MOUNT ZION

COLLEGE OF ENGINEERING AND TECHNOLOGY

(AUTONOMOUS)

(Approved by AICTE, Affiliated to Anna University & Accredited by NAAC with A+ Grade)

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Curriculum and Syllabus Handbook

M.E – COMMUNICATION SYSTEMS [Regulation 2025]

[CHOICE BASED CREDIT SYSTEM]

Approved by Academic Council on 24.06.2026

INSTITUTE VISION AND MISSION	
VISION	• To be the preferred choice of students who aspire to become Engineers of the highest calibre.
MISSION	• Provide world-class physical and digital infrastructure and learning environment. • Develop the competencies of students to make them job-ready and entrepreneurs. • Facilitate mental, physical, emotional and spiritual development of students and ensure their holistic development. • Preserve the environment through the implementation of eco-friendly and sustainable practices. • Serve the community through skill development and other need-based services. • Establish sustainable partnerships with industries and R&D laboratories for mutual benefit.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING	
VISION	• To be a leading department in Electronics and Communication Engineering education, fostering innovation, research, and technological advancement while empowering students with the knowledge, skills, and ethical values to contribute to the development of society and the global technological landscape.
MISSION	• To provide a comprehensive education in electronics and communication engineering that blends theoretical knowledge, practical skills, and hands-on experience to prepare students for successful careers in industry and research. • To foster a culture of innovation and research by encouraging students and faculty to explore advanced technologies and contribute to solving real-world challenges in electronics, communication, and related fields. • To promote leadership, teamwork, and ethical responsibility, preparing students to be well-rounded professionals who can address the challenges of a rapidly evolving global technology landscape. • To establish strong partnerships with industry and research organizations, enhancing learning opportunities, promoting entrepreneurship, and creating solutions that address societal needs through electronics and communication.

PROGRAMME OUTCOMES (POs)

At the end of this programme the students will be able to

PO NO.	PROGRAMME OUTCOMES	
PO1	Engineering Knowledge	Apply math, science, and engineering fundamentals to complex problems.
PO2	Problem Analysis	Identify and analyze complex problems using research and sustainability principles.
PO3	Design Solutions	Design systems and processes considering health, safety, cost, culture, and environment.
PO4	Investigations	Use experiments, modelling, and data analysis to reach valid conclusions.
PO5	Engineering Tools	Apply modern tools for modelling and problem-solving, recognizing their limits.
PO6	Society and Environment	Assess societal, legal, and environmental impacts of engineering solutions.
PO7	Ethics	Commit to ethics, human values, diversity, and legal compliance.
PO8	Team work	Work effectively as an individual and in multidisciplinary teams.
PO9	Communication	Communicate clearly in reports, presentations, and documentation across diverse groups.
PO10	Management and finance	Apply management and economic principles in projects and teamwork.
PO11	Life-long learning	Engage in continuous learning, adapt to new technologies, and think critically.

PROGRAMME SPECIFIC OUTCOMES (PSOs)	**Students will be able to** • **PSO1:**Apply core principles of electronics and communication engineering to design, analyze, and implement electronic circuits, communication systems, and signal processing solutions. • **PSO2:**Utilize advanced technologies such as wireless communication, embedded systems, IoT, and VLSI design to develop innovative solutions for real-world challenges in electronics and communication. • **PSO3:**Possess effective communication, teamwork, and problem-solving skills, along with an understanding of ethical practices, enabling them to work responsibly in diverse professional environments.

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
M.E. COMMUNICATION SYSTEMS

CURRICULUM

SEMESTER – I

S. NO.	COURSE CODE	COURSE TITLE	COURSE TYPE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
					L	T	P		
THEORY AND LAB INTEGRATED THEORY									
1.	MA25C05	Advanced Mathematical Methods	T	BSC	3	1	0	4	4
2.	CU25C01	Advanced Radiation Systems	T	PCC	3	0	0	3	3
3.	CU25C02	Modern Digital Communication Systems	T	PCC	3	0	0	3	3
4.	CU25C03	Advanced Digital Signal Processing	T	PCC	3	1	0	4	4
5.	CU25C04	Analog and Digital Electronic System Design	LIT	PCC	3	0	2	5	4
6.	CU25C05	Digital Communication Systems Laboratory	T	PCC	0	0	4	4	2
7.	CU25101	Technical Seminar	L	EEC	0	0	2	2	1
				TOTAL	**15**	**2**	**8**	**25**	**21**

SEMESTER – II									
S. NO.	**COURSE CODE**	**COURSE TITLE**	**COURSE TYPE**	**CATE GORY**	**PERIODS PER WEEK**			**TOTAL CONTACT PERIODS**	**CREDITS**
					L	**T**	**P**		
THEORY AND LAB INTEGRATED THEORY									
1.	CU25201	Radio Frequency Transceiver Design	T	PCC	3	0	0	3	3
2.	***	Programme Elective I	T	PEC	3	0	0	3	3
3.	CU25C06	Machine Learning	T	PCC	3	1	0	4	4
4.	CU25C07	Advanced Wireless Communication Networks	LIT	PCC	3	0	2	5	4
5.	CU25202	Advanced Communication Systems laboratory	T	PCC	0	0	4	4	2
6.	***	Industry Oriented Course I		EEC	1	0	0	1	1
7.	CU25203	Industrial Training		EEC	-	--	-	---	1
8.	***	Self-Learning Course		EEC	-	--	-	---	1
				TOTAL	**13**	**1**	**6**	**20**	**19**

SEMESTER III									
S. NO.	COURSE CODE	COURSE TITLE	COURSE TYPE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
					L	T	P		
THEORY									
1.	PE25P**	Programme Elective II	T	PEC	3	0	0	3	3
2.	PE25P**	Programme Elective III	T	PEC	3	0	0	3	3
3.	PE25P**	Programme Elective IV	T	PEC	3	0	0	3	3
4.	PE25P**	Programme Elective V	T	PEC	3	0	0	3	3
5.	PE25I02	Industry Oriented Course II		EEC	1	0	0	1	1
PRACTICALS									
6.	PE25301	Project Work I	L	EEC	0	0	12	12	6
				TOTAL	**13**	**0**	**12**	**25**	**19**

SEMESTER IV									
S. NO.	COURSE CODE	COURSE TITLE	COURSE TYPE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
					L	T	P		
PRACTICALS									
1.	PE25401	Project Work II	L	EEC	0	0	24	24	12
				TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: 71

PROGRAMME ELECTIVES

PROGRAMME ELECTIVES – I									
S.NO.	**COURSE CODE**	**COURSE TITLE**	**COURSE TYPE**	**CATE GORY**	**PERIODS PER WEEK**			**TOTAL CONTACT PERIODS**	**CREDITS**
					L	**T**	**P**		
1.	PE25P01	Wavelets and Sub band Coding	T	PEC	3	0	0	3	3
2.	PE25P02	Wireless Sensor Networks and WBAN	T	PEC	3	0	0	3	3
3.	PE25P03	Ultra Wide Band Communications	T	PEC	3	0	0	3	3
4.	VL25C01	VLSI for Wireless Communication	T	PEC	3	0	0	3	3

PROGRAMME ELECTIVES – II									
S.NO.	**COURSE CODE**	**COURSE TITLE**	**COURSE TYPE**	**CATE GORY**	**PERIODS PER WEEK**			**TOTAL CONTACT PERIODS**	**CREDITS**
					L	**T**	**P**		
1.	PE25P04	Cognitive Radio Communications	T	PEC	3	0	0	3	3
2.	PE25P05	Quantum Communication and Networking	T	PEC	3	0	0	3	3
3.	PE25P06	Telecommunication System Modeling and Simulation	T	PEC	3	0	0	3	3
4.	PE25P07	Massive MIMO and MMWAVE System	T	PEC	3	0	0	3	3

PROGRAMME ELECTIVES – III									
S.NO.	COURSE CODE	COURSE TITLE	COURSE TYPE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
					L	T	P		
1.	PE25P08	Advanced Satellite Based Systems	T	PEC	3	0	0	3	3
2.	PE25P09	Communication Network Design	T	PEC	3	0	0	3	3
3.	PE25P10	Digital Communication Receivers	T	PEC	3	0	0	3	3
4.	PE25P11	Co-operative Communication	T	PEC	3	0	0	3	3

PROGRAMME ELECTIVES – IV									
S.NO.	COURSE CODE	COURSE TITLE	COURSE TYPE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
					L	T	P		
1.	PE25P12	Security for Wireless Communication Networks	T	PEC	3	0	0	3	3
2.	PE25P13	Signal Detection and Estimation	T	PEC	3	0	0	3	3
3.	PE25P14	Solid State Device Modeling and Simulation	T	PEC	3	0	0	3	3
4.	PE25P15	RF Integrated Circuit Design	T	PEC	3	0	0	3	3

PROGRAMME ELECTIVES – V									
S.NO.	COURSE CODE	COURSE TITLE	COURSE TYPE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
					L	T	P		
1.	PE25P16	Image and Video Processing and Analytics	T	PEC	3	0	0	3	3
2.	PE25P17	MEMS and NEMS	T	PEC	3	0	0	3	3
3.	PE25P18	Image Processing and Pattern Recognition	T	PEC	3	0	0	3	3
4.	PE25P19	Analog and Mixed Signal VLSI Design	T	PEC	3	0	0	3	3

SUMMARY

Name of the Programme: M.E. Communication Systems						
S. No.	Subject Area	Credits per Semester				Total Credits
		I	II	III	IV	
1	BSC	4	-	-	-	4
2	PCC	16	13	-	-	29
3	PEC	-	3	12	-	15
4	EEC	1	3	7	12	23
Total		21	19	19	12	71

I SEMESTER

MA25C05	ADVANCED MATHEMATICAL METHODS	L	T	P	C
		3	1	0	4

Course Objectives:	• To understand advanced mathematical concepts used in engineering. • To develop analytical and problem-solving skills for engineering applications. • To apply numerical methods and computational techniques in engineering analysis. • To utilize mathematical tools for electronic circuit and system design. • To apply computational techniques for communication and embedded system applications.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Apply the principles of calculus of variations to formulate and solve optimization problems involving functionals and Euler's equations.	**K3**
CO2	Apply fundamental queueing models and performance measures to analyze single-server, multi-server, and finite-capacity queueing systems.	**K3**
CO3	Analyze advanced queueing systems and network models using M/G/1 queues, Pollaczek–Khinchin formula, and Jackson networks.	**K4**
CO4	Apply graph theoretic concepts and algorithms to solve shortest path, spanning tree, and network traversal problems.	**K3**
CO5	Analyze and solve optimization problems using linear programming, transportation, assignment, and simplex-based methods.	**K4**

UNIT I CALCULUS OF VARIATIONS	**9**
Variation and its properties, Euler's equation, Functionals dependent on first and higher order derivatives, Functionals dependent on functions of several independent variables, Some applications, Direct methods, Ritz method.	
UNIT II QUEUEING MODELS	**9**
Markovian queues, Birth and death processes, Single and multiple server queueing models, Little's formula, Queues with finite waiting rooms, Queues with impatient customers: Balking and reneging. Finite source models.	
UNIT III ADVANCED QUEUEING SYSTEMS AND NETWORKS	**9**
M/G/1 queue, Pollaczek Khinchin formula, M/D/1 and M/EK/1 as special cases, Series queues, Open Jackson networks.	
UNIT IV GRAPH THEORY	**9**
Introduction to paths, trees, Isomorphism, Matrix coloring and directed graphs, Some basic algorithms: Dijkstra's Algorithm, Depth-First search, Breadth-First search, Prims Algorithm, Kruskal Algorithm	

UNIT V OPTIMIZATION TECHNIQUES	9
Linear programming, Basic concepts, Graphical and simplex methods, Big M method, Transportation problems, Assignment problems.	
TOTAL: 45 PERIODS	

REFERENCES:

1. Elsgolc, L. D. – Calculus of Variations, Dover Publications,2007
2. Gross, D. and Harris, C. M. – Fundamentals of Queueing Theory, Wiley.5th Edition,2018.
3. Deo, N. – Graph Theory with Applications to Engineering and Computer Science, PHI,1974
4. Hillier, F. S. and Lieberman, G. J. – Introduction to Operations Research, McGraw-Hill,2015.
5. Kanti Swarup, Gupta P.K., and Man Mohan – Operations Research, Sultan Chand and Sons,2019.

E-RESOURCES:

1. https://nptel.ac.in/courses/111/105/111105039
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-262-discrete-stochastic-processes.
3. https://nptel.ac.in/courses/106/106/106106183.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	2	2	-	-	-	-	-	2	2	-	1
2	3	3	2	2	2	-	-	-	-	-	2	2	-	1
3	3	3	2	3	2	-	-	-	-	-	2	2	1	1
4	3	3	2	2	3	-	-	-	-	-	2	2	1	1
5	3	3	3	2	3	1	-	-	-	2	2	2	1	2
Avg.	**3.0**	**2.8**	**2.0**	**2.2**	**2.4**	**1.0**	**-**	**-**	**-**	**2.0**	**2.0**	**2.0**	**1.0**	**1.2**

CU25C01	ADVANCED RADIATION SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of antenna radiation and parameters. • To study various antenna types and their characteristics. • To analyze antenna arrays and beamforming techniques. • To evaluate antenna performance using measurement and analysis methods. • To explore advanced antenna technologies and emerging applications.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the radiation mechanism, Maxwell's equations, antenna parameters, and the operating principles of dipole, monopole, and loop antennas.	**K3**
CO2	Apply antenna array concepts and beamforming techniques to analyze and design linear, planar, phased, and smart antenna systems.	**K3**
CO3	Analyze and evaluate the performance of aperture and reflector antennas using radiation principles, Babinet's principle, and geometrical theory of diffraction (GTD).	**K4**
CO4	Apply the design principles of modern antennas including microstrip, fractal, reconfigurable, MIMO, mmWave, THz, wearable, and implantable antennas for specific applications.	**K3**
CO5	Perform antenna measurements and interpret gain, radiation pattern, impedance, and polarization characteristics using suitable test environments and simulation tools.	**K3**

UNIT I ANTENNA FUNDAMENTALS	**9**
Radiation mechanisms, Maxwell's equations, antenna parameters, dipole, monopole, loop analysis, current distribution, radiation integrals. Numerical methods -MoM, FEM, FDTD, simulation tools.	
UNIT II ANTENNA ARRAYS AND BEAMFORMING	**9**
Linear and planar arrays, beamforming, phased arrays, array synthesis (Binomial, Chebyshev), smart antennas, mutual coupling.	
UNIT III APERTURE AND REFLECTOR ANTENNAS	**9**
Aperture radiation, horn and slot antennas, Babinet's principle, reflector types and design, GTD, performance metrics.	
UNIT IV MODERN AND SPECIFIC ANTENNAS	**9**
Microstrip, fractal, reconfigurable, MIMO, mmWave, THz, wearable and implantable antennas, feeding and tuning methods.	
UNIT V ANTENNA MEASUREMENTS	**9**
Antenna test environments, anechoic/reverb chambers, gain, pattern, impedance, polarization	
	TOTAL: 45 PERIODS

REFERENCES:

1. Balanis, C. A. Antenna theory: Analysis and design, John Wiley and Sons,2016
2. Gross, F. B. Frontiers in antennas: Next generation design and engineering. McGraw Hill,2011
3. Drabowitch, S., Papiernik, A., Griffiths, H. D., Encinas, J., and Smith, B. L. Modern antennas. Springer,2013.
4. Krauss, J. D. Antennas. John Wiley and Sons, 2017.
5. Stutzman, W. L., and Thiele, G. A.Antenna theory and design. John Wiley and Sons,2012.

Mapping of COs with POs / PSOs														
	POs											**PSOs**		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	-	1	-	-	-	-	-	2	3	1	1
2	3	3	3	2	3	-	-	-	-	-	2	3	1	1
3	2	3	2	3	2	1	-	-	-	-	2	3	2	1
4	3	2	3	1	3	1	-	-	-	-	2	3	2	1
5	2	2	1	3	3	-	-	-	2	-	2	3	2	2
Avg.	**2.6**	**2.4**	**2.0**	**2.2**	**2.4**	**1.0**	**-**	**-**	**2.0**	**-**	**2.0**	**3.0**	**1.6**	**1.2**

CU25C02	MODERN DIGITAL COMMUNICATION SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand coherent and non-coherent communication receivers. • To study bandlimited signalling techniques for efficient spectrum utilization. • To analyze equalization methods for channel impairment mitigation. • To apply channel coding techniques for reliable data transmission. • To explore OFDM and CDMA techniques used in modern wireless communications.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Apply the principles of coherent and non-coherent communication systems to analyze the performance of digital receivers in fading channels.	**K3**
CO2	Apply equalization techniques to mitigate intersymbol interference and improve communication system performance.	**K3**
CO3	Analyze block-coded digital communication systems using channel coding techniques and evaluate their error-control capabilities.	**K4**
CO4	Analyze convolutional coding and decoding techniques, including Viterbi and turbo decoding, for reliable digital communication.	**K4**
CO5	Apply OFDM and CDMA techniques to evaluate multicarrier and multiuser communication systems.	**K3**

UNIT I COHERENT AND NON-COHERENT COMMUNICATION	**9**
Coherent receivers, IQ modulation/demodulation, QAM, MFSK, DPSK, Rayleigh/Rician channels, BER performance, synchronization techniques.	
UNIT II EQUALIZATION TECHNIQUES	**9**
ISI, Nyquist criterion, partial response signaling, linear and decision feedback equalizers, adaptive equalization.	
UNIT III BLOCK CODED DIGITAL COMMUNICATION	**9**
Binary block codes, channel capacity, Shannon's theorem, spread spectrum, BPSK/DPSK with coding, Hamming, BCH, Reed-Solomon, STBC.	
UNIT IV CONVOLUTIONAL CODED DIGITAL COMMUNICATION	**9**
Polynomial, state/tree/trellis diagrams, Viterbi decoding, error performance, turbo coding and iterative decoding.	

UNIT V MULTICARRIER AND MULTIUSER COMMUNICATIONS	9
OFDM modulation/demodulation, FFT implementation, bit/power allocation, PAPR, CDMA, multiuser detection, SIC.	
TOTAL: 45 PERIODS	

REFERENCES:

1. Proakis, J. G., and Salehi, M. Digital communication. McGraw Hill,2014.
2. Haykin, S. Digital communication systems. John Wiley and Sons,2014.
3. Sklar, B., and Ray, P. K.Digital communications: Fundamentals and applications. Pearson Education,2009.
4. Lathi, B. P., and Ding, Z., Modern Digital and Analog Communication Systems,Oxford University Press,2025.
5. Rappaport, T. S. Wireless communications,Pearson Education,2002.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	2	2	-	-	-	-	-	2	3	2	-
2	3	3	2	2	3	-	-	-	-	-	2	3	2	-
3	3	3	2	3	2	-	-	-	-	-	2	3	2	-
4	3	3	2	3	3	-	-	-	-	-	2	3	3	-
5	3	2	2	2	3	-	-	-	-	-	2	3	3	-
Avg.	**3.0**	**2.6**	**2.0**	**2.4**	**2.6**	**-**	**-**	**-**	**-**	**-**	**2.0**	**3.0**	**2.4**	**-**

CU25C03	ADVANCED DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	1	0	4
Course Objectives:	• To understand advanced DSP techniques and communication applications. • To study multirate signal processing methods for efficient signal processing. • To apply adaptive filtering techniques in communication systems. • To analyze signals using spectral estimation methods. • To implement real-time DSP architectures for signal processing applications.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Apply multirate signal processing techniques such as decimation, interpolation, polyphase filters, and filter banks in communication systems.	**K3**
CO2	Apply adaptive filtering algorithms for channel equalization, system identification, and noise/echo cancellation in communication applications.	**K3**
CO3	Analyze spectral estimation techniques for determining power spectral density and signal characteristics in speech, radar, and communication systems.	**K4**
CO4	Explain the architecture and real-time implementation aspects of DSP processors, FPGA-based DSP systems, and software-defined radio platforms.	**K4**
CO5	Analyze the role of DSP techniques in modern communication systems including channel estimation, cognitive radio, IoT, and biomedical applications.	**K3**

UNIT I MULTIRATE SIGNAL PROCESSING IN COMMUNICATION	**9**
Decimation, interpolation, multistage conversion, polyphase filters, filter banks, fractional rate conversion, communication applications.	
UNIT II ADAPTIVE FILTERING FOR CHANNEL EQUALIZATION	**9**
LMS, NLMS, RLS algorithms, convergence, system identification, noise/echo cancellation, equalizers in mobile/wired systems.).	
UNIT III SPECTRAL ESTIMATION FOR SIGNAL ANALYSIS	**9**
Non-parametric (Periodogram, Welch), parametric (AR, MA, ARMA), high-resolution (MUSIC, ESPRIT), PSD for speech/radar.	
UNIT IV DSP ARCHITECTURES AND REAL-TIME IMPLEMENTATION	**9**
Fixed/floating-point DSPs, TMS320C67x, pipelining, FPGA-based DSP, SDR, DSP in 5G and IoT applications.	

UNIT V APPLICATIONS IN MODERN COMMUNICATION SYSTEMS	9
DSP in modulation/demodulation, channel estimation, spectrum sensing, cognitive radio, speech/audio, IoT, biomedical.	
TOTAL: 45 PERIODS	

REFERENCES:

1. Proakis, J. G., and Manolakis, D. G. (). Digital signal processing: Principles, algorithms, and applications, Pearson,2007.
2. Mitra, S. K. Digital signal processing: A computer-based approach. McGraw-Hill,2010.
3. Hayes, M. H. Statistical digital signal processing and modeling. Wiley,2009.
4. Orfanidis, S. J. Optimum signal processing. McGraw-Hill,2007.
5. Jones, D. L. MATLAB for signal processing. Cambridge University Press,2020.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	2	1	3	-	-	-	-	-	2	3	2	-
2	3	3	2	2	3	-	-	-	-	-	2	3	2	-
3	2	3	1	3	2	-	-	-	-	-	2	3	2	-
4	2	1	2	2	3	-	-	-	1	-	2	2	3	2
5	3	3	2	2	3	1	-	-	1	-	2	3	3	2
Avg.	**2.6**	**2.4**	**1.8**	**2.0**	**2.8**	**1.0**	**-**	**-**	**1.0**	**-**	**2.0**	**2.8**	**2.4**	**2.0**

CU25C04	ANALOG AND DIGITAL ELECTRONIC SYSTEM DESIGN	L	T	P	C
		3	0	2	4

Course Objectives:	• To understand the fundamentals of analog, digital, and mixed-signal circuits. • To design basic analog and digital circuit blocks. • To analyze the performance of mixed-signal systems. • To apply simulation tools for circuit design and verification. • To optimize mixed-signal circuits for efficient operation.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the operating principles of MOS transistors, CMOS logic gates, and basic analog building blocks.	**K2**
CO2	Analyze the performance of single-stage MOS amplifiers using small-signal models.	**K4**
CO3	Design differential amplifiers and high-gain amplifier circuits to meet specified requirements.	**K3**
CO4	Implement digital systems using FPGA architecture, synchronous circuits, and ASM-based design techniques.	**K3**
CO5	Develop HDL-based designs and synthesize finite state machines for mixed-signal system integration.	**K3**

UNIT I MOS TRANSISTOR PRINCIPLES AND LOGIC GATES	**9**
MOS transistor characteristics, CMOS inverter, logic gate design, secondary effects, CS, CG, CD amplifiers, cascode, current mirrors.	
UNIT II SINGLE STAGE AMPLIFIERS	**9**
MOS models and small-signal equivalents, common-source (CS), common-gate (CG), and source-follower (CD) amplifiers, cascode amplifiers, current mirrors.	
UNIT III DIFFERENTIAL AMPLIFIERS AND HIGH-GAIN CIRCUITS	**9**
Differential amplifier design, gain, CMR, slew rate, bandwidth, power, op-amp design principles, high-gain structures.	
UNIT IV DIGITAL CIRCUIT DESIGN AND FPGA IMPLEMENTATION	**9**
FPGA architecture, datapath design, clocked synchronous circuits, iterative circuits, ASM chart and realization using ASM blocks.	
UNIT V SYSTEM DESIGN USING HDL AND INTEGRATION	**9**
Logic system and data types in HDL, behavioral and structural modeling, FSM synthesis, mixed-signal integration using simulation tools.	
TOTAL: 45 PERIODS	

REFERENCES:

1. Razavi, B. Design of analog CMOS integrated circuits. Tata McGraw Hill,2016.
2. Sansen, W. M. C.Analog design essentials. Springer,2007.
3. Grebene, K. Bipolar and MOS analog integrated circuit design. John Wiley and Sons,2003.
4. Roth, C. H., Jr. Fundamentals of logic design. Thomson Learning,2005.
5. Palnitkar, S. Verilog HDL: A guide to digital design and synthesis. Pearson,2003.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	1	-	-	-	-	-	2	3	1	-
2	3	3	1	2	2	-	-	-	-	-	2	3	2	-
3	2	3	3	2	2	-	-	-	2	-	2	3	2	1
4	2	2	3	2	3	-	-	2	2	-	2	2	3	1
5	2	2	3	2	3	-	-	1	2	-	2	2	3	1
Avg.	**2.4**	**2.4**	**2.5**	**2.0**	**2.2**	**-**	**-**	**1.5**	**2.0**	**-**	**2.0**	**2.6**	**2.2**	**1.0**

CU25C05	DIGITAL COMMUNICATION SYSTEMS LABORATORY	L	T	P	C
		0	0	4	2

Course Objectives:	• To understand the fundamentals of digital communication systems. • To analyze the performance of wireless communication techniques. • To design digital filters for signal processing applications. • To apply adaptive filtering algorithms for system optimization. • To evaluate modern communication systems and signal processing techniques.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Implement digital modulation and spread spectrum communication techniques using SDR tools.	**K3**
CO2	Design and evaluate MIMO, CDMA, and OFDM communication systems using simulation platforms.	**K3**
CO3	Develop channel coding and decoding schemes for reliable digital communication.	**K3**
CO4	Apply adaptive filtering and spectrum estimation techniques for signal analysis and noise reduction.	**K3**
CO5	Analyze synchronization methods and wireless channel characteristics in communication systems.	**K3**

LIST OF EXPERIMENTS:

1. Generation and detection of binary digital modulation techniques using SDR
2. Spread Spectrum communication system-Pseudo random binary sequence generation- Baseband DSSS.
3. MIMO system transceiver design using MATLAB/SCILAB/LABVIEW
4. Performance evaluation of simulated CDMA system
5. Channel Coder/decoder design (block codes / convolutional codes/ turbo codes)
6. OFDM transceiver design using MATLAB /SCILAB/LABVIEW
7. Channel equalizer design using MATLAB (LMS, RLS algorithms)
8. Design and Analysis of Spectrum Estimators (Bartlett, Welch) using MATLAB
9. BER performance Analysis of M-ary digital Modulation Techniques (coherent and non coherent) in AWGN Environment using MATLAB/SCILAB/LABVIEW
10. Design and performance analysis of Lossless Coding Techniques - Huffman Coding and Lempel Ziv Algorithm using MATLAB/SCILAB/LABVIEW
11. Noise / Echo cancellation using MATLAB (LMS / RLS algorithms).
12. Study of synchronization (frame, bit, symbol.)
13. Wireless channel characterization.

HARDWARE / SOFTWARE REQUIRED:
HARDWARE: -
SOFTWARE: • MATLAB
TOTAL: 60 PERIODS

Mapping of COs with POs / PSOs														
POs												**PSOs**		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	2	1	3	-	-	-	1	-	2	2	-	2
2	3	3	3	2	3	-	-	-	2	-	2	3	-	3
3	3	3	3	2	2	-	-	-	2	-	2	2	-	3
4	3	3	2	3	3	-	-	-	2	-	2	2	-	3
5	3	3	2	3	2	1	-	-	2	-	2	3	1	3
Avg.	**3.0**	**2.8**	**2.4**	**2.2**	**2.6**	**1.0**	**-**	**-**	**1.8**	**-**	**2.0**	**2.4**	**1.0**	**2.8**

II SEMESTER

CU25201	RADIO FREQUENCY TRANSCEIVER DESIGN	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamental principles and key parameters of RF communication systems. • To analyze digital baseband signaling techniques used in wireless communication systems. • To study the modeling and performance characteristics of RF amplifiers, mixers, and oscillators. • To examine modern radio architectures and their applications in wireless networks. • To design practical RF transceivers for multimode and multiband wireless communication systems.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain RF system parameters, digital baseband signaling concepts, and performance metrics such as noise figure, S-parameters, EVM, BER, and dynamic range	**K2**
CO2	Analyze RF amplifier behavior including noise modeling, nonlinear characteristics, intermodulation distortion, and cascade performance.	**K4**
CO3	Develop and simulate mixer and oscillator models, frequency translation effects, phase noise, and spurious responses in RF systems.	**K3**
CO4	Design and evaluate RF receiver and transmitter architectures including superheterodyne, direct conversion, and low-IF systems for multimode and multiband applications.	**K3**
CO5	Apply RF system design concepts to analyze and evaluate overall communication system performance.	**K3**

UNIT I BASICS OF RADIO FREQUENCY SYSTEM DESIGN	**9**
System Parameter definitions: Gain, noise figure, SNR, Characteristic impedance, Sparameters, Impedance matching and Decibels, Average value, RMS value, Crest factor, sensitivity, selectivity, dynamic range and, adjacent and alternate channel power leakages. Elements of digital base band signaling: complex envelope of band pass signals, Sampling, jitter, ISI, pulse shaping, IQ imbalance, EVM, BER.	

UNIT II AMPLIFIER MODELING AND ANALYSIS	9
Noise: Noise equivalent model for Radio frequency device, amplifier noise model, cascade performance, minimum detectable signal, performance of noisy systems in cascade. Non-Linearity: Amplifier power transfer curve, gain compression, AM-AM, AM-PM, polynomial approximations, Saleh model, Wiener model and Hammerstein model, intermodulation, Single and two tone analyses, second and third order distortions and measurements, SOI and TOI points, cascade performance of nonlinear systems.	
UNIT III MIXER AND OSCILLATOR MODELING AND ANALYSIS	**9**
Mixers: Frequency translation mechanisms, frequency inversion, image frequencies, spurious calculations, principles of mixer realizations. Oscillators: phase noise and its effects, effects of oscillator spurious components, frequency accuracy, oscillator realizations: Frequency synthesizers, NCO.	
UNIT IV RADIO ARCHITECTURES AND DESIGN CONSIDERATIONS	**9**
Superheterodyne architecture, direct conversion architecture, Low IF architecture, bandpass sampling radio architecture.	
UNIT V CASE STUDY: APPLICATIONS OF SYSTEMS DESIGN	**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	
TOTAL : 45 PERIODS	

REFERENCES:

1. QizhengGu, RF System Design of Transceivers for Wireless Communications, Springer, 2005.
2. Kevin Mc Claning, Wireless Receiver Design for Digital Communications, 2/3, Yes Dee Publications, 2012.
3. M C Jeruchim, P Balapan and K S Shanmugam, Simulation of Communication systems: Modeling, Methodology and Techniques, Kluwer Academic/Plenum Publishers, 2nd Edition,2000.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	2	-	-	-	-	-	2	2	1	–
2	3	3	-	2	2	-	-	-	-	-	2	3	2	1
3	2	2	3	2	3	-	-	-	-	-	2	3	2	2
4	2	2	3	2	3	1	-	-	-	-	2	3	3	2
5	3	3	2	2	2	2	-	-	-	-	2	3	2	2
Avg.	**2.6**	**2.4**	**2.6**	**2.0**	**2.4**	**1.5**	**-**	**-**	**-**	-	**2.0**	**2.8**	**2.0**	**1.7**

VL25C01	VLSI FOR WIRELESS COMMUNICATION	L	T	P	C
		3	0	0	3
Course Objectives:	• To understand the fundamentals of wireless communication system design using VLSI technology. • To study RF front-end architectures and their role in wireless transceivers. • To analyze the design and performance of mixers, amplifiers, ADCs, and frequency synthesizers. • To evaluate the effects of power consumption, noise, and circuit non-idealities on system performance. • To implement wireless communication circuits using modern CMOS VLSI design techniques.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Understand the Wireless System Blocks and Their Circuit-Level Implications.	**K2**
CO2	Analyze and Design Front-End Receiver Components Like LNA And Mixers.	**K4**
CO3	Implement ADC Architectures AND Assess Their Performance for Wireless Systems.	**K3**
CO4	Develop And Simulate PLLS And Transmitter Components Including Pas.	**K3**
CO5	Analyze the impact of wireless channel conditions on system performance using modulation and BER evaluation techniques.	**K4**

UNIT I COMMUNICATION SYSTEMS and WIRELESS CHANNEL MODELS	**9**
Overview of Wireless Systems and Standards. TDMA, FDMA, CDMA, OFDMA. Modulation Schemes (BPSK, QPSK, MSK, OFDM). Classical And Wireless Channel Models – Path Loss, Multipath Fading, Doppler Spread, Coherence Bandwidth.	
UNIT II RECEIVER ARCHITECTURES AND LNA DESIGN	**9**
Receiver Types: Heterodyne, Homodyne, And Low-If. RF Front-End: Bandpass Filters, Noise Figure, Linearity, Gain. Wideband And Narrowband Lna Design, Matching Networks, NF Vs Power Trade-Off.	
UNIT III MIXER DESIGN – ACTIVE AND PASSIVE	**9**
Gilbert Cell Mixer, Conversion Gain, Distortion, Noise Figure, Lo-Rf Isolation. Switching Mixers, Sampling Mixers – Non-Idealities and Noise Analysis.	
UNIT IV A/D CONVERTERS IN WIRELESS SYSTEMS	**9**
Demodulators And ADC Types: Flash, Pipeline, And Sigma-Delta. Band Pass Vs Low Pass ΣΔ Modulators. Implementation With Switched-Capacitor Circuits. I/Q Mismatch.	
UNIT V FREQUENCY SYNTHESIZERS AND TRANSMITTER	**9**
PLL-Based Frequency Synthesizers, Phase Detectors, VCOS, Loop Filters. Phase Noise and Spur Analysis. Transmitter Architectures – Quadrature Lo Generation, Pa Design (Class A, B, E), Linearity, Output Control.	
TOTAL : 45 PERIODS	

REFERENCES:
1. Bosco Leung, VLSI for Wireless Communication, Second Edition, Springer, 2011.
2. BehzadRazavi, RF Microelectronics, Second Edition, Pearson, 2011.
3. BehzadRazavi, Design of Analog CMOS Integrated Circuits, Second Edition, McGraw-Hill, 2017.
4. K. K. Parhi, VLSI Digital Signal Processing Systems: Design and Implementation, Reprint, Wiley India, 2019.
5. Andreas F. Molisch, Wireless Communications: From Fundamentals to beyond 5G, Third edition, IEEE Press, 2022.

Mapping of COs with POs / PSOs														
	POs											**PSOs**		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	-	2	-	-	-	-	-	1	3	2	-
2	3	3	3	2	3	-	-	-	-	-	1	3	3	-
3	2	2	3	3	3	-	-	-	-	-	2	3	3	2
4	2	2	3	3	3	-	-	-	-	-	2	3	3	2
5	2	3	2	3	2	-	-	-	-	-	2	3	3	2
Avg.	**2.4**	**2.4**	**2.4**	**2.7**	**2.6**	**-**	**-**	**-**	**-**	**-**	**1.6**	**3.0**	**2.8**	**2.0**

CU25C06	MACHINE LEARNING	L	T	P	C
		3	1	0	4
Course Objectives:	• To understand the fundamental concepts and techniques of machine learning for communication systems. • To develop supervised, unsupervised, and deep learning models for signal processing applications. • To apply machine learning methods to network optimization and real-world communication problems. • To gain practical experience using open-source tools for designing and evaluating intelligent systems. • To explore emerging trends and ethical considerations in AI-driven communication technologies.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamental concepts of machine learning and summarize their significance in communication systems applications.	**K2**
CO2	Apply supervised learning algorithms to solve classification and regression problems in communication signal analysis.	**K3**
CO3	Analyze unsupervised learning techniques and demonstrate their use in clustering and dimensionality reduction of communication data.	**K4**
CO4	Design and implement deep learning models, including convolutional and recurrent neural networks, for advanced signal processing tasks.	**K3**
CO5	Develop reinforcement learning strategies and propose innovative solutions for dynamic resource management in communication systems.	**K3**

UNIT I INTRODUCTION TO MACHINE LEARNING AND COMMUNICATION SYSTEMS	**9**
Fundamentals of Machine Learning – Types of Learning: Supervised, Unsupervised, Reinforcement – Key Concepts: Model, Training, Testing, Overfitting, Underfitting – Performance Metrics for Regression and Classification – Relevance of Machine Learning in Modern Communication Systems – Overview of Communication Signal Processing Tasks – Case Studies: Modulation Classification, Channel Estimation – Introduction to ML Frameworks (Scikit-learn, TensorFlow) – Data Preprocessing andFeature Engineering for Communication Data.	
UNIT II SUPERVISED LEARNING METHODS AND APPLICATIONS	**9**
Linear Regression and Logistic Regression for Signal Detection – Decision Trees and Random Forests for Communication Protocol Analysis – Support Vector Machines for Modulation Recognition – k-Nearest Neighbors for Error Pattern Identification – Ensemble Methods in Communication Tasks –	

Model Evaluation and Cross-Validation Strategies – Feature Selection Techniques – Application Examples: Spectrum Sensing, QoS Prediction – Implementation Exercises Using Python Libraries

UNIT III UNSUPERVISED LEARNING AND DIMENSIONALITY REDUCTION	**9**

Linear Regression and Logistic Regression for Signal Detection – Decision Trees and Random Forests for Communication Protocol Analysis – Support Vector Machines for Modulation Recognition – k-Nearest Neighbors for Error Pattern Identification – Ensemble Methods in Communication Tasks – Model Evaluation and Cross-Validation Strategies – Feature Selection Techniques – Application Examples: Spectrum Sensing, QoS Prediction – Implementation Exercises Using Python Libraries

UNIT IV UNSUPERVISED LEARNING AND DIMENSIONALITY REDUCTION	**9**

Clustering Methods: k-Means, Hierarchical Clustering for Traffic Pattern Analysis – Gaussian Mixture Models for Signal Classification – Principal Component Analysis and Independent Component Analysis for Feature Extraction – Manifold Learning Techniques – Visualization of High-Dimensional Communication Data – Autoencoders for Denoising and Compression – Anomaly Detection in Network Traffic – Case Study: Blind Source Separation – Hands-on Session: Implementing Clustering and Dimensionality Reduction.

UNIT V DEEP LEARNING TECHNIQUES IN COMMUNICATION SYSTEMS	**9**

Artificial Neural Networks: Architectures and Training – Convolutional Neural Networks for Modulation and Signal Classification – Recurrent Neural Networks and LSTM for Sequential Data and Channel Modeling – Transfer Learning Approaches – Regularization and Optimization in Deep Networks – Model Interpretability and Explainability – Performance Metrics for Deep Learning Models – Applications: End-toEnd Communication Systems, MIMO Detection – Practical Implementation with TensorFlow/Keras.

TOTAL : 45 PERIODS

REFERENCES:

1. Goodfellow, I., Bengio, Y., and Courville, A. Deep learning (2nd ed.). MIT Press,2021.
2. Murphy, K. P. Probabilistic machine learning: An introduction (1st ed.). MIT Press,2022.
3. Géron, A. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow (3rd ed.). O'Reilly Media,2022.
4. Simeone, O. Machine learning for engineers (1st ed.). Cambridge University Press,2022.
5. Hastie, T., Tibshirani, R., and Friedman, J. The elements of statistical learning: Data mining, inference, and prediction (3rd ed.). Springer,2020.

Mapping of COs with POs / PSOs														
POs												PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	2	-	-	-	1	-	2	3	2	-
2	3	3	2	2	3	-	-	-	1	-	2	3	3	2
3	2	3	2	3	3	-	-	-	2	-	2	3	3	2
4	3	3	3	2	3	-	-	1	2	-	2	3	3	3
5	3	3	3	2	3	1	1	2	2	1	3	3	3	3
Avg.	**2.8**	**2.8**	**2.5**	**2.2**	**2.8**	**1.0**	**1.0**	**1.5**	**1.6**	**1.0**	**2.2**	**3.0**	**2.8**	**2.5**

CU25C07	ADVANCED WIRELESS COMMUNICATION NETWORKS	L	T	P	C
		3	0	2	4
Course Objectives:	• To understand the architectures and evolution of UMTS, LTE, and 5G wireless communication systems. • To study the key building blocks, use cases, and networking principles of 5G technology. • To examine the standards and advancements in 4G and 5G wireless networks. • To analyze emerging wireless communication paradigms, including massive machine-type communication (mMTC). • To learn the fundamentals of OFDM and CDMA techniques for multicarrier and multiuser communication.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the architecture and protocols of 4G LTE systems including E-UTRAN, EPC, and LTE air interface and 5G architecture, use cases, millimeter-wave communication principles, and massive MIMO concepts	**K2**
CO2	Analyze LTE air interface protocol stack, channel structures, resource grid, and bearer management mechanisms and5G radio access technologies including NOMA, V2X, mMTC, and METIS channel models	**K4**
CO3	Design and evaluate coordinated multi-point transmission, relaying techniques, and massiveMTC systems using simulation tools	**K4**
CO4	Implement and test 4G/5G network models, D2D communication, and smart antenna systems in laboratory environments	**K3**
CO5	Analyze the performance of 4G/5G wireless systems under different channel conditions and emerging applications.	**K4**

UNIT I 4G ARCHITECTURE	**9**
Overview of current advanced wireless technologies - High Level architecture of 4G – Evolved UMTS Terrestrial Radio Access Network – Evolved Packet Core – Communication Protocols – Bearer Management. Architecture of LTE Air Interface – Air Interface protocol stack, logical, physical and transport channels, The Resource grid, Resource element mapping.MAC Protocol – Radio Link Control Protocol – Packet Data Convergence Protocol.	
UNIT II 5G ARCHITECTURE AND MILLIMETER WAVE COMMUNICATIONS	**9**
Key building blocks of 5G – 5G use cases and System Concepts – The 5G Architecture. Millimeter Wave Communications : Hardware technologies for mmW systems Architecture and mobility – Massive MIMO – Resource Allocation and	

UNIT III 5G WAVEFORMS AND CHANNEL MODELS	9
5G Radio Access Technologies: Design principles - Multi-carrier with filtering - Nonorthogonal Multiple Access - Radio access for dense deployments – Radio Access for V2X Communication - Radio access for massive machine-type communication - 5G wireless propagation channel models: Modeling requirements and scenarios - The METIS channel models.	
UNIT IV NETWORKING IN 5G	**9**
Coordinated multi-point transmission in 5G: Joint Transmission CoMP enablers - Distributed cooperative transmission - JT CoMP with advanced receivers - Relaying and network coding in 5G: Multi-flow wireless backhauling - Buffer-aided relaying.	
UNIT V EVALUATION OF 5G AND 5G APPLICATIONS	**9**
Machine-type communications: Fundamental techniques for MTC - Massive MTC - Ultrareliable low-latency MTC - Device-to-device (D2D) communications - Multi-hop D2D communications - Multi-operator D2D communication - Simulation methodology: Evaluation methodology – Calibration - New challenges in the 5G modelling	
TOTAL : 45 PERIODS	

PRACTICALS:

1. Modeling a 4G LTE System
2. Test and Measurement of 4G LTE Baseband signals
3. Design of MIMO System 4. Analysis and study of millimetre wave applications
5. Simulation of NOMA Principles
6. METIS Modeling
7. Simulation of Joint Transmission CoMP
8. Analysis of buffer-aided relaying
9. Design of Massive MTC. 10 Implementation and testing of Device to Device Communication

TOTAL : 30 PERIODS

REFERENCES:

1. Cox, C. An introduction to LTE, LTE-Advanced, SAE and 4G mobile communications. Wiley,2012.
2. Osseiran, A., Monserrat, J. F., and Marsch, P. 5G mobile and wireless communications technology. Cambridge University Press,2016.
3. Xiang, W., Zheng, K., and Shen, X. 5G mobile communications. Springer,2017.
4. Rodriguez, J. Fundamentals of 5G mobile networks. John Wiley and Sons, Ltd,2015.
5. Ahmadi, S. LTE-Advanced: A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies. Elsevier,2014.

Mapping of COs with POs / PSOs														
POs												PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	1	-	-	-	-	-	2	3	2	-
2	3	3	-	2	2	-	-	-	-	-	2	3	3	2
3	2	3	3	3	3	-	-	-	-	-	2	3	3	2
4	2	2	2	3	3	-	-	-	1	-	2	3	3	3
5	2	3	2	3	2	1	-	-	-	-	2	3	3	2
Avg.	**2.4**	**2.6**	**2.3**	**2.8**	**2.2**	**1.0**	**-**	**-**	**1.0**	**-**	**2.0**	**3.0**	**2.8**	**2.2**

CU25202	ADVANCED COMMUNICATION SYSTEMS LABORATORY	L	T	P	C
		0	0	4	2
Course Objectives:	• To study and measure the performance of digital communication systems. • To provide a comprehensive knowledge of Wireless Communication. • To learn about the design of digital filter and its adaptive filtering algorithms.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Implement and demonstrate binary digital modulation and demodulation techniques and analyze their performance under ideal and noisy channel conditions.	**K3**
CO2	Design and implement channel coding and decoding schemes including linear, cyclic, convolutional, and turbo codes for error control	**K3**
CO3	Design and simulate advanced communication systems such as DSSS, CDMA, OFDM, synchronization modules, and channel equalizers	**K3**
CO4	Evaluate wireless channel characteristics and adaptive algorithms such as LMS and RLS for noise and echo cancellation using simulation tools.	**K5**
CO5	Analyze the performance of digital communication systems under various channel conditions using simulation tools	**K4**

LIST OF EXPERIMENTS(MATLAB/SCILAB/LABVIEW)

1. Generation and detection of binary digital modulation techniques.
2. Implementation of Linear and Cyclic codes.
3. Spread Spectrum communication system-Pseudo random binary sequence generation- Baseband DSSS.
4. Performance evaluation of simulated CDMA system
5. Channel Coder/decoder design (block codes / convolutional codes/ turbo codes) 6. OFDM transceiver design.
7. Channel equalizer design.
8. Noise / Echo cancellation using MATLAB (LMS / RLS algorithms).
9. Study of synchronization (frame, bit, symbol.)
10. Wireless channel characterization.

HARDWARE / SOFTWARE REQUIRED:

SOFTWARE: MATLAB
TOTAL: 60 PERIODS

Mapping of COs with POs / PSOs														
	POs											**PSOs**		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	2	3	-	-	-	-	-	2	3	3	2
2	3	2	3	2	3	-	-	-	-	-	2	3	3	2
3	3	3	3	2	3	-	-	-	1	-	2	3	3	3
4	2	3	2	3	3	1	-	-	-	-	2	3	3	3
5	2	3	2	3	3	2	-	-	-	-	2	3	3	2
Avg.	**2.6**	**2.6**	**2.2**	**2.4**	**3.0**	**1.5**	**-**	-	**1.0**	**-**	**2.0**	**3.0**	**3.0**	**2.4**

Programme Elective Courses

PE25P01	WAVELETS AND SUB BAND CODING	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of wavelets and subband coding for signal representation and analysis. • To apply multirate signal processing techniques, including sampling rate conversion methods. • To design and analyze digital filter banks for perfect reconstruction systems. • To implement the Discrete Wavelet Transform (DWT) using Multiresolution Analysis (MRA). • To evaluate and compare the performance of various wavelet and subband coding techniques for signal processing applications.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the concepts of Hilbert spaces, Fourier theory, sampling, and time-frequency signal representations.	**K2**
CO2	Apply discrete-time signal expansion techniques and design two-channel, multichannel, and tree-structured filter banks.	**K3**
CO3	Implement multiresolution analysis and construct wavelets using Fourier and filter bank techniques.	**K3**
CO4	Apply Continuous Wavelet Transform (CWT), Short-Time Fourier Transform (STFT), and frame theory for signal analysis and reconstruction.	**K3**
CO5	Utilize wavelet and subband coding techniques for speech, audio, image, and video compression applications.	**K3**

UNIT I INTRODUCTION TO SIGNAL DECOMPOSITIONS	**9**
Notations - Hilbert Spaces: Vector Spaces and Inner products, Complete Inner Product Spaces, Orthonormal Bases - Elements of Linear Algebra - Fourier Theory and Sampling - Signal Processing - Time Frequency Representations	
UNIT II DISCRETE-TIME BASES AND FILTER BANKS	**9**
Series Expansions of Discrete - Time Signals - Two-Channel Filter Banks - Tree-Structured Filter Banks - Multichannel Filter Banks - Pyramids and Over complete Expansions - Multidimensional Filter Banks - Tran multiplexers and Adaptive Filtering in Subbands	
UNIT III MULTIRESOLUTION ANALYSIS AND CONSTRUCTION OF WAVELETS	**9**
Multiresolution Concept and Analysis - Construction of Wavelets Using Fourier Techniques - Wavelets Derived from Iterated Filter Banks and Regularity - Wavelet Series and Its Properties - Generalizations in One Dimension – Multidimensional Wavelets - Local Cosine Bases	

UNIT IV CONTINUOUS WAVELET AND FRAMES	9
Continuous Wavelet Transform: Analysis and Synthesis, Properties, Morlet Wavelet - Continuous Short-Time Fourier Transform: Properties - Frames of Wavelet and Short-Time Fourier Transforms: Discretization of Continuous-Time Wavelet and Short-Time Fourier Transforms, Reconstruction in Frames, Frames of Wavelets and STFT	
UNIT V SIGNAL COMPRESSION AND SUB BAND CODING	**9**
Compression Systems Based on Linear Transforms - Speech and Audio Compression - Image Compression: Transform and Lapped Transform Coding of Images, Pyramid Coding of Images, Subband and Wavelet Coding of Images, Advanced Methods in Subband and Wavelet Compression - Video Compression - Joint Source-Channel Coding	
TOTAL : 45 PERIODS	

REFERENCES:

1. Vetterli, M., and Kovačević, J. Wavelets and subband coding. Prentice Hall,1995.
2. Soman, K. P., and Ramachandran, K. I. Insight into wavelets – From theory to practice (3rd ed.). PHI Learning Private Limited,2013.
3. Rao, R. M., and Bopardikar, A. S. Wavelet transforms: Introduction to theory and applications (3rd ed.). Prentice Hall PTR,2012.
4. Strang, G., and Nguyen, T. Wavelets and filter banks (2nd ed.). Wellesley-Cambridge Press,1996.
5. Mallat, S. A wavelet tour of signal processing (3rd ed.). Academic Press,2008.
6. Akay, M. Time frequency and wavelets in biomedical signal processing. Wiley-IEEE Press,1997.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	1	2	-	-	-	-	-	1	3	2	1
2	3	3	3	2	3	-	-	-	-	-	1	3	3	2
3	3	2	3	3	3	-	-	-	-	-	2	3	3	2
4	2	3	2	3	3	-	-	-	2	-	2	3	3	2
5	2	3	3	2	3	2	-	-	2	-	2	3	3	3
Avg.	**2.6**	**2.6**	**2.75**	**2.2**	**2.8**	**2.0**	**-**	**-**	**2.0**	**-**	**1.6**	**3.0**	**2.8**	**2.0**

PE25P02	WIRELESS SENSOR NETWORKS AND WBAN	L	T	P	C
		3	0	0	3
Course Objectives:	• To understand the architecture, characteristics, challenges, and applications of Wireless Sensor Networks (WSNs). • To analyze sensor node components, energy consumption models, and network architectures for WSNs. • To apply MAC and routing protocols for efficient communication and energy management in wireless sensor networks. • To implement topology control, clustering, localization, synchronization, and data aggregation techniques in WSNs. • To explore Wireless Body Area Networks (WBANs), including architecture, protocols, energy management, and performance analysis for healthcare applications.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the architecture, characteristics, challenges, and applications of Wireless Sensor Networks (WSNs).	**K2**
CO2	Apply sensor node design principles, energy consumption models, and network architecture concepts in WSNs.	**K3**
CO3	Apply MAC protocols, IEEE 802.15.4/ZigBee standards, and energy-efficient routing techniques in wireless sensor networks.	**K4**
CO4	Implement topology control, clustering, localization, synchronization, and data aggregation techniques for WSN data management.	**K3**
CO5	Apply Wireless Body Area Network (WBAN) architectures, protocols, and energy management techniques to analyze system performance.	**K3**

UNIT I OVERVIEW OF WIRELESS SENSOR NETWORKS	**9**
Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks- case study, Enabling Technologies for Wireless Sensor Networks	
UNIT II MAC AND ROUTING	**9**
Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts. Physical Layer and Transceiver Design Considerations	

UNIT III ARCHITECTURES	9
MAC Protocols for Wireless Sensor Networks, IEEE 802.15.4, ZigBee, Low Duty Cycle Protocols and Wakeup Concepts - S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy Efficient Routing, Geographic Routing.	
UNIT IV INFRA STRUCTURE ESTABLISHMENT AND DATA MANAGEMENT	**9**
Topology Control, Clustering, Time Synchronization, Localization and Positioning- Data management in WSN, Storage and indexing in sensor networks, Query processing in sensor, Data aggregation.	
UNIT V WIRELESS BODY AREA NETWORK	**9**
Introduction to WBAN Standard-Architecture-WBAN layers- Network and MAC Protocol Design for WBAN-Energy Management in WBAN-Performance Analysis of WBAN- Miniaturized Antennas Implanted Antennas- PHY layer for UWB WBAN. Case study using Simulation Tools.	
TOTAL : 45 PERIODS	

REFERENCES:

1. Karl, H., and Willig, A.Protocols and architectures for wireless sensor networks. John Wiley,2005.
2. Akyildiz, I. F., and Vuran, M. C. Wireless sensor networks. John Wiley,2010.
3. Li, Y., Thai, M. T., and Wu, W. Wireless sensor networks and applications. Springer,2008.
4. Li, H.-B., Yekeh Yazdandoost, K., and Bin-Zhen.Wireless body area networks. River Publishers,2010.
5. Thotahewa, K. M. S., Redoute, J.-M., and Yuce, M.R.Ultra-wideband wireless body area networks. Springer,2016.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	1	-	-	-	-	-	2	2	2	2
2	3	3	2	1	2	-	-	-	-	-	2	3	2	2
3	3	3	2	2	3	-	-	-	-	-	2	3	3	2
4	2	3	3	3	3	-	-	-	-	-	2	3	3	2
5	2	3	2	2	2	2	2	-	-	-	2	2	3	2
Avg.	**2.6**	**2.8**	**2.2**	**2.0**	**2.2**	**2.0**	**2.0**	**-**	**-**	**-**	**2.0**	**2.6**	**2.6**	**2.0**

PE25P03	ULTRA WIDE BAND COMMUNICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand UWB fundamentals, technologies, regulations, and benefits in wireless communication systems. • To analyze UWB antenna design, performance, and compatibility with multiband and MIMO systems. • To model and evaluate UWB channels for path loss, delay, and interference. • To explore UWB signal processing, modulation, access methods, and receiver architectures. o To examine UWB applications in radar, positioning, healthcare, automotive, and future trends.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamentals, regulations, standards, and applications of Ultra-Wideband (UWB) communication systems.	**K2**
CO2	Apply UWB antenna design principles and evaluate the performance of MIMO multiband OFDM systems.	**K3**
CO3	Analyze UWB wireless channel models and implement interference mitigation techniques.	**K4**
CO4	Apply UWB modulation, multiple access, and receiver techniques to evaluate system performance.	**K3**
CO5	Utilize UWB technologies for radar, imaging, positioning, medical, automotive, and emerging wireless applications.	**K3**

UNIT I INTRODUCTION ABOUT UWB FOR WIRELESS COMMUNICATIONS	**9**
UWB concepts, advantages and challenges, single band versus multiband, FCC emission limits, UWB technologies - IR-UWB, pulsed multiband, MB-OFDM, MIMO variants and their features, UWB applications. Overview of UWB Regulation in various countries, UWB Regulation in ITU, IEEE Standardization.	
UNIT II UWB ANTENNAS	**9**
UWB Antennas: Antenna Requirements, Radiation Mechanism - Link Budget for UWB System-Short Range Analysis of UWB Antennas. MIMO Multiband OFDM, Differential multiband OFDM, Performance characterization.	
UNIT III UWB WIRELESS CHANNELS AND INTERFERENCE	**9**
UWB channel modeling: impulse response, IEEE models, path loss, delay/frequency profiles Modified Impulse Response Method-IEEE UWB Channel Model - Frequency Modeling of UWB Channels - Comparison of Time and Frequency Models. **UWB Interference:** Interference with WLAN, Signal to Interference ratio calculation, Interference with other wireless services. Interference of UWB to OFDM System, Narrowband Systems - Interference Reduction- Interference Mitigation of Wideband System on UWB using Multicarrier Templates.	

UNIT IV UWB SIGNAL PROCESSING	9
Data Modulation schemes and their comparison-UWB Multiple Access Modulation-Uniform Pulse Train Spacing-Pseudorandom Time Hopping-Direct Sequence UWB (DS-UWB)- BER of Modulation Schemes- Rake Receiver- Transmit-Reference (T-R) Technique-UWB Range- Data Rate Performance-UWB Channel Capacity.	
UNIT V APPLICATIONS AND RECENT TRENDS IN UWB	**9**
Receiver architecture, ad-hoc networks and sensor systems - UWB in radar and imaging systems, indoor positioning systems (IPS), medical applications and wearable devices, automotive (collision avoidance, keyless entry), Emerging research trends and future challenges	
	TOTAL : 45 PERIODS

REFERENCES:

1. Nikookar, H., and Prasad, R. Introduction to ultra wideband for wireless communications (1st ed.). Springer Science and Business Media B.V.,2010.
2. Reed, J. H.An introduction to ultra wideband communication systems. Prentice Hall PTR,2005.
3. Ghavami, M., Michael, L. B., and Kohno, R. Ultra wideband signals and systems in communication engineering (2nd ed.). Wiley,2007.
4. N, F. Ultra-wideband communications: Fundamentals and applications. Prentice Hall PTR,2011.
5. Zwick, T., and Wiesbeck, A. Ultra-wideband RF system engineering (1st ed.). Wiley-IEEE Press,2012.
6. Siwiak, K., and McKeown, D. Ultra-wideband radio technology. John Wiley and Sons,2004.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	1	-	-	-	1	-	2	2	1	2
2	3	2	3	2	3	-	-	-	-	-	2	3	3	2
3	2	3	2	3	3	2	2	-	-	-	2	3	3	2
4	3	3	2	2	3	-	-	-	-	-	2	3	3	2
5	2	2	3	1	2	2	2	-	2	-	2	2	3	2
Avg.	**2.6**	**2.4**	**2.5**	**2.0**	**2.4**	**2.0**	**2.0**	**-**	**2.0**	**-**	**2.0**	**2.6**	**2.6**	**2**

PE25P04	COGNITIVE RADIO COMMUNICATIONS	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of Software Defined Radio (SDR) and Cognitive Radio (CR) technologies. • To explain the architectures, functions, and operational principles of SDR and CR systems. • To analyze spectrum sensing and dynamic spectrum access techniques in cognitive radio networks. • To apply cognitive behavior and decision-making strategies for adaptive wireless communications. • To evaluate cooperative communication methods and performance limits of cognitive radio networks

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the concepts, architecture, and functional components of Software Defined Radio (SDR).	**K2**
CO2	Describe the architecture, cognition cycle, and operational principles of Cognitive Radio (CR) systems.	**K2**
CO3	Apply spectrum sensing and spectrum opportunity detection techniques for cognitive radio networks.	**K3**
CO4	Utilize cognitive behavior models and interference management techniques to enhance cognitive radio network performance.	**K3**
CO5	Apply user cooperative communication and relay-based networking concepts in cognitive wireless systems.	**K3**

UNIT I SOFTWARE DEFINED RADIO AND ITS ARCHITECTURE	**9**
Definitions and potential benefits, software radio architecture evolution, technology tradeoffs and architecture implications. Essential functions of the software radio, SDR, hardware architecture, software architecture, top level component interfaces, interface topologies among plug and play modules.	
UNIT II COGNITIVE RADIOS AND ITS ARCHITECTURE	**9**
Marking radio self-aware, cognitive techniques – position awareness, environment awareness in cognitive radios, optimization of radio resources, Cognitive Radio – functions, components and design rules, Cognition cycle – orient, plan, decide and act phases, Inference Hierarchy, Architecture maps, Building the Cognitive Radio Architecture on Software defined Radio Architecture.	
UNIT III SPECTRUM SENSING AND IDENTIFICATION	**9**
Primary Signal Detection: Energy Detector, Cyclostationary Feature Detector, Matched Filter, Cooperative Sensing , Definition and Implications of Spectrum Opportunity, Spectrum Opportunity Detection , Fundamental Trade-offs: Sensing Accuracy versus Sensing Overhead.	

UNIT IV INFORMATION THEORETICAL LIMITS ON CR NETWORKS	9
Types of Cognitive Behavior, Interference-Avoiding Behavior: Spectrum Interweave, Interference-Controlled Behavior: Spectrum Underlay, Underlay in Small Networks: Achievable Rates, Underlay in Large Networks: Scaling Laws, Interference-Mitigating Behavior: Spectrum Overlay, Opportunistic Interference Cancellation.	
UNIT V 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	
TOTAL : 45 PERIODS	

REFERENCES:

1. Wyglinski, A. M., Nekovee, M., and Hou, Y. T. Cognitive radio communications and networks: Principles and practice. Elsevier,2010.
2. Chen, K.-C., and Prasad, R. Cognitive radio networks. John Wiley and Sons,2009.
3. Khattab, A., Perkins, D., and Bayoumi, M.Cognitive radio networks: From theory to practice. Springer,2009.
4. Mitola, J.Cognitive radio: An integrated agent architecture for software defined radio (Doctoral dissertation, Royal Institute of Technology, Sweden),2000.
5. Haykin, S. Cognitive radio: Brain-empowered wireless communications. IEEE Journal on Selected Areas in Communications, 23(2), 201–220. https://doi.org/10.1109/JSAC.2004.839380,2005.
6. Akyildiz, I. F., Lee, W.-Y., Vuran, M. C., and Mohanty, S. Next generation/dynamic spectrum access/cognitive radio wireless networks: A survey.Computer Networks, 50(13), 2127–2159,2006.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	2	-	-	-	2	-	2	3	2	1
2	3	2	-	-	2	-	-	-	2	-	2	3	3	2
3	3	3	2	2	3	-	-	-	-	-	2	3	3	2
4	3	3	3	2	3	2	-	-	-	-	2	3	3	2
5	3	2	3	2	3	2	-	2	2	-	2	2	3	3
Avg.	**3.0**	**2.4**	**2.6**	**2.0**	**2.6**	**2.0**	**-**	**2.0**	**2.0**	**-**	**2.0**	**2.8**	**2.8**	**2.0**

PE25P05	QUANTUM COMMUNICATION AND NETWORKING	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of quantum information and quantum communication. • To explain the principles of quantum states, qubits, and quantum operations. • To apply quantum communication protocols for information transfer. • To implement quantum cryptographic techniques for secure communication. • To analyze quantum networking concepts and emerging quantum communication systems.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamental concepts of quantum information, qubits, quantum states, and quantum gates.	**K2**
CO2	Apply quantum communication principles and protocols, including quantum teleportation and superdense coding	**K3**
CO3	Implement quantum cryptographic protocols such as BB84 and E91 for secure communication.	**K3**
CO4	Apply quantum networking techniques including entanglement distribution, quantum repeaters, and routing mechanisms.	**K3**
CO5	Utilize hybrid classical–quantum networks and quantum internet concepts to address emerging communication challenges.	**K3**

UNIT I FUNDAMENTALS OF QUANTUM INFORMATION	**9**
Quantum carriers Qubits and quantum states, Superposition and measurement, Bloch sphere, Multi-qubit systems, Tensor products, Quantum gates and circuits, No-cloning theorem.	
UNIT II QUANTUM COMMUNICATION PRINCIPLES	**9**
Classical vs quantum communication, Quantum channels, Density matrices, Noise and decoherence, Quantum error models, Holevo bound, protocols: Quantum teleportation, Superdense coding, Entanglement-based communication, Bell states.	
UNIT III QUANTUM CRYPTOGRAPHY	**9**
Introduction to cryptography, Quantum Key Distribution (QKD), BB84 protocol, E91 protocol, Security analysis, Eavesdropping strategies, Practical QKD implementations.	
UNIT IV QUANTUM NETWORKING FUNDAMENTALS	**9**
Entanglement distribution, Quantum repeaters, Quantum routing and switching, Quantum network architectures	

UNIT V QUANTUM INTERNET AND ADVANCED NETWORKING	9
Hybrid classical–quantum networks, Quantum internet vision, Challenges and future directions	
TOTAL : 45 PERIODS	

REFERENCES:

1.Van Meter, R. Quantum networking. Wiley,2014.
2.Imre, S., and Gyongyosi, L. Advanced quantum communications: An engineering approach. Wiley-IEEE Press,2013.
3.Wiesner, S., and Zbinden, H. Quantum cryptography. Springer,2019.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	1	2	-	-	-	2	-	2	2	2	1
2	3	3	2	2	3	1	-	-	2	-	2	2	3	2
3	2	3	2	2	3	2	3	-	2	-	2	3	3	2
4	3	3	3	2	3	1	-	2	2	-	2	3	3	2
5	2	3	3	2	3	2	1	2	2	2	3	2	3	2
Avg.	**2.6**	**2.8**	**2.2**	**1.8**	**2.8**	**1.5**	**2.0**	**2.0**	**2.0**	**2.0**	**2.2**	**2.4**	**2.8**	**1.8**

PE25P06	TELECOMMUNICATION SWITCHING SYSTEM MODELING AND SIMULATION	L	T	P	C
		3	0	0	3
Course Objectives:	• To enable the student to understand the various aspects of simulation methodology and performance, appreciate the significance of selecting sampling frequency and modelling different types of signals and processing them. • To expose the student to the different simulation techniques, their pros and cons and enable him to understand and interpret results using case studies.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain simulation methodologies, performance estimation techniques, and communication system models.	**K2**
CO2	Apply random number generation and random signal processing techniques for communication system simulations.	**K3**
CO3	Implement Monte Carlo simulation methods for performance evaluation of wireless communication systems.	**K3**
CO4	Apply modeling techniques for non-linear, time-varying, and waveform communication channels.	**K3**
CO5	Utilize efficient simulation techniques such as importance sampling, tail extrapolation, and PDF estimation for cellular radio system performance evaluation.	**K3**

UNIT I SIMULATION METHODOLOGY	**9**
Introduction, Aspects of methodology, Performance Estimation, Simulation sampling frequency, Low pass equivalent simulation models for bandpass signals, Multicarrier signals, Non-linear and time-varying systems, Post processing – Basic graphical techniques and estimations	
UNIT II RANDOM SIGNAL GENERATION AND PROCESSING	**9**
Uniform random number generation, Mapping uniform random variables to an arbitrary pdf, Correlated and Uncorrelated Gaussian random number generation, PN sequence generation, Random signal processing, Testing of random number generators.	
UNIT III MONTE CARLO SIMULATION	**9**
Fundamental concepts, Application to communication systems, Monte Carlo integration, Semianalytic techniques, Case study: Performance estimation of a wireless system	

UNIT IV ADVANCED MODELS AND SIMULATION TECHNIQUES	9
Modeling and simulation of non-linearities : Types, Memoryless non-linearities, Non-linearities with memory, Modeling and simulation of Time varying systems : Random process models, Tapped delay line model, Modelling and simulation of waveform channels, Discrete memoryless channel models, Markov model for discrete channels with memory.	
UNIT V EFFICIENT SIMULATION TECHNIQUES	**9**
Tail extrapolation, pdf estimators, Importance Sampling methods, Case study: Simulation of a Cellular Radio System.	
TOTAL : 45 PERIODS	

REFERENCES:

1. Pätzold, M. Mobile Radio Channels (2nd ed.). Wiley,2012.
2. Jeruchim, M. C., Balaban, P., and Shanmugan, K. S. Simulation of Communication Systems: Modeling, Methodology and Techniques (2nd ed.). Springer,2006.
3. Law, A. M. Simulation Modeling and Analysis (5th ed.). McGraw-Hill Education,2014.
4. Rappaport, T. S. Wireless Communications: Principles and Practice (2nd ed.). Prentice Hall,2002.
5. Proakis, J. G., and Salehi, M. Digital Communications (5th ed.). McGraw-Hill,2008.
6. Yates, R. D., and Goodman, D. J. Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers (3rd ed.). Wiley,2014.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	2	3	-	-	-	-	-	2	3	2	1
2	3	3	-	2	3	-	-	-	-	-	2	2	3	2
3	3	3	2	3	3	-	-	-	-	-	2	2	3	2
4	3	3	2	2	3	-	-	-	-	-	2	3	3	2
5	2	3	1	3	3	-	-	-	-	-	2	2	3	2
Avg.	**2.8**	**2.8**	**1.6**	**2.4**	**3.0**	**-**	**-**	**-**	**-**	**-**	**2.0**	**2.4**	**2.8**	**1.8**

PE25P07	MASSIVE MIMO AND MMWAVE SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of massive MIMO and millimeter-wave communication systems. • To explain the propagation characteristics and challenges of millimeter-wave channels. • To apply massive MIMO techniques for improving wireless system performance. • To design beamforming and signal processing schemes for next-generation networks. • To evaluate the applications and performance of massive MIMO and millimeter-wave technologies in advanced wireless communications.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamentals, architecture, and applications of Massive MIMO and millimeter-wave communication systems.	**K2**
CO2	Describe the propagation characteristics and channel models of millimeter-wave and Massive MIMO systems.	**K2**
CO3	Apply beamforming and precoding techniques for efficient transmission in Massive MIMO and millimeter-wave networks.	**K3**
CO4	Implement signal processing techniques for channel estimation, detection, and performance optimization in Massive MIMO systems.	**K3**
CO5	Apply Massive MIMO and millimeter-wave technologies in the design and evaluation of 5G and beyond wireless communication systems.	**K3**

UNIT I INTRODUCTION TO MASSIVE MIMO AND MMWAVE COMMUNICATION	**9**
Overview of 5G and Beyond Technologies- Introduction to Massive MIMO: Concept, evolution, and significance- Motivation for MMWAVE communication- MIMO vs. Massive MIMO- Basic architecture and key features of MMWAVE systems- Use cases and applications: 5G, IoT, vehicular, indoor	
UNIT II PROPAGATION AND CHANNEL MODELING	**9**
MMWAVE propagation characteristics: path loss, blockage, and reflection- Channel modeling for MMWAVE: LOS and NLOS scenarios- Spatial characteristics and sparsity in MMWAVE channels- Frequency selectivity and time variance- Massive MIMO channel modeling: Rayleigh, Rician, and geometry-based stochastic models- Channel correlation and estimation challenges.	
UNIT III BEAMFORMING AND PRECODING TECHNIQUES	**9**
Fundamentals of beamforming: analog, digital, and hybrid beamforming- Directional transmission and beam management- Codebook-based beamforming-	

Precoding techniques: MRT, ZF, MMSE- Hybrid precoding for MMWAVE MIMO- Beam training and feedback strategies.

UNIT IV SIGNAL PROCESSING IN MASSIVE MIMO SYSTEMS	9
Uplink and downlink processing- Channel estimation methods: TDD reciprocity, pilot contamination- Detection techniques: linear detectors, MMSE, successive interference cancellation-Power control and scheduling in large antenna systems-Spectral and energy efficiency optimization-Hardware impairments and mitigation.	
UNIT V SYSTEM DESIGN, STANDARDS, AND APPLICATIONS	**9**
5G NR and beyond physical layer overview-Integration of Massive MIMO and MMWAVE in 5G architecture- Antenna array design considerations for MMWAVE-Resource allocation and mobility management- Massive MIMO and MMWAVE in vehicular and industrial applications- Case studies and simulation platforms (MATLAB, NS-3, etc.)	
	TOTAL : 45 PERIODS

REFERENCES:

1. Marzetta, T. L., Larsson, E. G., Yang, H., and Ngo, H. Q. Fundamentals of massive MIMO. Cambridge University Press,2016.
2. Rappaport, T. S., Heath, R. W., Jr., Daniels, R. C., and Murdock, J. N. Millimeter wave wireless communications. Pearson Education,2014.
3. Osseiran, A., Monserrat, J. F., and Marsch, P. 5G mobile and wireless communications technology. Cambridge University Press,2016.
4. Tranter, W. H., Shanmugan, K. S., Rappaport, T. S., and Kosbar, K. L. Principles of communication systems simulation with wireless applications. Pearson Education,2004.
5. Du Preez, J., and Sinha, S. Millimeter wave antennas for 5G mobile terminals and base stations. Springer,2016.
6. Simon, M. K., and Alouini, M.-S. Digital communication over fading channels. Wiley,2005.
7. Dahlman, E., Parkvall, S., and Skold, J. 5G NR: The next generation wireless access technology. Academic Press,2018.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	-	2	-	-	-	2	-	1	3	2	–
2	3	3	-	2	2	-	-	-	2	-	1	3	–	–
3	3	3	3	2	3	-	-	-	2	-	1	3	3	2
4	3	3	2	3	3	-	-	-	2	-	2	3	2	–
5	3	3	3	2	3	2	1	1	2	1	2	–	3	2
Avg.	**3.0**	**2.8**	**2.25**	**2.25**	**2.6**	**2.0**	**1.0**	**1.0**	**2.0**	**1.0**	**1.4**	**3.0**	**2.4**	**2.0**

PE25P08	ADVANCED SATELLITE BASED SYSTEMS	L	T	P	C
		3	0	0	3
Course Objectives:	• To understand the fundamentals of satellite communication and navigation systems. • To explain the principles and applications of global navigation satellite systems. • To analyze remote sensing concepts for safety-of-life and monitoring services. • To design satellite-based communication and networking systems. • To simulate image processing and satellite-based IPv6 networks using open-source tools.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamentals of satellite communication systems, orbital mechanics, and Global Navigation Satellite Systems (GNSS).	**K2**
CO2	Apply GPS, inertial navigation, and differential GPS techniques for positioning and navigation applications.	**K3**
CO3	Utilize remote sensing systems, sensors, and image processing techniques for Earth observation and monitoring applications.	**K3**
CO4	Apply satellite-based broadcast and multimedia communication technologies for various communication services.	**K3**
CO5	Implement IPv6-based satellite communication networks and evaluate their impact on network architecture and services.	**K3**

UNIT I INTRODUCTION TO SATELLITE AND GPS	**9**
Origin of satellite communication, Development, Space segment, Ground segment, Types of orbit, Evolution of satellite communications, Development of service Global Navigation Satellite Systems – Basic concepts of GPS and its segments, GPS constellation, GPS measurement characteristics, selective availability (AS), Anti spoofing (AS).	
UNIT II INERTIAL NAVIGATION AND DIFFERENTIAL GPS	**9**
Systems Introduction to Inertial Navigation- Inertial Sensors - Navigation Coordinates-System Implementations- System-Level Error Models- Introduction to Differential GPSL,ADGPS,WADGPS-WAAS - GEO Uplink Subsystem (GUS) - GEO Uplink Subsystem (GUS) Clock Steering Algorithms - GEO Orbit Determination – Problems.	
UNIT III REMOTE SENSING SYSTEMS AND TECHNIQUES	**9**
Introduction - Commercial Imaging - Digital Globe – GeoEye - Meteorology – Meteosat – Land Observation – Landsat- Remote Sensing Data- Sensors- Overview	

- Optical Sensors: Cameras- Non-Optical Sensors- Image Processing - Image Interpretation-System Characteristics.

UNIT IV BROADCAST SYSTEMS **9**

Introduction - Satellite Radio Systems - XM Satellite Radio Inc. - Sirius Satellite Radio - world space- Direct Multimedia Broadcast- MBCO and TU Multimedia - European Initiatives - Direct-to-Home Television - Implementation Issues - DTH Services Representative DTH Systems – Military Multimedia Broadcasts - US Global Broadcast Service (GBS)- Business TV(BTV), GRAMSAT, Specialized services – E – mail, Video conferencing, Internet.

UNIT V SATELLITE COMMUNICATION IN IPV6 ENVIRONMENT **9**

Overview ofIPv6 and its benefits for Satellite Networks - Migration and Coexistence-Implementation scenarios and support- Preparations for IPv6 in Satellite communication-Satellite specific Protocol issues in IPv6 – Impact of IPv6 on Satellite Network architecture and services Detailed transitional plan- IPv6 demonstration over satellites - Key results and recommendations

TOTAL : 45 PERIODS

REFERENCES:

1. Maini, A. K., and Agrawal, V. Satellite technology: Principles and applications (3rd ed.). Wiley,2014.
2. Pratt, T., Bostian, C., and Allnutt, J. Satellite communications (2nd ed.). John Wiley,2013.
3. Pritchard, W. L., Suyderhoud, H. G., and Nelson, R. A.Satellite communication system engineering (2nd ed.). Pearson,2014.
4. Hofmann-Wellenhof, B., Lichtenegger, H., and Wasle, E. Global navigational satellite systems. Springer-Verlag,2008.
5. Minoli, D. Satellite systems engineering in an IPv6 environment (1st ed.). CRC Press,2009.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	2	-	-	-	-	-	1	3	2	-
2	3	3	2	2	3	-	-	-	-	-	1	2	3	-
3	2	3	2	3	3	2	-	-	-	-	1	-	3	-
4	3	2	2	-	3	-	-	-	2	-	1	3	3	-
5	3	3	2	2	3	-	-	-	2	1	1	-	3	-
Avg.	**2.8**	**2.6**	**2.0**	**2.3**	**2.8**	**2.0**	**-**	**-**	**2.0**	**1.0**	**1.0**	**2.6**	**2.8**	**-**

PE25P09	COMMUNICATION NETWORK DESIGN	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of telecommunication network architectures and services. • To apply quantitative modeling techniques for network performance analysis. • To explain multiplexing and switching principles in communication networks. • To design routing strategies for wired and wireless telecommunication networks. • To simulate and evaluate the performance of telecommunication network systems..

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamental concepts of telecommunication networks, quantitative modeling, and network performance measures.	**K2**
CO2	Apply multiplexing techniques and traffic models to evaluate network performance in wired and wireless environments.	**K3**
CO3	Apply queuing and switching models to analyze the performance of packet and circuit-switched networks.	**K3**
CO4	Implement shortest-path and QoS-based routing algorithms for efficient network operation.	**K3**
CO5	Design and simulate wired and wireless telecommunication networks using appropriate network simulation tools.	**K3**

UNIT I INTRODUCTION	**9**
Importance of Quantitative Modeling in Engineering of Telecommunication Networks, The Functional Elements of Networking, Evolution of Networking in the Wired and Wireless Domain.	
UNIT II MULTIPLEXING	**9**
Performance Measures and Engineering Issues Network performance and source characterization, Circuit multiplexed Networks, packet Multiplexing over wireless networks, Events and processes in packet multiplexer models, Deterministic traffic Models and network calculus, stochastic traffic models, LRD traffic, Link Scheduling and network capacity in wireless networks.	
UNIT III SWITCHING	**9**
Performance Measures of packet switches and circuit switches, queuing in packet switches, delay Analysis in Output Queued Switch, Input Queued Switch and CIOQ Switch with Parallelism, Blocking in Switching Networks, Closed Networks.	

UNIT IV ROUTING	9
Algorithms for Shortest Path Routing - Dijkstra's Algorithm, Bellman Ford Algorithm, Generalized Dijkstra's Algorithm, Optimal Routing, Routing Protocols-Distance Vector, Link State and Exterior gateway protocols, Formulations of the Routing Problem-minimum interference Routing, MPLS, QoS Routing, Non-additive and Additive metrics	
UNIT V CASE STUDIES	**9**
Design of a wireless network and a wired network, prototype implementation to be simulated in a network simulator.	
	TOTAL : 45 PERIODS

REFERENCES:

1.Kumar, A., Manjunath, D., and Joy, J. Communication networking. Morgan Kaufmann Publishers,2005.

2.Lean Garcia, A., and Widjaja, I. Communications networks. Tata McGraw-Hill,2004.

3.Robertazzi, T. G. Computer networks and systems (3rd ed.). Springer,2006.

4.Keshav, S.An engineering approach to computer networking. Addison–Wesley,1999.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	2		-	-	-	2	-	2	3	1	1
2	3	3	-	2	2	-	-	-	-	-	2	3	2	2
3	3	3	2	3	2	-	-	-	-	-	2	3	2	2
4	2	3	3	2	3	-	-	-	-	-	2	3	3	2
5	2	2	3	3	3	-	-	-	2	-	2	2	3	2
Avg.	**2.6**	**2.6**	**2.6**	**2.4**	**2.5**	-	-	-	**2.0**	-	**2.0**	**2.8**	**2.2**	**1.8**

PE25P10	DIGITAL COMMUNICATION RECEIVERS	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the architecture and principles of digital communication receivers. • To analyze the mathematical models of noise and synchronization in receiver design. • To explore techniques for carrier recovery, timing recovery, and equalization in practical systems. • To evaluate the performance of receivers in various modulation and fading environments. • To develop simulation models for modern digital receivers and validate theoretical findings.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the architecture, functional blocks, and performance metrics of digital communication receivers.	**K2**
CO2	Apply carrier and timing synchronization techniques for reliable signal recovery in digital communication systems.	**K3**
CO3	Implement channel estimation and adaptive equalization techniques to mitigate channel impairments.	**K3**
CO4	Apply advanced receiver algorithms, including MIMO detection and iterative decoding methods, for enhanced receiver performance.	**K3**
CO5	Design and simulate digital communication receivers using software and hardware implementation platforms.	**K3**

UNIT I INTRODUCTION TO DIGITAL COMMUNICATION RECEIVERS	**9**
Overview of digital communication system - Receiver model and functional blocks - Noise and channel impairments: AWGN, fading - Signal space representation, matched filter receiver - Performance metrics: BER, SNR, eye diagram analysis	
UNIT II CARRIER AND TIMING SYNCHRONIZATION	**9**
Carrier phase and frequency offset effects - Carrier recovery: Costas loop, PLL-based recovery - Timing recovery methods: early-late gate, Gardner timing error detector - Non-data-aided and decision-directed synchronization - Implementation challenges in practical systems	
UNIT III CHANNEL ESTIMATION AND EQUALIZATION	**9**
Channel modeling and effects on signals - Linear and decision-feedback equalizers - Adaptive equalization: LMS and RLS algorithms - Channel estimation techniques: pilot-based, blind estimation - Performance trade-offs in equalizer design	
UNIT IV ADVANCED RECEIVER ARCHITECTURES	**9**
Maximum likelihood and MAP receivers - Viterbi and BCJR algorithms - MIMO receivers: ZF, MMSE, successive interference cancellation Turbo equalization and iterative decoding - Software-defined radio (SDR) based receiver implementation.	

UNIT V SIMULATION AND IMPLEMENTATION ASPECTS	9
Simulation of baseband receivers using MATLAB/Simulink - FPGA/RTL modeling for digital front-ends - Hardware noise modeling and quantization effects - RF impairments: IQ imbalance, DC offset - Test frameworks for digital receivers	
TOTAL : 45 PERIODS	

REFERENCES:

1. Grami, A. Introduction to digital communications (2nd ed.). Academic Press,2021.
2. Rimoldi, B.Digital communication: A discrete-time approach (2nd ed.). Cambridge University Press,2022.
3. Proakis, J. G., and Salehi, M. Digital communications (5th ed.). McGraw-Hill,2007.
4. Meyr, H., Moeneclaey, M., and Fechtel, S. A.Digital communication receivers: Synchronization, channel estimation, and signal processing. Wiley,1997.
5. Sklar, B.Digital communications: Fundamentals and applications (2nd ed.). Prentice Hall,2001.
6. Rappaport, T. S. Wireless communications: Principles and practice (2nd ed.). Prentice Hall,2002.
7. Feher, K.Digital communications: Satellite/earth station engineering. Prentice Hall,1997.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	-	-	1	-	-	-	-	-	2	3	2	1
2	3	3	1	1	2	-	-	-	-	-	2	3	2	1
3	2	3	2	2	3	-	-	-	-	-	2	3	3	2
4	2	3	3	2	3	-	-	-	-	-	2	3	3	2
5	2	2	3	2	3	-	-	-	2	2	2	3	3	3
Avg.	**2.4**	**2.6**	**2.2**	**1.8**	**2.4**	**-**	**-**	**-**	**2.0**	**2.0**	**2.0**	**3.0**	**2.6**	**1.8**

PE25P11	CO-OPERATIVE COMMUNICATION	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of cooperative communication and green radio networks. • To explain energy-efficient communication techniques for wireless systems. • To apply cooperative diversity and relay-based transmission strategies. • To design resource allocation and power management schemes for green communications. • To evaluate the performance and energy efficiency of modern wireless networks.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the concepts, architectures, and design trade-offs of cooperative communication and green radio networks.	**K2**
CO2	Apply cooperative communication techniques in OFDM, MIMO, and LTE-Advanced wireless networks.	**K3**
CO3	Implement relay-based cooperative communication and resource allocation techniques for enhanced network performance.	**K3**
CO4	Apply power management and energy-saving strategies in green cellular wireless networks.	**K3**
CO5	Utilize cross-layer design and resource optimization techniques to improve the energy efficiency of green radio networks.	**K3**

UNIT I COOPERATIVE COMMUNICATIONS AND GREEN CONCEPTS	**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, Green modulation and coding schemes.	
UNIT II COOPERATIVE TECHNIQUES	**9**
Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbobasestations; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying and Coordinated multi-point transmission in LTE-Advanced.	
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; Network coding in relay-based networks, Co-operative relaying in NOMA, Coordinated Multipoint transmission in NOMA.	

UNIT IV GREEN RADIO NETWORKS	9
Base Station Power-Management Techniques- Opportunistic spectrum and load management, Energy-saving techniques in cellular wireless base stations , Power-management for base stations in smart grid environment , Cooperative multicell 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 multi hop cellular networks; Resource allocation for green communication in relay- based cellular networks; Green Radio Test-Beds and Standardization	
TOTAL : 45 PERIODS	

REFERENCES:

1. Hossain, E., Kim, D. I., and Bhargava, V. K. (). Cooperative cellular wireless networks. Cambridge University Press,2011.
2. Hossain, E., Bhargava, V. K., and Fettweis, G. P. (Eds.).Green radio communication networks. Cambridge University Press,2012.
3. Yu, F. R., Zhang, Y., and Leung, V. C. M.Green communications and networking. CRC Press,2012.
4. Al Noor, M.Green radio communication networks: Applying radio-over-fibre technology for wireless access. GRIN Verlag,2012.
5. Obaidat, M. S., Anpalagan, A., and Woungang, I.Handbook of green information and communication systems. Academic Press,2012.
6. Prasad, R., Ohmori, S., and Simunic, D.Towards green ICT. River Publishers, 2010.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	2	1	1	2	-	2	1	-	2	3	2	1
2	3	2	3	2	2	1	1	1	2	2	2	3	3	2
3	3	3	3	3	2	2	2	2	2	2	2	3	3	2
4	2	2	2	2	1	3	2	2	2	2	2	2	3	3
5	2	3	3	3	2	3	1	2	2	2	2	3	3	3
Avg.	**2.6**	**2.4**	**2.6**	**2.2**	**1.6**	**2.2**	**1.5**	**1.8**	**1.8**	**2.0**	**2.0**	**2.8**	**2.8**	**2.2**

PE25P12	SECURITY FOR WIRELESS COMMUNICATION NETWORKS	L	T	P	C
		3	0	0	3
Course Objectives:	• To understand the fundamentals of network and wireless communication security. • To explain cryptographic algorithms and security mechanisms for data protection. • To apply key management and authentication techniques in secure communication systems. • To analyze security protocols used in wired and wireless networks. • To evaluate security challenges and countermeasures in modern wireless communication networks.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain security goals, cryptographic attacks, security services, and fundamental cryptographic techniques.	**K2**
CO2	Apply symmetric and asymmetric key cryptographic algorithms for secure communication.	**K3**
CO3	Implement integrity, authentication, digital signature, and key management mechanisms in communication systems.	**K3**
CO4	Apply security protocols such as IPsec, PGP, S/MIME, SSL, and TLS to protect network communications.	**K3**
CO5	Utilize security techniques to address challenges in broadband, 4G, and 5G wireless communication networks.	**K3**

UNIT I INTRODUCTION ON SECURITY	**9**
Security goals, cryptographic attacks, security services and mechanisms, techniques: cryptography and steganography, traditional symmetric key ciphers, mathematics of cryptography.	
UNIT II SYMMETRIC AND ASYMMETRIC KEY ALGORITHMS	**9**
Introduction to block and stream ciphers, advanced encryption standard (AES), RC4, principle of asymmetric key algorithms.	
UNIT III INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT	**9**
Message integrity, hash functions, digital signatures: digital signature standards. Authentication: entity authentication: biometrics, key management techniques..	
UNIT IV SECURITY PROTOCOLS	**9**
Ip security, e-mail security :pgp, s/mime, web security: ssl, tls and set.	
UNIT V WIRELESS NETWORK SECURITY	**9**
Security for broadband networks: security challenges in 4g and 5g deployments, introduction to side channel attacks and their counter measures.	
TOTAL : 45 PERIODS	

REFERENCES:

1. Forouzan, B. A. Cryptography and network security. McGraw-Hill,2011.
2. Stallings, W. Cryptography and network security: Principles and practice (2nd ed.). Prentice Hall of India,2002.
3. Kahate, A.Cryptography and network security (2nd ed.). Tata McGraw-Hill,2008.
4. Nichols, R. K., and Lekkas, P. C.Wireless security: Models, threats, and solutions. McGraw-Hill,2001.
5. Yang, H., et al. Security in mobile ad hoc networks: Challenges and solutions. IEEE Wireless Communications, February 2004. https://doi.org/10.1109/MWC.2004.1274245,2004.
6. IEEE Network Magazine, Securing ad hoc networks. IEEE Network Magazine, 13(6), 24–30.1999.
7. Aram, A. (n.d.). Security of wireless ad hoc networks. University of Maryland. http://www.cs.umd.edu/~aram/wireless/survey.pdf
8. Boel, D., et al.Securing wireless sensor networks – Security architecture. Journal of Networks, 3(1), 65–76,2008.
9. Perrig, A., Stankovic, J., and Wagner, D.Security in wireless sensor networks,2004.
10. Communications of the ACM, 47(6), 53–57. https://doi.org/10.1145/990680.990707

Mapping of COs with POs / PSOs														
POs												PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	3	2	2	2	2	2	2	1	1	2	3	3	2
2	3	3	3	3	3	2	1	2	2	2	2	3	3	2
3	3	3	3	3	3	2	2	2	2	2	2	3	3	2
4	2	2	3	3	2	3	2	1	1	1	2	3	3	2
5	2	3	3	3	3	2	2	2	2	2	2	3	3	2
Avg.	**2.6**	**2.8**	**2.8**	**2.8**	**2.6**	**2.2**	**1.8**	**1.8**	**1.6**	**1.6**	**2.0**	**3**	**3**	**2**

PE25P13	SIGNAL DETECTION AND ESTIMATION	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of signal detection and estimation theory. • To analyze signals in the presence of noise and uncertainty. • To apply detection and estimation techniques in communication and radar systems. • To design algorithms for signal detection and parameter estimation. • To implement and evaluate detection and estimation methods using simulation and open-source tools.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the probabilistic foundations, random processes, and statistical concepts used in signal detection and estimation.	**K2**
CO2	Apply hypothesis testing techniques and optimal detectors for signal detection in noisy environments.	**K3**
CO3	Implement parameter estimation methods such as MLE, least squares, and Bayesian estimation for signal processing applications.	**K3**
CO4	Apply Bayesian decision theory, Wiener filtering, and Kalman filtering techniques for detection and estimation problems.	**K3**
CO5	Utilize advanced detection and estimation techniques for radar, communication, spectrum analysis, and adaptive signal processing applications.	**K3**

UNIT I INTRODUCTION ON SECURITY	**9**
Review of probability theory – Random variables and expectations – Moments and characteristic functions – Stationary and ergodic random processes – Gaussian processes and their properties – Vector random variables and random vectors – Covariance matrices and correlation functions – Transformations and independence of random variables – Orthogonality principle – Review of Hilbert space concepts for random processes	
UNIT II SYMMETRIC AND ASYMMETRIC KEY ALGORITHMS	**9**
Binary hypothesis testing fundamentals – Neyman-Pearson criterion and likelihood ratio test – Receiver Operating Characteristic (ROC) curves – Bayes criterion and minimum probability of error – Detection of signals in Gaussian noise – Matched filter and its properties – Composite hypothesis testing – Performance analysis of detectors – Introduction to sequential detection and Wald's SPRT.	

UNIT III INTEGRITY, AUTHENTICATION AND KEY MANAGEMENT	9
Principles of parameter estimation – Minimum variance unbiased estimators – Cramér-Rao lower bound – Maximum Likelihood Estimation (MLE) techniques – Method of moments – Bayesian estimation fundamentals – Linear models and least squares estimation – Properties of estimators: consistency, sufficiency, and efficiency – Applications in signal parameter estimation.	
UNIT IV SECURITY PROTOCOLS	**9**
Bayesian decision theory and detection – A priori and posteriori probabilities – Minimum risk criterion – Bayesian estimation: MAP and MMSE estimators – Linear Bayesian estimation – Wiener filter derivation and applications – Kalman filter fundamentals and recursive estimation – Examples of Bayesian detectors – Performance measures for Bayesian estimators.	
UNIT V WIRELESS NETWORK SECURITY	**9**
Detection and estimation of random signals – Detection of known signals in colored noise – Multiple hypothesis testing and M-ary detection – Nonparametric detection and estimation techniques – Applications in radar and communication systems – Spectrum estimation methods – Introduction to adaptive detection and estimation – Overview of machine learning approaches in detection – Case studies and practical implementations.	
TOTAL : 45 PERIODS	

REFERENCES:

1. Poor, H. V.An introduction to signal detection and estimation (3rd ed.). Springer,2020.
2. Van Trees, H. L., and Bell, K. L.Detection, estimation, and modulation theory, Part I (3rd ed.). Wile,2021.
3. Kay, S. M.Fundamentals of statistical signal processing: Estimation theory (Reprint ed.). Pearson,2019.
4. Scharf, L. Statistical signal processing: Detection, estimation, and time series analysis (2nd ed.). Addison-Wesley,2022.
5. Hayes, M. H.Statistical digital signal processing and modeling (2nd ed.). Wiley,2023.

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	2	1	1	2	1	2	1	2	3	-	-
2	2	3	2	2	2	2	1	2	2	1	2	2	-	-
3	2	3	3	3	2	2	2	2	2	2	2	3	2	2
4	2	3	3	3	3	2	2	2	2	2	3	-	3	2
5	2	3	3	3	3	2	2	2	2	2	3	-	3	2
Avg.	**2.2**	**2.8**	**2.4**	**2.6**	**2.2**	**1.8**	**1.8**	**1.8**	**2.0**	**1.6**	**2.4**	**2.6**	**2.6**	**2.0**

<table>
<tr><td rowspan="2">PE25P14</td><td rowspan="2">SOLID STATE DEVICE MODELING AND SIMULATION</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Course Objectives:</td><td colspan="5">• To understand the device physics of semiconductor and integrated electronic devices.
• To apply modeling techniques for diodes, MOS capacitors, and MOSFET devices.
• To analyze the operation and characteristics of advanced semiconductor devices such as FINFETs, UTBs, MESFETs, HBTs, HEMTs, and MODFETs.
• To model the electrical behavior of modern nanoscale and high-speed electronic devices.
• To evaluate the performance and characteristics of optoelectronic devices through analytical modeling.</td></tr>
</table>

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the semiconductor physics principles and modeling techniques of PN junction and Schottky diodes.	**K2**
CO2	Apply MOS capacitor concepts to analyze band diagrams, threshold voltage, and C–V characteristics.	**K3**
CO3	Implement MOSFET device models and compact modeling techniques for circuit simulation.	**K3**
CO4	Apply technology scaling concepts and advanced MOSFET structures such as SOI, UTB, and FINFET devices to evaluate device performance.	**K3**
CO5	Utilize modeling and analysis techniques for optoelectronic devices including LEDs, lasers, photodiodes.	**K3**

UNIT I INTRODUCTION TO SEMICONDUCTOR PHYSICS AND DIODE MODELLING	**9**
Review of Quantum Mechanics - Boltzman transport equation - Continuity equation - Poisson equation. Junction and Schottky diodes in monolithic technologies - static and dynamic behavior - small and large signal models . SPICE modeling and simulation of PN junction and Schottky diode.	
UNIT II INTEGRATED MOS CAPACITANCE	**9**
Band diagram- flat band condition and flat band voltage-surface accumulation, surface depletion- threshold condition and threshold voltage, charge versus gate voltage, MOS C-V Characteristics, Poly Si gate depletion-effective Increase In Tox.	
UNIT III MOSFET FUNDAMENTALS AND DEVICE MODELING	**9**
NMOS and PMOS Transistor - Threshold voltage - Threshold voltage equations - MOS device equations - Basic DC equations Second order effects - Small signal AC Characteristics- MOS models SPICE model, EKV Model, BSIM Model. Compact Model for Circuit Simulation using Verilog A.	

UNIT IV ADVANCED MOSFET STRUCTURES AND TECHNOLOGY SCALING	9
Technology scaling for cost, speed and power consumption, Subthreshold Current – Subthreshold Swing, Threshold voltage Roll Off-Short Channel Leakage, reducing gate insulator electrical thickness And Tunneling Leakage, Short Channel Effects. Ultra Thin body, SOI and Multigate MOSFET - FINFET	
UNIT V OPTOELECTRONICS DEVICES	**9**
Light Emitting Diodes, Lasers, Photoconductors, Junction Photodiodes, Avalanche Photodiodes, Solar Cells.	
TOTAL : 45 PERIODS	

REFERENCES:

1. Tyagi, M. S.Introduction to semiconductor materials and devices. John Wiley,2008.
2. Hu, C. C. Modern semiconductors for integrated circuits. Prentice Hall,2010.
3. Neamen, S. A., and Biswas, D. Semiconductor physics and devices (4th ed.). Tata McGraw-Hill,2012.
4. Tsividis, Y.Operation and modeling of the MOS transistor. Oxford University Press,2003.
5. Bhattacharya, P. Semiconductor optoelectronics devices (2nd ed.). PHI,2009.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	2	3	1	2	1	1	1	1	2	3	1	2
2	3	3	2	3	2	2	2	1	1	2	2	3	2	1
3	3	3	2	2	3	1	1	2	2	1	2	3	3	2
4	3	3	2	2	2	2	2	1	1	2	2	3	3	2
5	3	2	2	3	2	1	2	1	1	2	2	2	3	2
Avg.	**3.0**	**2.6**	**2.0**	**2.6**	**2.0**	**1.6**	**1.6**	**1.2**	**1.2**	**1.6**	**2.0**	**2.8**	**2.4**	**1.8**

PE25P15	RF INTEGRATED CIRCUIT DESIGN	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of CMOS RF transceiver architectures and design principles. • To analyze noise sources, impedance matching, and signal integrity in RF circuits. • To design RF amplifiers and feedback systems for communication applications. • To apply mixer and oscillator design techniques in wireless transceivers. • To evaluate frequency synthesizers and RF building blocks for high-performance communication systems.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain CMOS device physics, RF transceiver architectures, and key performance specifications of communication systems.	**K2**
CO2	Apply impedance matching techniques and amplifier design principles for RF front-end circuits.	**K3**
CO3	Implement feedback and power amplifier design techniques to enhance stability, linearity, and efficiency.	**K3**
CO4	Apply mixer and oscillator design concepts for frequency conversion and signal generation in RF systems.	**K3**
CO5	Design and evaluate PLLs and frequency synthesizers for high-performance wireless communication applications.	**K3**

UNIT I CMOS PHYSICS, TRANSCEIVER SPECIFICATIONS AND ARCHITECTURES	**9**
Introduction to MOSFET Physics, Noise: Thermal, shot, flicker, popcorn noise, Two port Noise theory, Noise Figure, THD, IP2, IP3, Sensitivity, SFDR, Phase noise - Specification distribution over a communication link, Homodyne Receiver, Heterodyne Receiver, Image reject, Low IF Receiver Architectures Direct up conversion Transmitter, Two step up conversion Transmitter.	
UNIT II IMPEDANCE MATCHING AND AMPLIFIERS	**9**
S-parameters with Smith chart, Passive IC components, Impedance matching networks, Common Gate, Common Source Amplifiers, OC Time constants in bandwidth estimation and enhancement, High frequency amplifier design, Power match and Noise match, Single ended and Differential LNAs, Terminated with Resistors and Source Degeneration LNAs.	
UNIT III FEEDBACK SYSTEMS AND POWER AMPLIFIERS	**9**
Stability of feedback systems: Gain and phase margin, Root-locus techniques, Time and Frequency domain considerations, Compensation, General model – Class A, AB, B, C, D, E and F amplifiers, Power amplifier Linearization Techniques, Efficiency boosting techniques, ACPR metric, Design considerations	

UNIT IV MIXERS AND OSCILLATORS	9
Mixer characteristics, Non-linear based mixers, Quadratic mixers, Multiplier based mixers, Single balanced and double balanced mixers, subsampling mixers, Oscillators describing Functions, Colpitts oscillators Resonators, Tuned Oscillators, Negative resistance oscillators, Phase noise.	
UNIT V PLL AND FREQUENCY SYNTHESIZERS	**9**
Linearized Model, Noise properties, Phase detectors, Loop filters and Charge pumps, Integer-N frequency synthesizers, Direct Digital Frequency synthesizers.	
TOTAL : 45 PERIODS	

REFERENCES:

1. Lee, T.Design of CMOS RF integrated circuits. Cambridge University Press,2004.
2. Razavi, B.RF microelectronics (2nd ed.). Pearson Education,2013.
3. Crols, J., and Steyaert, M.CMOS wireless transceiver design. Kluwer Academic Publishers,1997.
4. Razavi, B. Design of analog CMOS integrated circuits (2nd ed.). McGraw-Hill Education,2017.
5. Indian Institute of Technology Madras. (n.d.). EE6240 – Recorded lectures and notes. http://www.ee.iitm.ac.in/~ani/ee6240/

Mapping of COs with POs / PSOs

	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	3	2	2	2	1	2	2	2	2	2	3	2	–
2	3	3	3	2	3	1	1	2	2	1	2	3	1	–
3	3	3	3	3	3	2	2	2	2	2	2	3	2	–
4	3	3	3	3	3	2	1	2	2	1	2	3	2	–
5	3	3	3	3	3	2	2	2	2	2	2	2	3	–
Avg.	**3.0**	**3.0**	**2.8**	**2.6**	**2.8**	**1.6**	**1.6**	**2.0**	**2.0**	**1.6**	**2.0**	**2.8**	**2.0**	**–**

PE25P16	IMAGE AND VIDEO PROCESSING AND ANALYTICS	L	T	P	C
		3	0	0	3

Course Objectives:	• To understand the fundamentals of image processing and video analytics. • To apply feature extraction and motion analysis techniques for visual data processing. • To design object detection and tracking systems for video applications. • To utilize open-source tools for developing computer vision and video analytics solutions. • To evaluate video intelligence applications in surveillance, smart cities, and human activity recognition.

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamentals of visual perception, image representation, and video analytics concepts.	**K2**
CO2	Apply feature extraction and dimensionality reduction techniques for image and video analysis.	**K3**
CO3	Implement motion analysis, video segmentation, and enhancement techniques for intelligent video processing.	**K3**
CO4	Apply object detection, tracking, and recognition algorithms for real-world computer vision applications.	**K3**
CO5	Utilize open-source tools and datasets to develop and evaluate video analytics solutions for surveillance, smart city, and human activity recognition applications.	**K3**

UNIT I VISION AND PERCEPTION FUNDAMENTALS FOR ANALYTICS	**9**
Digital image structure and visual perception – Color models and their relevance in vision analytics (HSV, YCbCr) – Key differences in image vs video understanding – Fundamentals of human motion perception – Introduction to image features and importance in analytics – Review of spatial and frequency domain concepts (brief recap) – Concept of high-level vs low-level vision – Role of datasets and annotations in analytics – Emerging trends in perceptual image processing.	
UNIT II FEATURE DESCRIPTORS AND MACHINE PERCEPTION	**9**
Importance of feature extraction in analytics – Advanced feature detectors and descriptors: SIFT, SURF, ORB – Shape and contour-based features – Texture features using GLCM and LBP – Color histograms and signatures – Deep features using pre-trained CNNs – Feature matching and point correspondences – Use of feature vectors in clustering/classification – Feature selection and dimensionality reduction (PCA, t-SNE).	
UNIT III INTELLIGENT VIDEO PROCESSING	**9**
Video representation: frames, shots, scenes – Temporal continuity and key frame extraction – Motion analysis using optical flow (Horn-Schunck, Lucas-Kanade) – Activity zones and region-of-interest detection – Shot boundary detection and scene segmentation – Real-time video enhancement – Camera calibration and view transformations – Depth estimation from motion – Challenges in video-based perception.	

UNIT IV OBJECT DETECTION, TRACKING AND RECOGNITION	9
Object detection using Haar cascades, HOG, and YOLO – Tracking methods: Kalman Filter, Mean-Shift, CamShift, Particle Filter – Introduction to multi-object tracking – Face detection and recognition techniques – Gesture and posture analysis – Action recognition using spatio-temporal features – Tracking-by-detection paradigm – Occlusion handling and re-identification – Evaluation metrics (IoU, mAP, MOTP).	
UNIT V APPLICATIONS AND TOOLS IN VIDEO ANALYTICS	**9**
Applications in surveillance, smart cities, retail analytics, and transportation – Case study: pedestrian detection and people counting – Case study: facial recognition and identity verification – Case study: behavior and anomaly detection – Use of OpenCV, OpenPose, and MediaPipe – Overview of real-world datasets (e.g., COCO, Kinetics, AVA, Cityscapes) – Introduction to real-time deployment (Edge/Cloud) – Ethical issues and data privacy in video analytics – Trends: multimodal analytics, Explainable AI, and embedded vision systems.	
TOTAL : 45 PERIODS	

REFERENCES:

1. Szeliski, R.Computer vision: Algorithms and applications (2nd ed.). Springer,2022.
2. Nixon, M., and Aguado, A.Feature extraction and image processing for computer vision (3rd ed.). Academic Press,2020.
3. Zhang, Y.-J,A comprehensive guide to image enhancement techniques (1st ed.). Springer,2021.
4. Bhowmik, D., and Elhamifar, E.Video analytics: From basics to intelligent solutions (1st ed.). CRC Press,2023.
5. Venugopal, K. R., Gopalakrishna, S. R., and Patnaik, L. M. Digital image and video processing (1st ed.). McGraw Hill Education,2019.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	2	1	1	2	1	1	1	2	2	1	1
2	3	3	2	3	3	1	1	1	1	2	2	3	2	1
3	3	3	3	3	3	2	2	2	1	2	2	3	3	2
4	3	3	3	3	3	2	2	2	2	2	2	3	3	2
5	2	2	2	3	3	2	2	2	2	2	3	2	3	3
Avg.	**2.8**	**2.6**	**2.2**	**2.8**	**2.6**	**1.6**	**1.8**	**1.6**	**1.4**	**1.8**	**2.2**	**2.6**	**2.4**	**1.8**

PE25P17	MEMS AND NEMS	L	T	P	C
		3	0	0	3
Course Objectives:	•To understand MEMS fundamentals and fabrication processes. •To impart knowledge of the photolithographic process, photo resist and pattern transfer. •To provide a fundamental of NEMS and its fabrication methods. •To explore carbon-based NEMS materials and fabrication challenges. •To learn about the diverse applications of MEMS and NEMS.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamentals, fabrication processes, materials, and scaling concepts of MEMS and NEMS technologies.	**K2**
CO2	Describe photolithography, pattern transfer techniques, and nanofabrication processes used in MEMS/NEMS device manufacturing.	**K2**
CO3	Apply MEMS and NEMS fabrication techniques to develop micro- and nano-scale devices.	**K3**
CO4	Implement material selection and processing methods for the design and analysis of MEMS/NEMS structures.	**K3**
CO5	Apply MEMS/NEMS concepts in the design and evaluation of sensors, actuators, RF MEMS devices, resonators, and related applications.	**K3**

UNIT I FUNDAMENTALS OF MEMS	**9**
R MEMS Introduction - Low Cost - Redundancy and Disposability – Scaling – Made – Substrates –Processing – Mask – Developing – Etching - Road Map and Perspective Silicon Substrate – Silicon Growth – Crystal - Miller Indices – Semiconductor – Doping - Additive Techniques.	
UNIT II PATTERN TRANSFORMATION OF MEMS	**9**
Photolithographic Process - Clean room - Photo Resist - Positive Resist - Negative Resist –Working with Resist – Applying Photo Resist - Exposure and Pattern Transfer - Printing Methods – Contact Proximity – Projection Printing - Development and Post Treatment -Masks – Resolution –Sensitivity and Resist Profiles – Mask Alignment - Permanent Resists	
UNIT III INTRODUCTION OF NEMS	**9**
Introduction – Basic properties - Benefits of Nanomachines – Miniaturization - NEMS Memory – Importance of AFM - Top-Down Approach - NEMS devices - NEMS Advantages.	
UNIT IV FEEDBACK AMPLIFIERS AND WAVEFORM GENERATORS	**9**
Materials – Carbon Allotropes - Carbon Based Materials - Metallic Carbon Nanotubes – Difficulties – Simulations - Current Challenges and future of NEMS – Deposition processes – Lithography – Etching processes.	

UNIT V POWER AMPLIFIERS	9
Pressure sensor - Piezoresistive sensor - Capacitive sensor – RF applications – Gyroscope – Optical MEMS - Optical Data - Switching - RF MEMS - MEMS switches - MEMS Resonators. Case study: Cantilever piezoelectric actuator, Capacitive accelerometer, Piezoresistive pressure sensor	
TOTAL : 45 PERIODS	

REFERENCES:

1. Senturia, S. D.Microsystem Design. Kluwer Academic Publishers,2001.
2. Madou, M. J. Fundamentals of Microfabrication and Nanotechnology (4th ed.). CRC Press,2018
3. Liu, C.Foundations of MEMS (2nd ed.). Pearson Education,2011.
4. Nathanson, H. C., Newell, W. E., Wickstrom, R. A., and Davis, J. R. The Resonant Gate Transistor. IEEE Transactions on Electron Devices,1967.
5. Bhushan, B. (Ed.).Springer Handbook of Nanotechnology (4th ed.). Springer,2017.
6. Chang, R. P. H., and Alivisatos, A. P. (Eds.).Nanotechnology: Science and Application. CRC Press,2010.
7. Hsu, T. R.MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering (2nd ed.). Wiley,2008.
8. Campbell, S. A. Fabrication Engineering at the Micro and Nanoscale (3rd ed.). Oxford University Press,2008.

Mapping of COs with POs / PSOs													
	POs										PSOs		
COs	1	2	3	4	5	6	7	8	9	10	11	1	2	3
1	3	3	2	2	2	1	1	1	1	1	2	2	2	-
2	2	3	2	3	2	1	2	1	1	2	2	-	-	-
3	2	3	3	3	2	2	2	2	2	2	2	-	-	-
4	3	3	2	3	2	2	2	1	1	1	2	2	2	-
5	2	2	3	3	2	3	2	2	2	2	3	2	3	3
Avg.	2.4	2.8	2.4	2.8	2.0	1.8	1.8	1.4	1.4	1.6	2.2	2.0	2.3	3

PE25P18	IMAGE PROCESSING AND PATTERN RECOGNITION	L	T	P	C
		3	0	0	3
Course Objectives:	• To understand the fundamentals of digital image acquisition and representation. • To apply image enhancement and restoration techniques for improving image quality. • To analyze image segmentation and compression methods for efficient image processing. • To implement watermarking and security techniques in digital images. • To utilize feature extraction and computer vision descriptors for image analysis and recognition.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain the fundamentals of image acquisition, image formation, and image transformation techniques.	**K2**
CO2	Describe image enhancement, restoration, and filtering methods used in digital image processing.	**K2**
CO3	Apply image segmentation techniques for object and region extraction from digital images.	**K3**
CO4	Implement image compression and digital watermarking techniques for efficient storage and secure transmission.	**K3**
CO5	Utilize feature extraction and image representation methods such as SIFT, SURF, Fourier descriptors, and PCA for image analysis and recognition.	**K3**

UNIT I IMAGING PRELIMINARIES	**9**
Image Acquisition, Sensors, Image formation, Image transformations: 2D-DFT, DCT, DST, Hadamard, Walsh, Hotelling transformation, 2D-Wavelet transformation, Wavelet packets.	
UNIT II IMAGE ENHANCEMENT AND RESTORATION	**9**
Gray-level mapping, non-liner gray-level mapping, image histogram, histogram stretching, histogram equalization. Spatial filters- Smoothing and Sharpening- Frequency domain filters. Image Degradation/Restoration Model- Noise Model- Linear Position Invariant Degradations- Wiener Filtering.	
UNIT III IMAGE SEGMENTATION	**9**
Point, Line, and Edge segmentation. Edge linking and Boundary detection. Segmentation using thresholding, Region-based segmentation. Segmentation by morphological watersheds. Use of motion in segmentation.	
UNIT IV IMAGE COMPRESSION AND WATER MARKING	**9**
Error free compression: Variable length coding, LZW, Bit-plane coding Lossy compression: Lossy predictive coding, transform coding, wavelet coding. Image compression standards (CCITT, JPEG, JPEG 2000) and Video compression standards. Digital Image Watermarking.	

UNIT V FEATURE EXTRACTION	9
Boundary Representation - Chain codes, Boundary segments. Boundary Descriptors-Simple, Fourier Descriptors- Regional Descriptors- Simple, Texture. Corner Detection, Scale-invariant Feature Transform (SIFT), Speed-up Robust Features (SURF), Principal Component Analysis	
TOTAL : 45 PERIODS	

REFERENCES:

1. Gonzalez, R. C., and Woods, R. E.Digital image processing (4th ed.). Pearson Education, Inc,2018.
2. Jain, A. K. Fundamentals of digital image processing. Pearson Education, Inc,2002.
3. Pratt, W. K. Digital image processing. John Wiley,2002.
4. Castleman, K. R.Digital image processing. Pearson,2006.
5. Dudgeon, D. E., and Mersereau, R. M.Multidimensional digital signal processing. Prentice Hall Professional Technical Reference,1990.
6. Sonka, M., Hlavac, V., and Boyle, R.Image processing, analysis, andmachine vision (2nd ed.). Brooks/Cole; Vikas Publishing House,1999.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	2	1	2	1	2	1	1	2	3	2	-
2	3	2	1	2	2	2	1	2	1	2	2	3	2	-
3	2	3	3	3	2	1	2	2	2	2	2	3	2	-
4	2	2	2	3	3	2	2	1	2	2	2	2	3	-
5	3	3	2	3	3	1	2	1	2	2	3	2	3	-
Avg.	**2.6**	**2.4**	**1.8**	**2.6**	**2.2**	**1.6**	**1.6**	**1.6**	**1.6**	**1.8**	**2.2**	**2.6**	**2.4**	**-**

PE25P19	ANALOG AND MIXED SIGNAL VLSI DESIGN	L	T	P	C
		3	0	0	3
Course Objectives:	• To understand the fundamentals of Analog IC design, MOSFET models, and device-level noise behavior. • To analyze and design CMOS analog building blocks including amplifiers, current mirrors, REFERENCES, and op-amps. • To explore mixed-signal design concepts and implement circuits like data converters, comparators, and PLLs.				

Course Outcomes The students will be able to		**Knowledge Level**
CO1	Explain MOSFET characteristics, models, and fundamental building blocks used in analog IC design.	**K2**
CO2	Describe the operation of CMOS single-stage amplifiers, differential amplifiers, and cascode structures.	**K2**
CO3	Apply current mirror and biasing techniques for designing CMOS analog sub-circuits.	**K3**
CO4	Design and analyze CMOS operational amplifiers with compensation, CMRR, and PSRR considerations.	**K3**
CO5	Implement mixed-signal circuits including comparators, data converters, and PLL-based systems for analog and digital integration.	**K3**

UNIT I INTRODUCTION	**9**
Introduction to Analog IC Design, Design Flow of Analog ICs, MOSFET Characteristics and Parameters, MOSFET Models, MOS Diode, MOS Capacitors, MOS Switches, Noise in MOSFETs.	
UNIT II CMOS AMPLIFIERS	**9**
Single stage amplifiers: CS, CG and CD stages, Small Signal Models, Input Output Impedances, and Frequency Response. Differential Amplifier, Cascode Amplifiers, Current Amplifiers..	
UNIT III CMOS SUB-CIRCUITS	**9**
Current Sinks and Sources, Simple and Cascode current Mirrors, Wilson Current Mirror, and High Swing Current Mirror. Current and Voltage REFERENCES, Band gap Reference.	
UNIT IV CMOS OPERATIONAL AMPLIFIERS	**9**
Design of CMOS Op-Amps, Compensation of Op Amps, Design of Two-Stage Op-Amps, Common-mode Rejection Ratio (CMRR), Power- Supply Rejection Ratio (PSRR), Cascode Op-Amps, and Characterization Techniques of OP-Amps.	
UNIT V MIXED SIGNAL DESIGN FUNDAMENTALS	**9**
Design of MOS Comparators, Data Converter Fundamentals, Digital-to-analog Converters, Analog-to-Digital Converters, Switch Capacitor Circuits, Phase locked loops, Techniques of Analog Layout.	

TOTAL : 45 PERIODS

REFERENCES:

1. Allen, P. E., and Holberg, D. R.CMOS analog circuit design. Oxford University Press,2004.
2. Razavi, B. Design of analog CMOS integrated circuits. Tata McGraw-Hill,2002.
3. Baker, R. J., Li, H. W., and Boyce, D. E.CMOS circuit design, layout, and simulation. PHI,2002.
4. Van de Plassche, R. J. CMOS integrated analog-to-digital and digital-to-analog converters. Springer,2003.

Mapping of COs with POs / PSOs														
	POs											PSOs		
COs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**1**	**2**	**3**
1	3	2	1	2	2	-	-	--	-	-	-	3	2	1
2	3	3	2	2	2	2	-	--	1	-	-	3	2	2
3	3	2	3	2	2	2	-	-	-	1	-	3	3	1
4	2	2	3	3	3	1	-	-	2	-	-	3	3	2
5	3	3	3	3	3	2	1	-	2	2	1	3	3	3
Avg.	**2.8**	**2.4**	**2.4**	**2.4**	**2.4**	**1.7**	**1.0**	**-**	**1.6**	**1.5**	**1.0**	**3.0**	**2.6**	**1.8**