers - PN sequence generators; Establishing a PDF and a PSD Post

Processing: Basic graphical techniques - estimation - coding.

UNIT III METHODOLOGY FOR SIMULATING A WIRELESS SYSTEM 9

Monte Carlo Simulation Fundamental Concepts: Applications and integration - two Monte Carlo examples; Semi Analytic Techniques System: Level simplifications and sampling rate considerations - overall methodology; Modeling and Simulation of Nonlinearities: Introduction - modeling and simulation of memory less nonlinearities - modeling and simulation of nonlinearities with memory - techniques for solving nonlinear differential equations.

UNIT IV MODELING AND SIMULATION OF TIME-VARYING SYSTEMS 9

Introduction: Models for LTV systems - random process models - simulation models for LTV systems; Wired and guided wave - radio channels - multipath fading channels - modeling multipath fading channels; Random process models - simulation methodology; Discrete Channel Models: Discrete memory less channel models - Markov models for discrete channels with memory-example HMMs - Gilbert and Fritchman models - estimation of Markov model parameters.

UNIT V EFFICIENT SIMULATION TECHNIQUES 9

Tail Extrapolation: PDF estimators- importance sampling; Case study of a cellular radio system; Cellular radio system - simulation methodology - modeling co-channel interference - two example simulations; A code-division multiple access system - FDM system with a nonlinear satellite transponder - preprocessors for CDMA application.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Design various models for wireless communication.
CO2: Simulate various channels.
CO3: Simulations for various wireless communication technologies.
CO4: Choose appropriate simulation techniques to reduce run time.
CO5: Differentiate between wireless and wired systems with respect to simulationrequirements.

REFERENCES:

1. M. Law and W. David Kelton , “Simulation Modelling and Analysis”, McGraw Hill, fifth edition, 2014.
2. M. C. Jeruchim, Philip Balaban and K.Sam shanmugam. “Simulation of Communication Systems”, Plenum Press, second edition , 2012.
3. Banks, J. S. Carson, Nelson and D. M. Nicol, “Discrete Event System Simulation”, fifth Edition, Pearson, 2009.
4. William H. Tranter, K. Sam Shanmugan, Theodore S. Rappaport and Kurt L. Kosbar “Principles of Communication Systems Simulation with Wireless Applications”, Prentice Hall, Upper Saddle River, 2004.
5. K. Hayes, “Modelling and Analysis of Computer Communication Networks”,Plenum Press, 1984.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	2	3	2	1
CO2	2	1	2	2	1	1
CO3	2	1	3	3	2	1
CO4	2	1	3	3	1	1
CO5	1	1	2	2	2	1

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AVG	1.6	1	2.4	2.6	1.6	1

WT3052 **NETWORK ROUTING PROTOCOLS** **L T P C**
3 0 0 3

UNIT I INTRODUCTION TO ROUTING ALGORITHMS 9

Routing: Basics and Foundations – Addressing and Internet service an overview, IPv4 addressing, IPV6 addressing, Router architecture. Routing Algorithms: Bellman ford, distance vector approach, Dijikstra algorithm, shortest path computations with candidate path caching, widest path algorithm, Spanning tree, K-shortest path algorithms.

UNIT II ROUTING PROTOCOL 9

Routing protocols – routing algorithm, routing table, routing information representation and protocol messages, DSR, LSR, path vector routing protocol. Internet Routing Protocol – basics, static routes, RIP, IGRP, EIGRP, OSPF.

UNIT III MULTICAST ROUTING 9

Multicast IP addressing, IGMP, MLD, RPF, DVMRP, Multicast OSPF, protocol independent multicast. Inter domain multicast routing – BGMP, Multiprotocol Extension of BGMP.

UNIT IV ROUTING IN RESERVATION ORIENTED NETWORKS 9

Circuit switching, hierarchical call routing, dynamic routing, DNHR, DCR, DAR, RTNR, classification of dynamic call routing, QoS routing – attributes, adaptive shortest path and widest path routing, routing protocols for QoS routing.

UNIT V ROUTING IN GSTN AND VOIP 9

Signaling System : SS7 – protocol stack, call processing, call routing with single service provider and multiple service provider. VoIP – GSTN call routing using internet, managed IP approach. IP – GSTN internetworking for VoIP, IMS, All IP environments for VoIP services.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the various network routing algorithms.

CO2: Differentiate and design routing protocols of internet.

CO3: Design routing protocols for multicast transmission.

CO4: Understand routing protocols in reservation oriented networks

CO5: Analyze routing protocols of mobile network and VoIP network.

REFERENCES:

1. Deep Medhi, Karthik Ramasamy, “Network Routing: Algorithms, Protocols and Architecture”, Morgan Kaufmann publishers, 2nd Edition, 2018.
2. Jochen H.Schiller, “Mobile Communication”, Pearson Ed, 2nd Edition, 2014.
3. William Stallings, ”High speed networks and Internets Performance and Quality of Service", Pearson Education Asia. Reprint India, 2nd Edition, 2002.
4. S. Keshav, „An engineering approach to computer networking" Addison Wesley 1999.
5. M. Steen Strub, “Routing in Communication network, Prentice –Hall International, New york, 1995

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	1	1	2
CO2	3	1	2	1	1	1
CO3	3	1	2	2	2	1
CO4	3	1	2	2	2	1
CO5	3	1	2	2	2	1
AVG	3	1	2	1.6	1.6	1.2

WT3005 MULTIMEDIA COMPRESSION TECHNIQUES L T P C
3 0 0 3

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 Wavelet Based compression – Implementation using Filters – Vector Quantization- EZW, SPIHT coders – JPEG 2000 standards – JBIG and JBIG2 standards.

UNIT IV AUDIO COMPRESSION 9

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

UNIT V VIDEO COMPRESSION 9

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

TOTAL: **45 PERIODS**

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Analyze the pros and cons of different coding schemes
CO2: Design and implement text and image compression approaches.
CO3: Examine audio and video compression in real time environment
CO4: Design compression algorithms using MATLAB or equivalent open source software.
CO5: Analyze and apply the concepts of compression algorithms in multimedia applications

REFERENCES:

1. Khalid Sayood: Introduction to Data Compression", Morgan Kauffman Harcourt India, 5th Edition, 2017.

2. Mark S. Drew, Ze-Nian Li, “Fundamentals of Multimedia”, PHI, 2014.
3. David Solomon, “Data Compression – The Complete Reference”, Springer Verlog, New York, 2010.
4. Yun Q.Shi, Huifang Sun, “Image and Video Compression for Multimedia Engineering, Algorithms and Fundamentals”, CRC Press, 2008.
5. Peter Symes : Digital Video Compression, McGraw Hill Pub., 2004.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	2	1	1
CO2	3	1	2	2	1	1
CO3	3	1	2	1	1	1
CO4	3	1	2	1	1	1
CO5	3	1	2	1	1	1
AVG	3	1	2	1.4	1	1

WT3006 MICRO ELECTRO MECHANICAL SYSTEM FOR WIRELESS COMMUNICATION

L T P C
3 0 0 3

UNIT I FUNDAMENTALS & SWITCHES 9

Micromachining- Bulk micromachining, Surface Micromachining, LIGA Process, RF MEMS relays and switches. Switch parameters. Actuation mechanisms. Bistable relays and micro actuators. Dynamics of switching operation.

UNIT II TUNNABLE MEMS 9

MEMS inductors and capacitors. Micromachined inductor. Effect of inductor layout. Modeling and design issues of planar inductor. Gap tuning and area tuning capacitors. Dielectric tunable capacitors.

UNIT III FILTERS 9

Micromachined RF filters. Modeling of mechanical filters. Electrostatic comb drive. Micromechanical filters using comb drives. Electrostatic coupled beam structures.

UNIT IV MEMS DEVICES 9

MEMS phase shifters. Types. Limitations. Switched delay lines. Micro machined transmission lines. Co planar lines. Micro machined directional coupler and mixer.

UNIT V MICROMACHINED ANTENNA 9

Micro machined antennas. Microstrip antennas – design parameters. Micromachining to improve performance. Reconfigurable antennas.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the fabrication techniques in MEMS technology.
CO2: Analyze different type of MEMS based devices, circuits andsubsystems.
CO3: Demonstrate an understanding of the different aspects ofmicrosystem design.
CO4: capable of applying his knowledge and design tools and will be wellpracticed in design

skills.

CO5: Solve the integration issues in mechanical and electricalmicrosystem components.

REFERENCES:

1. Varadan, V. K., Jose, K. A., Vinoy, Kalarickaparambil Joseph, "RF MEMS and their Applications", Chichester, England ; Hoboken, NJ : John Wiley, 2014.
2. G.M.Rebeiz , RF MEMS Theory , Design and Technology, wiley , 2013.
3. Marc Madou, "Fundamentals of Microfabrication" , CRC Press, 1st Ed.2007.
4. H.J.D.Santos, RF MEMS Circuit Design for Wireless Communications, Artech House, 2002.
5. Stephen D. Senturia, "Microsystem Design", Kluwer Academic Publishers, 1st Ed., 2001.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	3	1	3	2
CO2	1	2	1	1	2	3
CO3	1	1	2	2	2	1
CO4	2	2	1	2	1	2
CO5	2	1	3	1	1	3
AVG	1.4	1.4	2	1.4	1.8	2.2

WT3007 GLOBAL POSITIONING SYSTEMS L T P C
3 0 0 3

UNIT I GPS FUNDAMENTALS 9

History of GPS – BC-4 System – HIRAN – NNSS – NAVSTAR GLONASS and GNSS Systems – GPS Constellation – Space Segment – Control Segment – User Segment – Single and Dual Frequency – Point – Relative – Differential GPS – Static and Kinematic Positioning – 2D and 3D –reporting Anti Spoofing (AS); Selective Availability (SA) – DOP Factors.

UNIT II CO-ORDINATE SYSTEM AND SATELLITE MOTION 9

Coordinate Systems – Geo Centric Coordinate System – Conventional Terrestrial Reference System – Orbit Description – Keplerian Orbit – Kepler Elements – Satellite Visibility – TopocentricMotion – Disturbed Satellite Motion – Perturbed Motion – Disturbing Accelerations - Perturbed Orbit — Time Systems — Astronomical Time System — Atomic Time — GPS Time — Need forCoordination – Link to Earth Rotation – Time and Earth Motion Services.

UNIT III TRACKING TECHNIQUES 9

C/A code; P-code; Y-code; L1, L2 Carrier frequencies – Code Pseudo Ranges – Carries Phases –Pseudo Ranges – Satellite Signal Signature – Navigation Messages and Formats – Un differenced and Differenced Range Models – Delta Ranges – Signal Processing and Processing Techniques – Tracking Networks — Ephemerides — Data Combination: Narrow Lane; Wide Lane — OTF Ambiguity.

UNIT IV ATMOSPHERIC EFFECTS 9

Propagation Media – Multipath – Antenna Phase Centre – Atmosphere in brief – Elements of Wave Propagation – Ionospheric Effects on GPS Observations – Code Delay – Phase Advances –Integer Bias – Clock Error – Cycle Slip – Noise-Bias – Blunders – Tropospheric Effects on GPS Oberservables – Multipath Effect – Antenna Phase Centre Problems and

Correction.

UNIT V APPLICATION **9**

Inner Disciplinary Applications – Crystal Dynamics – Gravity Field Mapping – Atmospheric Occulation – Surveying – Geophysics – Air borne GPS – Ground Transportation – Space borne GPS – Metrological and Climate Research using GPS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Design GPS and ability to comprehend and appreciate the significance and role of this course in the present contemporary world

CO2: Explain the necessity for GPS, the essential elements involved and the transmission methodologies

CO3: Analyze the fundamentals of coordinate systems, different interferences and attenuation mechanisms affecting the satellite motion

CO4: Demonstrate an understanding the necessity for GPS, the essential elements involved andthe transmission methodologies

CO5: Demonstrate an understanding the environmental factors involved in the design of GPS andthe different application scenarios and their implementation.

REFERENCES:

1. Guochang, Xu, “GPS Theory, Algorithms and Applications”, Springer, 2nd Edition Springer-Verlag Berlin Heidelberg, 3rd edition, 2016
2. A.Leick, "GPS Satellites Surveying", John Wiley & Sons, NewYork, 4th Edition, 2015
3. B.Hoffman - Wellenhof, H.Lichtenegger and J.Collins, "GPS: Theory and Practice", Springer, Wein, New york, 5th revised Edition, 2003
4. A.Kleusberg and P.Teunisen(Eds), “GPS for Geodesy”, Springer-Verlag, Berlin,1996
5. L.Adams, "The GPS - A Shared National Asset”, Chair, National Academy Press, Washington, DC, 1995

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	1	3	3	2
CO2	2	1	3	3	3	1
CO3	3	1	3	3	3	2
CO4	2	1	3	3	3	1
CO5	2	1	2	1	2	2
AVG	2.4	1	2.4	2.6	2.8	1.6

WT3008 MULTIRATE SIGNAL PROCESSING FOR COMMUNICATION **L T P C**
3 0 0 3

UNIT I DECIMATION AND INTERPOLATION **9**

Introduction – Representation of discrete signals – Down Sampling - Up Sampling - Decimation with transversal filters – Interpolation with transversal filters.

UNIT II DECIMATION WITH POLYPHASE FILTERS **9**

Interpolation with polyphase filters – Decimation and Interpolation with Rational sampling factors - Multistage implementations of decimators and interpolators.

UNIT III TWO CHANNEL FILTER BANKS 9

Analysis and synthesis filter banks – Quadrature mirror filter banks – Filter banks with perfect reconstruction – Paraunitary filter banks – Biorthogonal and linear phase filter banks – Transmuliplexer filter banks

UNIT IV UNIFORM M-CHANNEL FIILTER BANKS 9

Filter banks with tree structure – Filter banks with parallel structure – complex modulated filter banks –cosine modulated filter banks – Transmultiplexer filter banks.

UNIT V APPLICATIONS 9

Digital Audio Systems – Sub band coding of speech and image signals – Analog Voice privacy System – Timing recovery in a digital demodulator – FM Receiver and Demodulator.

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the concepts of multirate signal processing
CO2: Implement polyphase filters.
CO3: Design various filter banks.
CO4: Design complex M channel filter banks.
CO5: Design speech/ audio systems related applications.

REFERENCES:

1. Proakis J G and Manolakis D G, "Digital Signal Processing Principles, Algorithms and Applications", Pearson, 5th Edition, 2021.
2. Li Tan and Jean Jiang "Digital Signal Processing: Fundamentals and Applications", 2nd Edition, academic press, 2013,
3. Sanjit K Mitra , "Digital Signal Processing: A Computer-Based Approach", McGraw Hill Education, 4th Edition, 2013
4. Fliege N J, "Multirate Digital Signal Processing: Multirate Systems - Filter Banks - Wavelets ", John Wiley and sons, 2000.
5. Fredric J Harris "Multirate Signal Processing for Communication Systems" Pearson Education, 3rd Edition, 2009.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1
AVG	3	1	3	3	2	1

WT3058 SIGNAL INTEGRITY FOR HIGH SPEED ELECTRONIC SYSTEMS L T P C
3 0 0 3

UNIT I FUNDAMENTALS OF ELECTROMAGNETICS 9

The Basics - Maxwell's Equations, Common Vector Operators - Wave Propagations - Electrostatics - Magneto statics - Power flow and the Poynting Vector - Reflections of Electromagnetic Waves.

UNIT II CROSS TALK AND NONIDEAL CONDUCTOR MODELS 9

Mutual Inductance and Capacitance - Coupled Wave Equations - Coupled Line Analysis - Modal Analysis - Crosstalk Minimization - Signals Propagation in Unbounded Conductive Media - Classic Conductor Model for Transmission models.

UNIT III DIELECTRIC MATERIALS 9

Polarization of Dielectrics - Classification of Dielectric Materials - Frequency Dependent Dielectric Behavior - Fiber Weave Effect - Environmental Variation in Dielectric Behavior Transmission Line Parameters for Lossy Dielectrics and Realistic Conductors.

UNIT IV DIFFERENTIAL SIGNALING 9

Removal of Common Mode Noise - Differential Crosstalk - Virtual Reference Plane - Propagation of Modal Voltages - Common Terminology - Drawbacks of Differential Signaling.

UNIT V CHANNEL AND I/O CIRCUITS MODELLING 9

Creating a Physical Transmission Line Model - Non idea Return Paths - I/O Design Considerations - Push-Pull Transmitters - CMOS Receivers - ESD Protection Circuits - On Chip Termination - Bergeron Diagrams.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the fundamental concepts of signal integrity in high speed PCBs.
CO2: Identify and resolve crosstalk.
CO3: Interpret the frequency dependence of dielectrics
CO4: Analyze the design considerations in I/O circuits.
CO5: Comprehend transmission line model.

REFERENCES:

1. Stephen H. Hall, Howard L. Heck, “Advanced Signal Integrity for High-Speed Digital Designs”, Second Edition, John Wiley and Sons, 2009.
2. Mike Peng Li, “Jitter, Noise, and Signal Integrity at High-Speed”, First Edition, Prentice Hall, 2007.
3. Douglas Brooks, Signal Integrity Issues and Printed Circuit Board Design, First Edition, Prentice Hall PTR, 2003.
4. James Edgar Buchanan, “Signal and power integrity in digital systems: TTL, CMOS, and BiCMOS”, Second Edition, McGraw-Hill, 1996.
5. H. W. Johnson and M. Graham, “High-Speed Digital Design: A Handbook of Black Magic”, Second Edition, Prentice Hall, 1993.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	1	1	1	1
CO2	3	1	1	1	1	1
CO3	3	1	2	1	1	1
CO4	3	1	3	3	1	1
CO5	3	1	1	3	1	1
AVG	3	1	1.6	1.8	1	1

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NE3057 **IoT AND APPLICATIONS** **L T P C**
3 0 0 3

UNIT I INTRODUCTION AND APPLICATIONS 9

Introduction to IoT – Definition, Characteristics, functional requirements, motivation, Physical design - things in IoT, IoT protocols, Logical Design - functional blocks, communication models, Communication APIs, Applications – Home Automation, Cities, Environment, Energy, Agriculture, Health, Industry.

UNIT II IoT DESIGN & SYSTEM MANAGEMENT 9

IoT &M2M – Machine to Machine, Difference between IoT & M2M, Software Defined Network, Network function virtualization, IoT system management – SNMP, NETCONF, YANG, IoT Design methodology.

UNIT III IoT PROTOCOLS & SYSTEM 9

Protocols – HTTP, UPnP, CoAP, MQTT, XMPP. IoT systems logical design using python - python data types & data structures, control flow, functions or modules. Modules & package of python, python packages of interest for IoT-JSON, XML, HTTP & URL Lib, SMTP Lib. Exemplary Device: Raspberry Pi - Linux on Raspberry Pi – Programming Raspberry Pi with Python.

UNIT IV IoT CLOUD & DATA ANALYTICS 9

Introduction to Cloud storage Models – WAMP – Xively Cloud for IoT – Python Web Application Framework- Django – Designing a RESTful based Web API. Data Analytics for IoT – Apache Hadoop, Apache Oozie.

UNIT V IoT SECURITY 9

IoT attacks - Phase attacks, Attacks as per architecture, Attacks based on components. Security Protocols - Time-Based Secure Key Generation and Renewal - Security access algorithms for unidirectional data transmissions, Security access algorithms for bidirectional data transmissions.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Interpret the vision of IoT from a global context.
CO2: Compare and Contrast the use of Devices, Gateways and Data Management in IoT.
CO3: Design a portable IoT using any Single Board Computer and relevant protocols
CO4: Analyze applications of IoT in real time scenario
CO5: Deploy an IoT application and connect to the cloud.

REFERENCES:

1. Qusay F, Hassan, Atta Ur Rehman Khan and Sajjad A.Madani, “Internet of Things – Challenges, Advances and Applications” , CRC Press, Taylor & Francis Group, 2019
2. Olivier Hersent, David Boswarthick, and Omar Elloumi, “The Internet of Things – Key Applications and Protocols”, City Press, Delhi, 2017.
3. Fei Hu, “Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations,” 1st Edition, CRC Press, 2016.
4. Arshdeep Bahga, Vijay Madisetti, "Internet of Things - A hand on approach” ,Universities Press (India) Private Limited, 2014.
5. William Stallings, Lawrie Brown, “Computer Security: Principles and Practice”, Pearson, 3 rd Edition, 2014.

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	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	2
CO2	3	1	3	1	1	1
CO3	3	1	3	2	2	1
CO4	3	1	3	2	2	1
CO5	3	1	3	2	2	1
AVG	3	1	3	1.6	1.6	1.2

VE3051 **REAL TIME SYSTEMS** **L T P C**
3 0 0 3

UNIT I EMBEDDED DESIGN PROCESS AND HARDWARE COMPONENTS 9

Complex Systems and RISC processors - Embedded System Design Process - Formalism for System Design - CPU - CPU Bus- CPU performance-CPU Power Consumption - Memory System Mechanism–Configuring and Programming Input and Output Peripherals - Supervisor Mode, Exceptions and Traps -Coprocessors.

UNIT II SOFTWARE TOOLS AND EMBEDDED C PROGRAMMING 9

Compilation process - Native vs Cross-Compilers - Run-time libraries - Writing a library - Using Standard and alternative libraries - Porting Kernels –Techniques for Emulation and Debugging – Embedded C Program Structure– Data types - Operators, expressions and control statements – Functions and Procedures -Structures and union.

UNIT III ARMPROCESSOR 9

ARM features and architecture–Development Tools–ARM Instruction set-Thumb Instruction set– Architectural Support for System Development and operating systems.

UNIT IV REAL TIME OPERATING SYSTEM 9

Concurrent Software – Foreground/Background systems, Multithreaded Programming, Shared resources and Critical sections – Scheduling – Cyclic, Round-Robin, Priority based, Deadline driven and Rate Monotonic schedules – Memory Management – Shared Memory -Commercial operating systems.

UNIT V EMBEDDED SYSTEM DESIGN, MODELING AND VERIFICATION 9

Finite State Machines - Moore Machine - Mealy Machine - Nondeterministic Finite Automation - Programming - UML State Machines - Petri Net Definition -Properties - Timed Petri Nets - Model Checking-Temporal Logic-NuSMV Model Checking Tool-Real Time Computation Tree Logic-Practical Issues.

TOTAL:45 PERIODS

COURSEOUTCOMES:

CO1: To be able to explain about different hardware components and software development tools.
CO2:To be able to describe the features, architecture and instruction set of ARM processor.
CO3: To be able to detail the concept and usage of RTOS in Embedded applications.
CO4:To be able to apply the embedded system design process while building real-time applications.
CO5:To be able to design a real time embedded system.

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REFERENCES:

1. Daniel W. Lewis, "Fundamentals of Embedded Software with the ARM Cortex-M3",Pearson education limited,2nd Edition,2015.
2. Wayne Wolf, "Computers as Components-Principles of Embedded Computing System Design ",Morgan Kaufmann Publishers,2nd Edition,June2008.
3. Andrew N.Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide-Designing and Optimizing System Software", Morgan Kaufmann Publishers,2004.
4. Steve Heath, "Embedded Systems Design", Newnes Publications,2nd Edition,2003.
5. Steve Furber, “ARM system on chip architecture”, Pearson education limited, 2000.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	3	3	1	1	1
CO2	1	3	3	1	1	1
CO3	1	3	3	1	1	1
CO4	3	2	3	3	3	1
CO5	3	2	3	3	3	1
Avg	1.8	2.6	3	1.8	1.8	1

NE3055 GAME THEORY FOR COMMUNICATION AND NETWORKING L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction to theory of games- conflict, strategy, utility theory, games in extensive and normal forms, Examples.

UNIT II NON CO-OPERATIVE GAMES 9

Basics of Non-Cooperative games, Non-Cooperative games in strategic form – Matrix games, Nash Equilibrium, Mixed Strategies. Dynamic Non-Cooperative games – Non-Cooperative game in extensive form, repeated games, and stochastic games.

UNIT III COOPERATIVE GAMES 9

Basics of Cooperative games, bargaining theory – Introduction, Nash bargaining solution, Coalition game theory – shape value, Dynamic Coalition formation algorithms.

UNIT IV BAYESIAN GAMES 9

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

UNIT V GAME THEORY APPLICATIONS IN COMMUNICATION AND NETWORKING 9

Cellular & Broadband wireless access networks – Routing & Resource allocation, Power allocation, Network selection in Multi-technology, Game theoretic solutions for cooperation in ad hoc networks. Power Allocation Games and Learning in MIMO Multiuser Channels.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO 1: Explain the Game Theory models

CO 2: Classify and design strategies under Game Theory perspective
CO 3: Analyze the interaction of competitors in an imperfect market and its consequences in the short and long run.
CO 4: Make use of game theory concepts in communication and networking
CO 5: Interpret uncertainty and asymmetric information in the communication and networking field

REFERENCES:

1. Dixit, A. K., & Skeath, S. Games of Strategy: Fourth International Student Edition. WW Norton & Company, 2015.
2. Zhu Han, Dusit Niyato, Walid Saad, Tamer Basar, Are Hjorungnes, “Game Theory in Wireless and Communication Networks: Theory, Models, and Applications”, University PressCambridge, 1st Edition, 2012.
3. Samson Lasaulce and Hamidou Tembine “Game Theory and Learning for Wireless Networks” Fundamentals and Applications, 2011.
4. Vijay Krishna, "Auction Theory", Academic Press, 2010.
5. Martin J. Osborne, “An Introduction to Game Theory”, Oxford Press, 2006.
6. Allan MacKenzie, Luiz DaSilva, "Game Theory for Wireless Engineers, Synthesis Lectureson Communication", Morgan and Claypool Publishers, 2006.
7. Drew Fudenberg and Jean Tirole, "Game Theory", MIT Press, 1991.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	2	2	1
CO2	3	1	3	3	3	1
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	3	1	3	2.8	2.8	2.2

NE3059 WIRELESS PERSONAL AREA COMMUNICATION NETWORKS L T P C
3 0 0 3

UNIT I NETWORK INTERCONNECTION 9

Inter connection of networks- Interconnection issues, Interconnection devices: - Repeaters, Routers and Gateways. Internet protocols; IPV4, IPV6. Wireless Network Interconnection - Challenges and Issues address mobility, inefficiency of layers for wireless network inter connection - network layer, transport layer and application layer. mobile IP – simultaneous binding, route optimization, mobile IP variations, handoffs. TCP in wireless domain – TCP over wireless , TCPs -traditional, snoop, indirect, transaction- oriented, impact of mobility.

UNIT II PAN 9

Introduction to PAN - Bluetooth , Zigebee, Wireless Sensor Networks. WSN - MAC protocols – low duty cycle protocols and wakeup concepts, contention -based and Schedule-based protocols. WSN Routing protocols – Requirements, Classification -SPIN, LEACH, PEGASIS. Node and Network architecture, design principles.

UNIT III 6LOWPAN PROTOCOLS 9

6LoWPAN Architecture - protocol stack, Link layers – Addressing, BOOTSTRAPPING, MESH

topologies, Adaptation Layer - functions, assumptions in link layers, Header Compression - Stateless header compression - Context based header compression, Fragmentation and Reassembly , Forwarding and Routing - L2 forwarding - Mesh-Under - L3 Routing - Route-Over, Mobility and Routing - mobility types, solutions for mobility, mobile IPv6, Proxy Home Agent, Proxy MIPv6, Role of neighbor discovery.

UNIT IV INTER NETWORKING 9

3G Evolutions - Radio and Network Components -Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme - frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, SC-FDMA, interference cancellation – CoMP, Carrier aggregation, Services - multimedia broadcast/multicast, location-based services.

UNIT V OS FOR NETWORKS 9

IEEE 802.3 standard - Implementation , NIC card, protocols verifications - TinyOS – Introduction, NesC, Interfaces, modules, configuration, Programming in TinyOS using NesC, TOSSIM, CONTIKI OS – Structure, Communication Stack, Simulation environment – COOJA simulator, Programming.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1:Understand the network interconnection and heterogeneous network connection using internet protocol.

CO2: Find new design of the protocols for wireless network and wireless sensor network.

CO3: Develop protocols for resource constrained and low range networks.

CO4: Characterize and modeling the wireless channel

CO5: Implement network protocols on operating systems.

REFERENCES:

1. Jochen H.Schiller, “Mobile Communications”, 2/e, Pearson, 2014
2. Vijay K.Garg, “Wireless Network Evolution- 2G & 3G” Pearson, 2013.
3. Clint Smith,P.E, Dannel Collins, “3G Wireless Networks” 2nd edition, Tata McGraw-Hill, 2008.
4. Kaveh Pahlavan, “Principles of wireless networks”, Prentice-Hall of India, 2008.
5. Subir Kumar Sarkar, T G Basavaraju, C Puttamadappa, “Ad Hoc Mobile Wireless Networks”, Auerbach Publications, 2008
6. Holger Karl, Andreas Willig, “Protocols and Architectures for Wireless Sensor Networks”, John Wiley & Sons, Inc., 2005.
7. C.Siva Ram Murthy and B.S.Manoj, “Ad Hoc Wireless Networks – Architectures and Protocols”, Pearson Education, 2004.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	3	1	2	2	2
CO2	3	3	2	2	2	2
CO3	3	3	2	2	2	2
CO4	3	3	1	1	1	1
CO5	3	3	1	1	1	1
AVG	3	3	1.4	1.6	1.6	1.6

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NE3151 COGNITIVE RADIO COMMUNICATION AND NETWORKS L T P C
3 0 0 3

UNIT I SOFTWARE DEFINED RADIO 9

Introduction to SDR, Brief history of SDR, Networking and SDR, RF Architecture for SDR, Processing architectures for SDR, Software environments for SDR, Benefits of Using SDR, Problems Faced by SDR.

UNIT II COGNITIVE RADIO COMMUNICATION & NETWORKS 9

Cognitive Radio Communications: Cognitive Radios and Dynamic Spectrum Access, Analytical Approach and Algorithms for Dynamic Spectrum Access, Mathematical Models Toward Networking Cognitive Radios. Cognitive Radio Networks: CRN Architecture, Terminal Architecture of CRN, QoS Provisional Diversity Radio Access Networks. Radio XML coding for CRN

UNIT III SPECTRUM SENSING AND MANAGEMENT 9

Spectrum Sensing to Detect Specific Primary System : Conventional Spectrum Sensing, Power Control, Power Scaling, Cooperative Spectrum Sensing. Spectrum Sensing for Cognitive OFDMA Systems- Cognitive Cycle, Discrimination of States of the Primary System, Spectrum Sensing techniques - Energy detector, Matched filter, Feature detector. Spectrum Sensing for Cognitive Multi-Radio Networks : Multiple System Sensing, Radio Resource Sensing. Spectrum Management of CRN: Sharing, Pricing, Mobility Management of Heterogeneous Wireless Networks

UNIT IV USER COOPERATIVE COMMUNICATIONS 9

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

UNIT V APPLICATIONS OF COGNITIVE RADIO 9

Regulatory scenario for TV space, Dynamic spectrum access models. Overview of IEEE 802.22 standard - Applications, Reference architecture. IEEE 802.22 Physical layer, Medium access control layer, Spectrum sensing algorithms. Applications of Cognitive radio in IoT - Applications of Cognitive radio in 5G networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the basics of Software Defined Radio

CO2: Understand the fundamental concepts and architecture of cognitive radio communication and networks.

CO3: Evaluate different spectrum sensing mechanisms and management in cognitive radio communication and networks

CO4: Implementation of radio domain competence and formalizing radio knowledge using radio XML (RXML)

CO5: Explore various applications of cognitive radio systems in WRAN, IoT, 5G networks.

REFERENCES:

1. Travis F. Collins Robin Getz Di Pu Alexander M. Wyglinski ,"Software-Defined Radio for Engineers", Artech House Publishers; Unabridged edition, 2018.
2. Kwang-Cheng Chen, Ramjee Prasad, “Cognitive radio networks”, John Wiley & Sons Ltd., 2009.

3. Alexander M. Wyglinski, Maziar Nekovee , Thomas Hou, " Cognitive Radio Communications and Networks: Principles and Practice", Academic Press Inc; Illustrated edition, 2009.
4. Huseyin Arslan, “Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems”, Springer, 2007.
5. Joseph Mitola III, " Cognitive Radio Architecture: The Engineering Foundations of Radio XML", John Wiley & Sons, Inc., Hoboken, New Jersey, 2006.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	2	2	2
CO2	3	1	2	2	2	2
CO3	3	1	2	1	3	3
CO4	3	1	2	1	3	3
CO5	3	1	2	2	3	3
AVG	3	1	2	1.6	2.4	2.4

WT3053 PATTERN RECOGNITION AND MACHINE LEARNING L T P C
3 0 0 3

UNIT I BASICS OF PROBABILITY AND RANDOM PROCESS 9

Probability Theory - Conditional and Joint Probability - Expectation - Auto correlation - Cross Correlation - Eigen values - Eigen vectors - Decision Theory.

UNIT II DIMENSIONALITY REDUCTION 9

Introduction - Features, feature vectors - Feature selection and ranking - Discriminant functions - Fisher’s Discriminant analysis - Principal Component Analysis - Independent component analysis

UNIT III LEARNING MODELS 9

Linear models for Classification and Regression - Classifiers based on Bayes Decision theory – Naïve Bayes - Nearest neighbor rules - Mixture models - Mixture of Gaussian - Hidden Markov Model

UNIT IV ARTIFICIAL NEURAL NEWORKS 9

Supervised Learning - Unsupervised Learning- Reinforcement Learning – Feed Forward and Feedback architectures - Multilayer Perceptron - Backpropagation Algorithm- Radial Basis Function networks - Support vector Machines

UNIT V DEEP LEARNING NETWORKS 9

Introduction to Deep neural networks – Convolution neural networks – Deep Belief Networks - Recurrent neural networks- case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Employ different feature extraction and dimensionality reduction techniques
CO2: Design different learning models
CO3: Implement different neural network architectures
CO4: Realize basic Deep neural network architectures
CO5: Test and implement deep generative models for various data processing applications

REFERENCES:

1. Richard Szeliski, "Computer Vision - Algorithms and Applications", Springer Verlag London Limited, 2nd Edition, 2022.
2. Ethem Alpaydm, "Introduction to Machine Learning", The MIT Press, Cambridge, Fourth Edition, 2020.
3. Josh Patterson and Adam Gibson, "Deep Learning - A Practitioner's Approach", O'Reilly Media, Inc, 2017.
4. Kevin P. Murphy, "Machine Learning - A Probabilistic Perspective", The MIT Press, Cambridge, 2012.
5. Christopher M. Bishop,"Pattern Recognition and Machine Learning", Springer, 2011.
6. R.O. Duda, P.E. Hart and D.G. Stork, "Pattern Classification" John Wiley,2nd Edition, 2007.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	1	1	1	2	2	2
CO2	1	1	1	2	1	1
CO3	2	1	1	2	3	3
CO4	3	2	2	2	3	3
CO5	3	2	2	2	3	3
AVG	2	1.4	1.4	2	2.4	2.4

WT3060 **WIRELESS TRANSCEIVER DESIGN** **L T P C**
3 0 0 3

UNIT I FUNDAMENTALS OF SYSTEM DESIGN **9**

Linear systems and transformation, Non-linear system representation, Noise and Random process, elements of Digital base band system: Sampling, jitter, modulation techniques, pulse shaping, error probability detection.

UNIT II RADIO ARCHITECTURES AND DESIGN CONSIDERATIONS **9**

Super heterodyne architecture, direct conversion architecture, Low IF architecture, band-pass sampling radio architecture.

UNIT III RECEIVER SYSTEM ANALYSIS AND DESIGN **9**

Sensitivity and noise figure of receiver, intermodulation characteristics, single tone desensitization, adjacent channel selectivity and blocking characteristics, receiver dynamic range and AGC system, system design and performance evaluation.

UNIT IV TRANSMITTER SYSTEM ANALYSIS AND DESIGN **9**

Transmission power and spectrum, modulation accuracy, adjacent and alternate channel power, noise emission.

UNIT V CASE STUDY **9**

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

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TOTAL: 45 PERIODS

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COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Apply knowledge in transceiver design
CO2: Understand the receiver architecture
CO3: Analyze the system parameters in receiver
CO4: Understand the transmitter system design
CO5: Apply design techniques in the RF transceivers

REFERENCES:

1. Ariel Luzzatto, MottiHaridim. "Wireless Transceiver Design: Mastering the Design of Modern Wireless Equipment and Systems" Wiley, 2nd Edition, 2016.
2. Qizheng Gu, "RF System Design of Transceivers for Wireless Communications",Springer, 2005.
3. Kai Chang , RF and Microwave Wireless Systems, John Wiley, 2004.
4. K P Pun, J E D Franca and C A Leme, "Circuit Design For Wireless Communications – Improved Techniques for Image Rejection in Wideband Quadrature Receivers", Springer, 2003.
5. Crols, Jan, Steyaert, Michiel, " CMOS Wireless Transceiver Design" , Springer, 1 st Edition, 2003

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	2
CO2	3	1	3	1	1	2
CO3	3	1	3	3	2	1
CO4	3	1	3	3	2	1
CO5	3	1	3	3	2	1
AVG	3	1	3	2.2	1.6	1.4

WT3009 **VLSI DESIGN TECHNIQUES** **L T P C**
3 0 0 3

UNIT I MOS TRANSISTOR PRINCIPLES 9

MOS Technology and VLSI, CMOS Fabrication process and Electrical properties of CMOS circuits – secondary effects – device modeling – process variations – static and dynamic behavior of CMOS inverter – power and energy – scaling principles – stick diagram.

UNIT II COMBINATIONAL LOGIC CIRCUITS 9

Static CMOS logic design - Complementary CMOS – Ratioed logic – Pass transistor Logic. Dynamic CMOS logic — principles — speed and power dissipation — signal integrity issues — cascading dynamic gates.

UNIT III SEQUENTIAL LOGIC CIRCUITS AND MEMORY ARRAYSTRUCTURES 9

Static and Dynamic Latches and Registers, Timing Issues, Pipelines, Clocking strategies, Memory core and peripheral circuitry, memory reliability and power dissipation. Case Studies: PLA, SRAM and NAND flash memories.

UNIT IV DESIGNING ARITHMETIC BUILDING BLOCKS & TESTING 9

Data paths - Architectures for Adders - Multipliers and Shifters, Test procedures, Need for

testing- Manufacturing test principles - Design for testability – Scan based test – built in self test – test pattern generation – fault models and faultsimulation.

UNIT V IMPLEMENTATION STRATEGIES 9

Full custom and semicustom design — cell based design — array based implementation -Programmable ASIC logic cells - Actel ACT - Xilinx LCA - Altera FLEX and MAX,complete ASIC flow using Backend tool and fabrication flow.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Able to familiarize the basics of VLSI design.
CO2: Able to design combinational logic circuits.
CO3: Able to design sequential logic and memory circuits.
CO4: Able to analyze the various design techniques involved in arithmetic building blocks.
CO5: Able to analyze the implementation strategies in circuit design.

REFERENCES:

1. N.Weste, D.M.Harris, “CMOS VLSI Design: Circuits and System Perspective”, Pearson, 4th Edition,2015.
2. R.Jacob Baker, Harry W.LI., David E.Boyee, “CMOS Circuit Design, Layout and Simulation”, 3rd EditionPrentice Hall of India, 2011.
3. N.Weste, K.Eshraghian, “Principles of CMOS VLSI DESIGN”, A system Perspective, second edition,Addision Wesley, 2010.
4. M.J. Smith, “Application specific integrated circuits”, Addisson Wesley, 2009.
5. A.Pucknell, Kamran Eshraghian, “BASIC VLSI DESIGN”, Prentice Hall of India, 3rd Edition,2007.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	1	1	2
CO2	3	1	2	1	1	1
CO3	3	1	2	2	2	1
CO4	3	1	2	2	2	1
CO5	3	1	2	2	2	1
AVG	3	1	2	1.6	1.6	1.2

NE3051 ANTENNA FOR 5G AND 6G COMMUNICATION L T P C
3 0 0 3

UNIT I INTRODUCTION 9

5G Mobile Communication, spectrum, 5G antenna design considerations, Antenna integration with RFIC, Sub-6GHz 5G antennas, mm wave 5G antennas, Frequency reconfigurable multi band antenna, 6G spectrum, 6G antenna specifications, mm wave antennas, THz antennas, Lens antennas.

UNIT II ANTENNA FOR 5G MOBILE TERMINAL 9

Antenna for cellular communications, antenna for mobile terminal, requirements for mobile antenna, Wide band antenna for 5G mobile terminal, CPW feed antenna, CPW feed antenna with reflector, Wide band high gain antenna for mm wave 5G, Flexible antenna for 5G, Patch antenna, slot antenna and Vivaldi antenna.

UNIT III ANTENNA FOR 5G BASE STATIONS 9

Antenna for 5G base stations, mm wave tapered slot antenna, dielectric and metamaterial loaded tapered slot antenna, diversity antenna with radome, 3D radome for patch antenna, high aperture efficiency antenna, shared aperture antenna for base station, pattern diversity.

UNIT IV ANTENNA ARRAY FOR 5G AND 6G 9

5G requirement of antenna arrays, array characteristics, integration and Antenna-in Package, 6G antenna requirements, digital beamforming, hybrid beam forming, mm wave beam forming networks.

UNIT V ANTENNA ARRAY- TYPES AND TECHNIQUES 9

Decoupling methods- Electromagnetic Band Gap, Defected Ground Surface, neutralization lines, metamaterial, Polarization decoupling. Type of antenna arrays-differential feed, linear and circularly polarized differential antennas, conformal transmit arrays, multi beam transmit array.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Apply knowledge in 5G antenna design
CO2: Understand the design requirements of 5G and 6G antennas
CO3: Analyze the characteristics of antenna array
CO4: Understand the beamforming technique
CO5: Apply design techniques in the 5G and 6G mobile and base station antennas

REFERENCES:

1. Shiban Kishen Koul and G S Karthikaya, Millimater Wave antennas for 5G mobile terminals and base stations, CRC Press, 2021.
2. Yingjie Jay Guo, Richard W. Ziolkowski, Advanced Antenna Array Engineering for 6G and Beyond Wireless Communications, Wiley-IEEE press, 2022.
3. Qammer H. Abbasi, Syeda Fizzah Jilani,Akram Alomainy, Muhammad Ali Imran, Antenna and Propagation for 5G and beyond, IET,2020.
4. Paul RP Hoole, Smart Antennas and Electromagnetic Signal Processing in Advanced Wireless Technology, River Publishers,2020.
5. Mohammed Ali, Reconfigurable Antenna Design and Analysis, Artech House, 2021

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	3
CO2	3	1	3	1	1	1
CO3	3	1	3	2	3	1
CO4	3	1	3	2	3	1
CO5	3	1	3	2	3	1
AVG	3	1	3	1.6	2.2	1.4

NE3052 COMPUTATIONAL INTELLIGENCE L T P C
3 0 0 3

UNIT I NEURAL NETWORKS 9

Biological Neurons Networks - Artificial Neural Networks - Supervised - Unsupervised learning - Reinforcement Learning -Hebb learning- Perceptrons- Back Propagation networks -Radial Basis Function Networks-Adaptive Resonance architectures -Support Vector Machines

UNIT II FUZZY LOGIC 9

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

UNIT III NEURO-FUZZY MODELING 9

Adaptive Neuro-Fuzzy Inference Systems – Coactive Neuro-Fuzzy Modeling- Classification and Regression Trees-Data Clustering Algorithms-Hybrid learning Algorithms-Applications of Neuro -fuzzy concepts.

UNIT IV DEEP LEARNING NETWORKS 9

Introduction to Deep neural networks – Convolution neural networks – Deep Belief Networks-Recurrent neural networks – Case studies.

UNIT V EVOLUTIONARY ALGORITHMS 9

Heuristic search and optimization techniques – Introduction to Genetic Algorithms-Social Algorithms – Ant colony Optimization- Particle swarm Optimization - Case studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Design systems based on neural network architectures
CO2: Perform basic operations in fuzzy and design fuzzy systems
CO3: Implement neuro - fuzzy models for various applications
CO4: Design and implement deep learning architectures
CO5: Design optimization-based algorithm for various application

REFERENCES:

1. Lan Good fellow, Yoshua Bengio and Aaron Courville, “DeepLearning” The MIT Press, Cambridge,2016.
2. Jyh-ShingRogerJang,Chuen-TsaiSun,EijiMizutani,“Neuro-uzzy and Soft Computing”, Pearson Edn., 2015.
3. George J.Klir and BoYuan, “FuzzySetsand Fuzzy Logic-Theory and Applications”, Prentice Hall, 2011.
4. David E. Goldberg, “Genetic Algorithms in Search, Optimization and Machine Learning”, Pearson Education, 2008.
5. James A. Freeman and David M. Skapura, “Neural Networks Algorithms, Applications, and Programming Techniques”, Pearson Edn., 2003.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	2	3	1	1	1
CO2	3	2	3	1	1	1
CO3	3	2	3	2	2	2
CO4	3	2	3	2	3	3
CO5	3	2	3	2	3	3
AVG	3	2	3	1.6	2	2

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NE3054 ELECTROMAGNETIC INTERFERENCE AND ELECTROMAGNETIC COMPATIBILITY

L T P C
3 0 0 3

UNIT I EMI/EMC CONCEPTS **9**

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

UNIT II EMI COUPLING PRINCIPLES **9**

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

UNIT III EMI CONTROL TECHNIQUES **9**

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

UNIT IV EMC DESIGN OF PCBs **9**

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

UNIT V EMI MEASUREMENT AND STANDARDS **9**

EMI Measurements And Standards- Open area test site; TEM cell; EMI test shielded chamber and shielded ferrite lined anechoic chamber; Tx /Rx Antennas, Sensors, Injectors / Couplers, and coupling factors; EMI Rx and spectrum analyzer; Civilian standards-CISPR, FCC, IEC, EN; Military standardsMIL461E/462.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand EMI and susceptibility
CO2: Identify EMI coupling mechanisms
CO3: Use appropriate EMI control schemes in electronic systems
CO4: Design PCBs with EMC
CO5: Conduct EMI measurements according to standards.

REFERENCES:

1. C.R.Paul, ”Introduction to Electromagnetic Compatibility”, John Wiley and Sons, Inc, 3rd Edition, 2022
2. David A Weston,” Electromagnetic Compatibility — Methods, Analysis, circuits and measurements” CRC press, Boca raton 2017
3. Tim Williams, ”EMC for product designers” , Newness, 5th Edition, 2017.
4. Patrick G. Andre and Kenneth Wyatt,” EMI Troubleshooting Cookbook for Product Designers ,SciTech publishing, 2014
5. Henry W.Ott.,” Electromagnetic Compatibility Engineering, Revised edition, Wiley Black well Newyork, 2009.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	2	2	2
CO2	3	1	3	3	3	3

CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	2.8	1	2.8	2.8	2.8	2.8

WT3057 ULTRA WIDEBAND COMMUNICATION L T P C
3 0 0 3

UNIT I INTRODUCTION TO ULTRA-WIDEBAND 9

Introduction, UWB Modulation Options - UWB Signaling Techniques - Data Mapping - Spectral Characteristics - Data Mapping and Transceiver Complexity - Modulation Performances in Practical Conditions.

UNIT II ULTRA-WIDEBAND PULSE SHAPER DESIGN 9

Transmit Spectrum and Pulse Shaper - FIR Digital Pulse Design - Optimal UWB Single Pulse Design - Optimal UWB Orthogonal Pulse Design.

UNIT III ULTRA-WIDEBAND CHANNEL MODELING 9

Principles and Background of UWB Multipath Propagation Channel Modeling -Channel Sounding Techniques - UWB Statistical-Based Channel Modeling -Impact of UWB Channel on System Design - Potential Benefits of MIMO.

UNIT IV UWB TRANCEIVER DESIGN CONSIDERATIONS 9

System Model - UWB Receiver Related Issues - TH-IR-UWB Receiver Options. Multiple-Access Interference Mitigation at the Receiver Side - Multiple-Access Interference Mitigation at the Transmitter Side. Effect of NBI in UWB Systems - Avoiding NBI - Canceling NBI.

UNIT V MULTIBAND OFDM SYSTEM 9

Multiband Pulsed-OFDM UWB system. Medium Access Protocols - Network Applications. Multiple Access in UWB Sensor Systems - UWB Sensor Network Case Study -System Description-UWEN–Implementation - Location System - Position Calculation Methods. The 802.15.4 MAC Standard - Advanced MAC Design for Low-Bit-Rate UWB Networks

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Develop a comprehensive overview of UWB system design.
CO2: Understand the distinct UWB channel
CO3: Design UWB pulse shaper
CO4: Understand difference between UWB and legacy systems
CO5: Understand the future directions of UWB technology

REFERENCES:

1. Marian Verhelst and Wim Dehaene Energy Scalable Radio Design: for Pulsed UWBCommunication and Ranging (Analog Circuits and Signal Processing) , Springer, 2011.
2. Homayoun Nikcobar and Ramjee Prasad" Introduction to Ultra Wideband for Wireless Communications" Springer, 2009.
3. Huseyin Arsian, ZinNing Chen, "Ultra-Wide band Wireless Communication" Wiley, 2006.

4. Jeffrey H.Reed, “An Introduction to Ultra Wideband Communication Systems” Prentice Hall PTR, 2005.
5. Kayimierysiwiak and Debra mekown, “Ultra-Wideband Radio Technology”, John Willey & Sons, 2004.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	3
CO2	3	1	3	1	1	1
CO3	3	1	3	3	3	1
CO4	3	1	3	3	3	1
CO5	3	1	3	3	3	1
AVG	3	1	3	2.2	2.2	1.4

WT3051 ADVANCED WIRELESS COMMUNICATION TECHNIQUES L T P C
3 0 0 3

UNIT I COOPERATIVE COMMUNICATIONS 9

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

UNIT II COOPERATIVE TECHNIQUES 9

Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbo base stations; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying.

UNIT III RELAY-BASED COOPERATIVE CELLULAR NETWORKS 9

Distributed space-time block codes ; Collaborative relaying in downlink cellular systems ; Radio resource optimization; Adaptive resource allocation ; Cross-layer scheduling design for cooperative wireless two-way relay networks.

UNIT IV GREEN RADIO NETWORKS 9

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

UNIT V ACCESS TECHNIQUES FOR GREEN RADIO NETWORKS 9

Cross-layer design of adaptive packet scheduling for green radio networks; Energy-efficient relaying for cooperative cellular wireless networks ; Energy performance in TDD-CDMA multihop cellular networks ; Resource allocation for green communication in relay-based cellular networks .

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Appreciate the necessity and the design aspects of cooperative communication
CO2: Appreciate the necessity and the design aspects of cooperative base station techniques.
CO3: Evolve new techniques in relay-based cooperative networks
CO4: Appreciate green radio networks

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CO5: Identify the impact of the access techniques for green radio networks

REFERENCES:

1. Muhammad Ismail, Muhammad Zeeshan Shakir, Khalis A. Qaraqe, Erchin Serpedin, "Green Heterogeneous Wireless Networks", Wiley- IEEE Press, 2016.
2. Ekram Hossain, Vijay K. Bhargava (Editor), Gerhard P. Fettweis (Editor), “Green Radio Communication Networks”, Cambridge University Press, 2012.
3. F. Richard Yu, Yu, Zhang and Victor C. M. Leung “Green Communications and Networking”, CRC press, 2012.
4. Jinsong Wu, Sundeep Rangan and Honggang Zhang, “Green Communications: Theoretical Fundamentals, Algorithms and Applications”, CRC Press, 2012.
5. Ekram Hossain, Dong In Kim, Vijay K. Bhargava , “Cooperative Cellular Wireless Networks”, Cambridge University Press, 2011.
6. Ramjee Prasad and Shingo Ohmori, Dina Simunic, “Towards Green ICT”, River Publishers,2010.
7. Ahmed K. Sadek, Andres Kwasinski, K.J. Ray Liu, Weifeng Su,"Cooperative Communications and Networking", Cambridge University Press, Illustrated edition, 2008.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	2	1	1	1
CO2	2	1	2	1	1	1
CO3	3	1	2	3	1	1
CO4	2	1	2	2	1	2
CO5	2	1	2	2	2	2
AVG	2.4	1	2	1.8	1.2	1.4

WT3055 **RF IC DESIGN** **L T P C**
3 0 0 3

UNIT I COMPONENTS FOR RF IC **9**

Capacitance, Inductance, Circuit representations, Distributed and Lumped circuits, LC and RLC circuits, Antennas, Integrated capacitors, Integrated inductors, plane waves, Antennas.

UNIT II LOW NOISE AMPLIFIERS **9**

Types of Noise, Two port Equivalent Noise, Noise figure, Minimum NF,Noise figure of cascade of stages, CS and CG LNA, series and shunt feedback LNA,, Feed forward LNA,s, LNA power noise optimization, LNA design case study.

UNIT III POWER AMPLIFIER DESIGN **9**

Small and Large signal Non linearities, Class A, B, C, D, E and F amplifiers, Class D Digital power amplifiers, Linearization Techniques, RF power amplifier design example.

UNIT IV PLL, FREQUENCY SYNTHESIZERS AND OSCILLATORS **9**

PLL basics, Type I – PLL, Type – II PLL, Integer N frequency synthesizers, Fractional N frequency Synthesizers, Frequency divides, Digital PLLs. Ring oscillators, Quadrature Oscillators, Crystal and FBAR Oscillators

Attested

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

UNIT V SYSTEM ARCHITECUTRE 9

Analog Linear modulation, on linear Modulation, Modern radio modulation, SSB receivers, Receiver architectures, Blocker tolerant receivers, Receiver filtering and AGC design, Transmitter architectures, Transceiver design considerations.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Analyze the RF integrated circuits
CO2: Design low noise amplifiers
CO3: Design power amplifiers
CO4: Design PLL and frequency synthesizers
CO5: Develop RF transceivers and its building blocks

REFERENCES:

1. Hooman Darabi," Radio Frequency Integrated Circuits and Systems", Cambridge University Press, Cambridge, 2020.
2. Cam Nguyen," Radio frequency integrated circuit Engineering", John Wiley, New Jersy,2015.
3. Matthew M.Radmanesh "RF and Microwave Design Essentials", AuthorHouse, Bloomington,2007.
4. Thomas Lee, "The Design of Radio Frequency CMOS Integrated Circuits", Cambridge UniversityPress, 2nd Edition, Cambridge, 2004.
5. John W.M.Rogers and Calvin Plett, "Radio Frequency Integrated Circuit Design", 2nd Edition, Artech House, Norwood, 2010.

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

WT3054 RADIO OVER FIBER FOR 5G NETWORKS L T P C
3 0 0 3

UNIT I INTRODUCTION 9

Introduction to Radio over fiber (RoF), figure of merit and performance of RoF link, gain and frequency response, noise figure, distortion in RF links, directly modulated optical links, RF subcarrier link for local access networks, 5G oriented optical networks

UNIT II RADIO OVER FIBER LINKS 9

Fi-Wi link, Importance of Fi-Wi link elements, power link budget, signal to noise ratio, relative intensity noise, improved expression for relative intensity noise, subcarrier multiplexed RoF link, down link and uplink, externallay modulated RoF links.

UNIT III ANALYSIS OF FIBER-WIRELESS CHANNEL 9

RoF channel modelling, nonlinearity, DSP modelling of RoF link nonlinearity, adaptive compensation

techniques, joint estimation of Fi-Wi channel, joint equalization of Fi-Wi channel, performance evaluation, multiuser CDMA systems, Fi-Wi for 5G wireless networks.

UNIT IV OPTICAL TECHNOLOGIES FOR 5G NETWORKS 9

Analysis of analog fiber optic link, digital RoF links, convergence of optical and wireless technologies in 5G, common fiber system- RoF and PON, GPON and EPON architecture, D-RoF transmission in PON systems, mobile front haul for D-RoF transmission.

UNIT V BROADBAND ROF FOR WIRELESS NETWORKS 9

Broadband optical millimeter wave generation, broad band millimeter wave detection in RoF, Digital signal processing for RoF systems, broadband mm wave delivery, long distance mm wave transmission in RoF, RF transparent photonic demodulation techniques.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the properties of Radio over fiber link.
CO2: Identify Suitable Optical technology for wireless networks
CO3: Understand Fiber Wireless channel modelling and estimation
CO4: Design RoF based cellular systems.
CO5: Generate and detect millimeter wave in RoF technology

REFERENCES:

1. Alan E Willner, Optical Fiber Telecommunication VII, Academic Press, 2020.
2. Hamed Al-Rawesshidy and Shozo Komaki, “Radio Over Fiber Technology for Mobile Communication Networks”, Artech House, London, 2002.
3. Fei Hu, Opportunities in 5G Networks, A Research and Development Perspective, Taylor and Francis,2016.
4. Xavier Fernando,” Radio over fiber for wireless communication”, John Wiley and Sons, New York ,2014
5. Nathan J. Gomes, Paulo P.Monterio and Atilio Gameiro “Next Generation Wireless Communication using Radio Over Fiber” John Wiley and Sons, New York,2012.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	1	1	3
CO2	3	1	3	1	2	2
CO3	3	1	3	3	2	2
CO4	3	1	3	3	3	1
CO5	3	1	3	3	3	1
AVG	3	1	3	2.2	2.2	1.8

NE3056 INFORMATION THEORY AND CODING L T P C
3 0 0 3

UNIT I QUANTITATIVE STUDY OF INFORMATION 9

Entropy, Relative Entropy, Mutual information, Chain rule, Relationship Bounds on entropy, Fisher information, Cramer Rao inequality, Entropy rates of a Stochastic process .

UNIT II CAPACITY OF NOISELESS CHANNEL 9

Fundamental theorem for a noiseless channel, Data compression, Kraft inequality, Shannon-Fano

codes, Huffman codes , Asymptotic equi partition, Rate distortion theory.

UNIT III CHANNEL CAPACITY 9

Properties of channel capacity, jointly typical sequences, Channel Coding Theorem, converse to channel coding theorem, Joint source channel coding theorem.

UNIT IV DIFFERENTIAL ENTROPY AND GAUSSIAN CHANNEL 9

AEP for continuous random variables, relationship between continuous and discrete entropy, properties of differential entropy, Gaussian channel definitions, converse to coding theorem for Gaussian channel, channels with colored noise, Gaussian channels with feedback.

UNIT V CHANNEL CODING TECHNIQUES 9

Galois Fields, Fundamental Theorem of Galois Theory (FTGT), Reed-Solomon Codes, Turbo Codes, LDPC Codes, TCM, Polar Code.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Quantify information.
CO2: Implement various coding schemes.
CO3: Design efficient channel.
CO4: Apply coding techniques to information sources like video, audio and soon.
CO5: Implement the information theory and coding technique for effectivecommunication

REFERENCES:

1. P.S. Satyanarayana , “Concepts of Information Theory & Coding”, Medtech, 2nd Edition, 2016.
2. Varun Goyal, Gaurav Gupta “Information theory and coding” S.K. Kataria & Sons, 2014 Edition (2011).
3. Monica Borda, " Fundamentals in Information Theory and Coding ", Springer 2011.
4. Thomas Cover, Joy Thomas, “Elements of Information Theory “,Wiley, 2nd Edition, 2006
5. David J.C. MacKay, “Information Theory, Interference & Learning Algorithms”, Cambridge University Press, 2nd Edition, 2003

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	2	1	1
CO2	3	1	3	2	2	2
CO3	3	1	3	2	2	2
CO4	3	1	2	1	2	2
CO5	3	1	2	1	1	2
AVG	3	1	2.6	1.6	1.6	1.8

WT3056 SPREAD SPECTRUM TECHNIQUES AND APPLICATIONS L T P C
3 0 0 3

UNIT I SPREADING CODES 9

Finite-Field Arithmetic- Sequence Generator Fundamentals-State - Machine Representation of Shift-Register Generators-Generation &Properties of m-Sequences Gold Codes - Kasami Sequences (Small Set) - Quaternary Sequences - Complementary Code Keying - Walsh– Hadamard

Sequences.

UNIT II SPREAD SPECTRUM SYSTEMS 9

Direct Sequence Spread Spectrum (DSSS)- Processing Gain- Frequency Hop Spread Spectrum (FHSS)- Coherent & Noncoherent Slow FHSS – Coherent & Noncoherent Fast FHSS- Hybrid DS/FH Spread Spectrum.

UNIT III SYNCHRONIZATION IN SPREAD SPECTRUM 9

Sources of synchronization Uncertainty, Carrier Synchronization - Code Synchronization & Acquisition - Matched Filter Acquisition, Serial Search Acquisition, Sequential Acquisition, Code Tracking- Delay Lock Tracking loop, Noncoherent Tracking loop.

UNIT IV SPREAD SPECTRUM IN CELLULAR COMMUNICATION 9

Cellular Network and Power Control- DS-CDMA Cellular Networks, FH-CDMA Cellular Networks, Performance in Jamming Environment – Low Probability of Intercept methods- Optimum Intercept Receives for Spread - Spectrum Signals.

UNIT V APPLICATIONS OF SPREAD SPECTRUM METHODS 9

Space Systems, Avionics Systems, Test Systems and equipment, Message Protection, GPS System-Principles-Differential GPS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Realize the generation of PN sequence.
CO2: Appreciate spread spectrum systems.
CO3: Analyze synchronization issues in spread spectrum.
CO4: Design systems based on spread spectrum to mitigate the jamming.
CO5: Design GPS system

REFERENCES:

1. Jerry D. Gibson, "Mobile Communications Handbook", 3rd Edition, CRC Press, 2017.
2. Don Torrieri, "Principles of Spread-Spectrum Communication Systems",3rd edition, Springer International Publishing Switzerland, 2015.
3. Roger L. Peterson, Rodger E. Ziemer, Davis E. Borth, " Introduction to Spread Spectrum Communications", 1st edition, Pearson Education India, 2013
4. Rodger E. Ziemer, "Fundamentals of Spread Spectrum Modulation", Morgan & Claypool, Publishers series, 2007.
5. M.K. Simon, J.K. Omura, R.A. Scholtz, and B.K. Levitt, "Spread Spectrum Communications Handbook", Electronic Edition, McGraw-Hill, 2002.
6. Andrew J. Viterbi, "CDMA: Principles of Spread Spectrum Communication", Addison-Wesley Wireless Communications Series, 1995.
7. Robert C. Dixon, "Spread Spectrum Systems with Commercial Applications", 3rd Edition, John Wiley & Sons, Ins, 1994.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	2	1	1	1
CO2	2	1	2	2	1	1
CO3	2	1	2	2	2	1
CO4	3	1	2	3	2	1
CO5	2	1	2	2	3	2

AVG	2.2	1	2	2	1.8	1.2

WT3059 SPACE TIME WIRELESS COMMUNICATION L T P C
3 0 0 3

UNIT I MULTIPLE ANTENNA PROPAGATION AND ST CHANNEL CHARACTERIZATION 9

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

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.

UNIT V 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-S S.MIMO-MAC,MIMO-BC, Outage performance for MIMO-MU,MIMO-MU with OFDM.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Apply the knowledge of wireless technology using multiple antennas.
CO2: Analyze space time wireless propagation and space time channel.
CO3: Evaluate the performance of space time wireless communication.
CO4: Utilize the channel knowledge at the transmitter.
CO5: Understand space time multiuser communication.

REFERENCES:

1. Claude Oestges, Bruno Clerckx., "MIMO Wireless Communications: From Real-World Propagation to Space-Time Code Design" , Academic Press, 2010.
2. Erik G. Larsson, Petre Stoica ., "Space-Time Block Coding for Wireless Communications",Cambridge University Press, 2008.

3. Tolga M. Duman, Ali Ghrayeb., "Coding for MIMO Communication Systems", John Wiley & Sons, 2008.
4. H. Bölcskei, D. Gesbert, Constantinos, B. Papadias A.-J. van der Veen., "Space-Time Wireless Systems: From Array Processing to MIMO Communications ", Cambridge University Press, 2006.
5. A. Paulraj, Rohit Nabar, Dhananjay Gore., "Introduction to Space Time Wireless Communication Systems", Cambridge University Press, 2003

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	2	1	3	3	2	2
CO2	3	1	2	3	2	2
CO3	3	1	2	2	1	1
CO4	3	1	3	3	2	2
CO5	2	1	2	2	2	2
AVG	2.6	1	2.4	2.6	1.8	1.8

NE3058 SOFTWARE DEFINED NETWORK L T P C
3 0 0 3

UNIT I INTRODUCTION 9

History of Software Defined Networks (SDN) – Modern Data Center – Traditional Switch Architecture – Evolution of SDN – How SDN Works – Centralized and Distributed Control and Date Planes

UNIT II OPEN FLOW & SDN CONTROLLERS 9

Open Flow Specification – Drawbacks of Open SDN, SDN via APIs, SDN via Hypervisor- Based Overlays – SDN via Opening up the Device – SDN Controllers – General Concepts

UNIT III SOFTWARE DEFINED NETWORKING 9

Introduction- Deep Dive (North bound and South bound interface), active network, data and control plane separation abstraction, SDN Open flow prospects and challenges

UNIT IV NETWORK FUNCTION VIRTUALIZATION 9

Introduction – NFC concepts, Frame work and Architecture – key challenges – high performance packet processing, comparison of NFC and SDN

UNIT V DATA CENTER NETWORKING 9

Introduction – characteristics and Challenges – protocols innovation – network telemetry- server less computing, content distribution in IP networks- Information centric networking

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On completion of the course the student should be able to

CO1: Understand the evolution of software defined networks
CO2: Realize the various components of SDN and their uses
CO3: Realize the role of the Software Defined Networking
CO4: Realize the role of Network function virtualization
CO5: Realize the role of Data center Networking

REFERENCES:

1. Information-Centric Networking (ICN): Content Centric Networking (CCNx) and Named Data Networking (NDN) Terminology, B. Wissingh, C. Wood, A. Afanasyev, L. Zhang, D. Oran and C. Tschudin, RFC 8793, June 2020
2. Chayapathi R, Hassan SF, Shah P. Network Functions Virtualization (NFV) with a Touch of SDN: Netw Fun Vir (NFV ePub_1. Addison- Wesley Professional; 2016
3. Marschke D, Doyle J, Moyer P. Software Defined Networking (SDN): Anatomy of OpenFlow Volume 1. 2015.
4. Paul Goransson and Chuck Black, —Software Defined Networks: A Comprehensive Approach, First Edition, Morgan Kaufmann, 2014.
5. Cloud Networking: Understanding Cloud-based Data Centre Networks, Gary Lee Morgan Kaufmann Publisher, 2014, ISBN-139780128007280
6. Thomas D. Nadeau, Ken Gray, —SDN: Software Defined Networks, O'Reilly Media, 2013.
7. Information-Centric Networks: A New Paradigm for the Internet (Focus Series in Networks and Telecommunications), Gabriel M. de Brito, Pedro B. Velloso, Igor M. Moraes, Wiley-ISTE; 1st edition, 2013, ISBN: 9781848214491
8. Software-Defined Networks: A Systems Approach, Peterson, Cascone, O'Connor, Vachuska, and Davie, Online Free Reference Book available at
   https://sdn.systemsapproach.org/index.html

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO1	3	1	3	2	2	1
CO2	3	1	3	2	2	1
CO3	3	1	3	2	2	2
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3
AVG	3	1	3	2.4	2.4	2