NANDHA COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University Chennai)

Erode-52

www.nandhatech.org

REGULATIONS – 2025

CURRICULUM AND SYLLABUS

M.E- COMMUNICATION SYSTEMS

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

M.E. COMMUNICATION SYSTEMS

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES(PSOs):

PSO	Programme Specific Outcomes
PSO1	Ability to design and implement innovative solutions to solve complex problems in Communication Engineering.
PSO2	Competence to independently undertake research projects involving simulation, measurement, and product development in Communication-related fields.

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Programme: M.E., Communication Systems **Regulations:** 2025

Abbreviations:

BS – Basic Science (Mathematics, Physics, Chemistry)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**)

SD – Skill Development

SL – Self Learning

TCP – Total Contact Period(s)

L – Laboratory Course

T – Theory

LIT – Laboratory Integrated Theory

PW – Project Work

Semester I

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	MA25C05	Advanced Mathematical Methods (ECE)	T	3	1	0	4	4	BS
2.	CU25C01	Advanced Radiation Systems	T	3	0	0	3	3	ES(PC)
3.	CU25C02	Modern Digital Communication Systems	T	3	0	0	3	3	ES (PC)
4.	CU25C03	Advanced Digital Signal Processing	T	3	1	0	4	4	ES (PC)
5.	CU25C04	Analog and Digital Electronic System Design	LIT	3	0	2	5	4	ES(PC)
6.	CU25C05	Digital Communication Systems Laboratory	L	0	0	4	4	2	ES (PC)
7.	CU25101	Technical Seminar	-	0	0	2	2	1	SD
						Total	**25**	**21**	

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Erode - 638 052.

Semester II

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	CU25201	Radio Frequency Transceiver Design	T	3	0	0	3	3	ES(PC)
2.		Programme Elective I	T	3	0	0	3	3	ES(PE)
3.	CU25C06	Machine Learning	T	3	1	0	4	4	ES(PC)
4.	CU25C07	Advanced Wireless Communication Networks	LIT	3	0	2	5	4	ES(PC)
5.	CU25202	Advanced Communication Systems laboratory	L	0	0	4	4	2	ES(PC)
6.	-	Industry Oriented Course I	-	1	0	0	1	1	SD
7.	CU25203	Industrial Training	-	-	--	-	---	1	SD
8.	-	Self-Learning Course	-	-	--	-	---	1	--
						Total	20	19	

Semester III

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.		Programme Elective II	T	3	0	0	3	3	ES(PE)
2.		Programme Elective III	T	3	0	0	3	3	ES(PE)
3.		Programme Elective IV	T	3	0	0	3	3	ES(PE)
4.		Programme Elective V	T	3	0	0	3	3	ES(PE)
5.	-	Industry Oriented Course II	-	1	0	0	1	1	SD
6.	CU25301	Project Work I	-	0	0	12	12	6	SD
						Total	25	19	

Semester IV

S. No.	Course Code	Course Title	Type	Periods per week			TCP	Credits	Category
				L	T	P			
1.	CU25401	Project Work II	---	0	0	24	24	12	SD
						Total	24	12	

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Programme Elective Courses (PE)

S. No.	Course Code	Course Title	Periods per week			Total Contact Periods	Credits
			L	T	P		
1.	CU25001	Wavelets and Sub band Coding	3	0	0	3	3
2.	EL25C03	Wireless Sensor Networks and WBAN	3	0	0	3	3
3.	CU25C11	Ultra Wide Band Communications	3	0	0	3	3
4.	VL25C01	VLSI for Wireless Communication	3	0	0	3	3
5.	CU25002	Cognitive Radio Communications	3	0	0	3	3
6.	CU25C08	Quantum Communication and Networking	3	0	0	3	3
7.	NC25C01	Telecommunication System Modeling and Simulation	3	0	0	3	3
8.	CU25C09	Massive MIMO and MMWAVE System	3	0	0	3	3
9.	CU25C10	Advanced Satellite Based Systems	3	0	0	3	3
10.	CU25003	Communication Network Design	3	0	0	3	3
11.	CU25004	Digital Communication Receivers	3	0	0	3	3
12.	CU25005	Co-operative Communication	3	0	0	3	3
13.	CU25006	Security for Wireless Communication Networks	3	0	0	3	3
14.	CU25C12	Signal Detection and Estimation	3	0	0	3	3
15.	CU25007	Solid State Device Modeling and Simulation	3	0	0	3	3
16.	EL25C04	RF Integrated Circuit Design	3	0	0	3	3
17.	CU25C13	Image and Video Processing and Analytics	3	0	0	3	3
18.	VL25C02	MEMS and NEMS	3	0	0	3	3
19.	CU25008	Image Processing and Pattern Recognition	3	0	0	3	3
20.	CU25C14	Analog and Mixed Signal VLSI Design	3	0	0	3	3

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Semester I

MA25C05	Advanced Mathematical Methods (ECE)	L	T	P	C
		3	1	0	4

Course Objectives:

This course aims to equip students with advanced mathematical and computational techniques focuses on developing problem-solving skills for designing efficient circuits, communication protocols, and embedded systems.

Calculus of Variations: 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.

Queueing Models: 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, M/G/1 queue, Pollaczek Khinchin formula, M/D/1 and M/EK/1 as special cases, Series queues, Open Jackson networks.

Graph Theory: 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

Optimization Techniques: Linear programming, Basic concepts, Graphical and simplex methods, Big M method, Transportation problems, Assignment problems.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

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

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

CU25C01	Advanced Radiation Systems	L	T	P	C
		3	0	0	3

Course Objective:
This course aims to Provides foundation in antenna principles, arrays, modern structures, measurements, and recent trends in advanced antenna design.

Antenna Fundamentals: Radiation mechanisms, Maxwell's equations, antenna parameters, dipole, monopole, loop analysis, current distribution, radiation integrals. Numerical methods -MoM, FEM, FDTD, simulation tools.

Activities:

Write a report on real-world antenna installations

Antenna Arrays and Beamforming: Linear and planar arrays, beamforming, phased arrays, array synthesis (Binomial, Chebyshev), smart antennas, mutual coupling.
Activities:

1. MATLAB/Python simulation of linear and planar array patterns
2. Comparison chart activity of beamforming methods

Aperture and Reflector Antennas Aperture radiation, horn and slot antennas, Babinet's principle, reflector types and design, GTD, performance metrics.

Activities:

1. Design exercise: horn/reflector using standard formulas,
2. Concept map of diffraction and equivalence principles

Modern and Specific Antennas: Microstrip, fractal, reconfigurable, MIMO, mmWave, THz, wearable and implantable antennas, feeding and tuning methods.

Activites:

1. Mini project: Microstrip or fractal antenna design using CST/HFSS,
2. Invited expert talk on recent trends in antenna design

Antenna Measurements: Antenna test environments, anechoic/reverb chambers, gain, pattern, impedance, polarization

Activities:

1. Lab visit or virtual demo of anechoic chamber setup
2. Report writing on modern antenna testing

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References

1. Balanis, C. A. (2016). Antenna theory: Analysis and design . John Wiley & Sons.
2. Gross, F. B. (2011). Frontiers in antennas: Next generation design and engineering. McGraw Hill.

3. Drabowitch, S., Papiernik, A., Griffiths, H. D., Encinas, J., & Smith, B. L. (2013). Modern antennas. Springer.
4. Krauss, J. D. (2017). Antennas. John Wiley & Sons.
5. Stutzman, W. L., & Thiele, G. A. (2012). Antenna theory and design. John Wiley & Sons.

	CO description	PO Mapping	PSO1	PSO2
CO1	Analyze the radiation mechanisms in antennas.	PO3(3)	3	2
CO2	Design and evaluate antenna performance in various systems.	PO1(3) PO2(3)	2	2
CO3	Use the modern simulation tools and measurement techniques for design and analysis of antennas.	PO2(3) PO1(3)	3	3

CU25C02	Modern Digital Communication Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To understand the concepts of coherent/non-coherent receivers, bandlimited signalling, equalization, channel coding, OFDM, and CDMA for multiuser communication.

Coherent and Non-Coherent Communication: Coherent receivers, IQ modulation/demodulation, QAM, MFSK, DPSK, Rayleigh/Rician channels, BER performance, synchronization techniques.

Activities 1: Simulation and BER Analysis of Coherent vs Non-Coherent Receivers in MATLAB/Python
2: Hands-on Lab with Software-Defined Radio (SDR) or GNU Radio

Equalization Techniques: ISI, Nyquist criterion, partial response signaling, linear and decision feedback equalizers, adaptive equalization.

Activities 1: Simulating ISI and Equalization Techniques in MATLAB/Python
2: Nyquist Criterion and Partial Response Signaling – Practical Design and Analysis

Block Coded Digital Communication: Binary block codes, channel capacity, Shannon's theorem, spread spectrum, BPSK/DPSK with coding, Hamming, BCH, Reed-Solomon, STBC.

Project **1:** Simulate Hamming, BCH, and RS codes in noisy channels
2: Coded modulation with spread spectrum and STBC simulation

Convolutional Coded Digital Communication: Polynomial, state/tree/trellis diagrams, Viterbi decoding, error performance, turbo coding and iterative decoding.

Activities 1: Implement convolutional encoding and Viterbi decoding
2: Turbo Coding – Encoding and Iterative Decoding

Multicarrier and Multiuser Communications: OFDM modulation/demodulation, FFT implementation, bit/power allocation, PAPR, CDMA, multiuser detection, SIC.

Project **1:** OFDM System Design and Analysis using FFT in MATLAB/Python
2: CDMA System Simulation with Multiuser Detection

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

1. Proakis, J. G., & Salehi, M. (2014). Digital communication. McGraw Hill.
2. Haykin, S. (2014). Digital communication systems. John Wiley & Sons.
3. Sklar, B., & Ray, P. K. (2009). Digital communications: Fundamentals & applications. Pearson Education.

4. Lathi, B. P., & Ding, Z. (2025). Modern Digital and Analog Communication Systems. Oxford University Press.
5. Rappaport, T. S. (2002). Wireless communications. Pearson Education.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamental concepts of digital communication.	-	-	-
CO2	Analyze coherent and non-coherent receiver performance.	PO1(3) PO3(3)	2	2
CO3	Apply the convolutional coding i digital communication	PO3(3)	3	3
CO4	Design and evaluate multicarrier and multiuser systems using OFDM and CDMA..	PO1(3)	3	3

CU25C03	Advanced Digital Signal Processing	L	T	P	C
		3	1	0	4

Course Objective:

This course imparts advanced DSP techniques like multirate processing, adaptive filters, spectral estimation, and real-time architectures for communication applications

Multirate Signal Processing in Communication: Decimation, interpolation, multistage conversion, polyphase filters, filter banks, fractional rate conversion, communication applications.

Activities:

1. Simulate decimation and interpolation of speech signals in MATLAB/Python.
2. Design and evaluate polyphase filter banks for sub-band coding.

Adaptive Filtering for Channel Equalization: LMS, NLMS, RLS algorithms, convergence, system identification, noise/echo cancellation, equalizers in mobile/wired systems.).

Activities :

1. Implement LMS and RLS algorithms for channel equalization.
2. Compare convergence behavior with different step sizes and noise levels

Spectral Estimation for Signal Analysis: Non-parametric (Periodogram, Welch), parametric (AR, MA, ARMA), high-resolution (MUSIC, ESPRIT), PSD for speech/radar

Activities:

1. Mini project: PSD analysis of a real-world communication signal (e.g., FM, ECG).
2. Virtual demonstration on subspace-based estimation in MIMO systems.

DSP Architectures and Real-Time Implementation: Fixed/floating-point DSPs, TMS320C67x, pipelining, FPGA-based DSP, SDR, DSP in 5G and IoT applications.

Activities :

1. Mini Project: Optimization of FIR/IIR filters on FPGA or DSP kits..
2. Simulate pipelined filter processing on FPGA (Verilog or Vivado HLS optional).

Applications in Modern Communication Systems: DSP in modulation/demodulation, channel estimation, spectrum sensing, cognitive radio, speech/audio, IoT, biomedical.

Activities:

1. Design and simulate a complete QPSK system with matched filtering.
2. Implement a basic spectrum sensing block for a cognitive radio.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References:

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

	CO description	PO Mapping	PSO1	PSO2
CO1	Elaborate multirate signal processing techniques	-	-	-
CO2	Apply adaptive signal processing techniques to solve practical problems	PO1(3) PO3(3)	2	2
CO3	Analyse spectral estimation methods, and direction-of-arrival.	PO2(3)	2	2
CO4	Design and implement real-time DSP algorithms and architectures.	PO3(3)	3	2

CU25C04	Analog and Digital Electronic System Design	L	T	P	C
		3	0	2	4

Course Objective:
To develop skills to design and analyze integrated analog-digital circuits for efficient mixed-signal systems.

MOS Transistor Principles and Logic Gates: MOS transistor characteristics, CMOS inverter, logic gate design, secondary effects, CS, CG, CD amplifiers, cascode, current mirrors.

Activity:

1. Analyze CMOS inverter performance and power metrics.
2. Simulate and compare amplifier configurations using SPICE.

Practicals:

1. DC characteristics of NMOS/PMOS.
2. logic gate simulations (NOT, NAND, NOR).

Single Stage Amplifiers: MOS models and small-signal equivalents, common-source (CS), common-gate (CG), and source-follower (CD) amplifiers, cascode amplifiers, current mirrors.

Activity:

1. virtual demonstration on MOSFET amplifier configurations (CS, CG, CD)
2. Simulating cascode amplifier and current mirror circuits

Practical Experiments:

1. CS amplifier design and performance analysis (Zin, Zout, gain, bandwidth, transient)
2. Current mirror and cascode amplifier simulation

Differential Amplifiers and High-Gain Circuits: Differential amplifier design, gain, CMR, slew rate, bandwidth, power, op-amp design principles, high-gain structures.

Activity:

1. V9irtual demonstration high-gain amplifier structures and op-amp design

Practical Experiments:

1. Differential amplifier with resistive load (gain, bandwidth, power, CMRR, transient)
2. Design of op-amp style gain stages

Digital Circuit Design and FPGA Implementation: FPGA architecture, datapath design, clocked synchronous circuits, iterative circuits, ASM chart and realization using ASM blocks.

Activity:

1. Virtual demonstration on FPGA architecture and data path circuit design
2. Modelling of synchronous sequential circuits using ASM charts

Practical Experiments:

1. Implementation of combinational circuits on FPGA
2. Implementation of simple state machine and timing analysis

System Design Using HDL and Integration: Logic system and data types in HDL, behavioral and structural modeling, FSM synthesis, mixed-signal integration using simulation tools.

Activity:

1. Behavioral modeling and synthesis of combinational and sequential circuits
2. Design and synthesis of finite state machines (FSM) using HDL

Practical Experiments:

3. FPGA realization and real-time output analysis
1. Mixed-signal simulation using Cadence Spectre/Mentor Graphics/SPICE

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

References

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

	CO description	PO Mapping	PSO1	PSO2
CO1	Describe the integration of analog and digital subsystems in electronic system design	-	-	-
CO2	Analyze and design CMOS analog and digital building blocks using device-level models.	PO3(3)	3	3
CO3	Develop and simulate mixed-signal circuits simulation tools for real-time applications.	PO1(3)	3	3
CO4	Evaluate the analog and digital sub systems performance parameters through lab experiments..	PO1(3) PO3(2)	2	3

CU25C05	Digital Communication Systems Laboratory	L	T	P	C
		0	0	4	2

Course Objectives:

This course aims to covers digital communication performance, wireless systems, digital filter design, and adaptive filtering algorithms.

list of experiments(MATLAB/Scilab/Labview)

use appropriate simulation tools for the following experiments:

1. Generation & 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 & 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.

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Project (30%), Assignment (10%), Practical (30%), Internal Examinations (30%)

	CO description	PO Mapping	PSO1	PSO2
CO1	Apply simulation tools like MATLAB, Scilab, or LabVIEW to model, analyze, and evaluate digital communication systems	PO3(3)	2	2
CO2	Design and simulate advanced wireless communication systems and assess their performance under various channel conditions.	PO1(3)	3	2
CO3	Implement and analyze adaptive signal processing algorithms for applications noise/echo cancellation and data compression.	PO1(3) PO3(2)	2	3

SEMESTER-II

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

Course Objective:	To provide a comprehensive understanding of radio-frequency (RF) system design principles—including key system parameters, digital baseband signaling fundamentals, amplifier modeling, mixer and oscillator behavior, and modern radio architectures—culminating in practical transceiver design methodologies for multimode and multiband wireless communication systems.

Course Outcomes The Student will be able to		**Cognitive Level**
CO1	analyze fundamental RF system parameters (such as gain, noise figure, SNR, and S-parameters) alongside digital baseband signaling limitations (like IQ imbalance, jitter, and EVM).	K5
CO2	Evaluate noise performance and non-linear distortions (including gain compression, intermodulation, and SOI/TOI points) in cascaded RF amplifier stages using behavioral modeling algorithms (like Saleh, Wiener, and Hammerstein).	K4
CO3	Investigate frequency translation dynamics in mixers and analyze the limiting effects of phase noise, spurious signals, and frequency inaccuracies in RF oscillators and synthesizers.	K4
CO4	Critique and compare structural radio architectures (Superheterodyne, Direct Conversion, Low IF, and Bandpass Sampling) based on integration constraints and operational trade-offs.	K5
CO5	Design system-level transceiver blocks and frequency plans for complex multiband/multimode communication platforms to meet precise sensitivity and dynamic range requirements.	K6

UNIT I - BASICS OF RADIO FREQUENCY SYSTEM DESIGN	**9**
System Parameter definitions: Gain, noise figure, SNR, Characteristic impedance, S parameters, 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, intermediation, Single and two tone analyses, second and third order distortions and measurements, SOI and TOI points, cascade performance of nonlinear systems.	

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UNIT III - MIXER AND OSCILLATOR MODELING AND ANALYSIS MIXERS	9
Mixer: 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, band- pass 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 PERIODS	**45**

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.

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Mapping of COs with POs / PSOs					
COs	POs			PSOs	
	1	2	3	1	2
1	2	1	3	2	2
2	3	1	3	3	2
3	2	1	3	2	2
4	3	2	3	2	2
5	3	2	3	3	3
CO (W.A)	2.6	1.4	3.0	2.4	2.2

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CU25C06 - MACHINE LEARNING	L	T	P	C
	3	1	0	4

Course Objective:	This course aims to equip students with a solid understanding of machine learning concepts and their application to modern communication systems. It seeks to develop the ability to design, implement, and evaluate supervised, unsupervised, and deep learning models for solving real world signal processing and network optimization problems. The course also encourages critical thinking, hands-on experimentation with open-source tools, and awareness of emerging trends and ethical considerations in intelligent communication technologies.

Course Outcomes The Student will be able to		**Cognitive Level**
CO1	Explain the fundamental concepts of machine learning And summarize their significance in communication systems applications.	K2
CO2	Apply supervised learning algorithms regression to solve classification and regression problems in communication 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.	K6
CO5	Develop reinforcement learning Strategies and Propose innovative solutions for dynamic resource management in communication systems.	K6

UNIT I - INTRODUCTION TO MACHINE LEARNING AND COMMUNICATION SYSTEMS	**12**
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 and Feature Engineering for Communication Data.	

UNIT II -SUPERVISED LEARNING METHODS AND APPLICATIONS	**12**
.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.	

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UNIT III - UNSUPERVISED LEARNING AND DIMENSIONALITY REDUCTION	12
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 – Auto encoders for Denoising and Compression – Anomaly Detection in Network Traffic – Case Study: Blind Source Separation–Hands-on Session: Implementing Clustering and Dimensionality Reduction.	
UNIT IV - DEEP LEARNING TECHNIQUES IN COMMUNICATION SYSTEMS	**12**
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-to- End Communication Systems, MIMO Detection – Practical Implementation with TensorFlow/Keras.	
UNIT V - REINFORCEMENT LEARNING AND EMERGING TRENDS	**12**
Reinforcement Learning Principles and Markov Decision Processes – Q-Learning and Policy Gradient Methods – Applications: Dynamic Spectrum Access, Resource Allocation – Federated Learning Concepts in Distributed Communication Systems – Edge AI for Low-Latency Inference – Security and Privacy Challenges in ML-Enabled Communication – Ethical Considerations in Machine Learning – Emerging Research Directions and Future Trends – Capstone Project Discussion and Problem Formulation.	
TOTAL PERIODS	**60**

REFERENCES:

1.Good fellow, I., Bengio, Y., & Courville, A. (2021). Deep learning (2nd ed.). MIT Press.

2. Murphy, K. P. (2022). Probabilistic machine learning: An introduction (1st ed.). MIT Press.

3. Géron,A.(2022).Hands-on machine learning with Scikit-Learn, Keras, and Tensor Flow (3rd ed.). O'Reilly Media.

4.Simeone,O.(2022).Machinelearningforengineers(1sted.).Cambridge University Press.

5.Hastie,T., Tibshirani, R., & Friedman,J.(2020). The elements of statistical learning: Datamining, inference, and prediction(3rded.).Springer

E-Resources

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1. Course Type: NPTEL Course Title: Machine Link: https://nptel.ac.in/courses/106/106/106106202 Type: NPTEL

2. Course Title: Deep LearningWeb LearningWeb Link: https://nptel.ac.in/courses/106/105/106105215

3. Course Type: Online Course Title: Introduction to Machine Learning (Coursera)Web Link: https://www.coursera.org/learn/machine-learning

4. Course Type:WebResourceTitle: Scikit-learn User GuideWebLink:https://scikit learn.org/stable/user_guide.html

5. Course Type: Web ResourceTitle: TensorFlow Link: https://www.tensorflow.org/tutorials

Mapping of COs with POs / PSOs					
COs	POs			PSOs	
	1	2	3	1	2
1	1	1	3	1	2
2	2	1	3	2	2
3	3	2	3	2	2
4	3	2	3	3	3
5	3	2	3	3	3
CO (W.A)	2.4	1.6	3.0	2.2	2.4

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CU25C07- ADVANCED WIRELESS COMMUNICATION NETWORKS	L	T	P	C
	3	0	2	4

Course Objective:	This course aims to provide a comprehensive understanding of UMTS, LTE, and 5G architectures along with their key advancements. It covers 5G building blocks, use cases, and networking principles, as well as standards in 4G and 5G wireless technologies. Additionally, the course introduces emerging wireless networks such as massive machine-type communication, and explains the basics of OFDM for multicarrier communication and CDMA for multiuser access.

Course Outcomes The Student will be able to		**Cognitive Level**
CO1	Explain the architecture and protocols of4G LTE systems, including E-UTRAN, CPC, and LTE air interface, as well as 5G network architecture and key use cases.	K2
CO2	Analyze the LTE air interface protocol stack, channel structures, resource grid, and bearer management mechanisms.	K4
CO3	Evaluate advanced 5G radio access technologies such as NOMA, V2X communication, massive Machine-Type Communication (mMTC), and METIS channel models.	K4
CO4	Design and assess coordinated multi-point (CoMP) transmission, relaying techniques, and massive MTC systems using appropriate simulation tools.	K3
CO5	Implement and test 4G/5G network models, including device-to-device (D2D) communication and smart antenna systems in laboratory environments.	K3

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 Transceiver algorithms for Massive MIMO.	
UNIT III - 5G WAVEFORMS AND CHANNEL MODELS	(9)
5G Radio Access Technologies: Design principles - Multi-carrier with filtering - Non orthogonal 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)

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Machine-type communications: Fundamental techniques for MTC - Massive MTC - Ultra reliable 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

LIST OF EXPERIMENTS.

SIMULATION EXPERIMENTS:

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. Testing of Device to Device Communication

SOFTWARE REQUIRED FOR A BATCH OF 30 STUDENTS:

1. MATLAB

TOTAL PERIODS	75

REFERENCES:

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

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Erode - 638 052.

Mapping of COs with POs / PSOs					
COs	POs			PSOs	
	1	2	3	1	2
1	1	1	3	1	1
2	2	2	3	2	2
3	3	2	3	2	2
4	3	2	3	3	3
5	3	2	3	3	3
CO (W.A)	2.4	1.8	3.0	2.2	2.2

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Nandha College of Technology (Autonomous)
Erode - 638 052.

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

Course Outcomes : The Student will be able to		**Cognitive Level**
CO1	Generate and detect digital communication signals of various modulation techniques using MATLAB, modeling structural transceivers (such as OFDM) to evaluate data integrity.	**K3**
CO2	Evaluate cellular mobile communication technologies and wireless channel propagation models by conducting channel characterization tests.	**K5**
CO3	Apply mathematical formulations to analyze the power spectrum estimation of a signal (using Bartlett/Welch estimators) and determine the absolute bit rate of a transmission link.	**K3**
CO4	Analyze the performance of optimization algorithms (such as LMS and RLS) used for channel equalization, noise reduction, and echo cancellation in simulated CDMA networks.	**K4**
CO5	Design and implement synchronization algorithms (encompassing frame, bit, and symbol tracking loops) along with channel codecs (Block, Linear, Cyclic, Convolutional, and Turbo codes) for digital communication links.	**K6**

List of Experiments: (MATLAB/SCILAB/Lab VIEW)

1. Generation & 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.

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TASK	
1. Generate and detect digital communication signals of various modulation techniques using MATLAB. 2. Evaluate cellular mobile communication technology and propagation model. 3. Apply mathematical formulation to analyze spectrum estimation of a signal and bit rate determination of a transmission link. 4. Analyze the performance of optimization algorithms for equalizing the channel or Noise/echo cancellation. 5. Able to design synchronization algorithm for Digital Communication systems.	
TOTAL PERIODS	**60**

Mapping of COs with POs / PSOs					
COs	**POs**			**PSOs**	
	1	**2**	**3**	**1**	**2**
1	2	2	3	3	3
2	3	2	3	2	3
3	3	1	3	2	2
4	2	2	3	3	3
5	3	2	3	3	3
CO (W.A)	**2.8**	**1.8**	**3.0**	**2.6**	**2.8**

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Erode - 638 052.

CU25001-WAVELETS AND SUB BAND CODING	L	T	P	C
	3	0	0	3

Course Objective:	This course aims to equip students with a comprehensive understanding of wavelets and subband coding, enabling them to analyze and differentiate various signal representation techniques, master the fundamentals of multirate signal processing, and design and evaluate digital filter banks for perfect reconstruction. Furthermore, students will gain proficiency in implementing the Discrete Wavelet Transform (DWT) using Multiresolution Analysis (MRA) and ultimately allowing them to critically assess the performance of different wavelet and subband coding schemes.

CourseOutcomes The Student will be able to		**Cognitive Level**
CO1	Explain the fundamentals of signal decompositions, Hilbert spaces, Fourier theory, sampling, and time-frequency representations.	K2
CO2	Illustrate the concepts of discrete-time bases, filter banks, multichannel filter banks, and adaptive subband filtering.	K2
CO3	Apply multiresolution analysis and construct wavelets using Fourier techniques and iterated filter banks.	K3
CO4	Analyze Continuous Wavelet Transform (CWT), Short-Time Fourier Transform (STFT), frame theory, and reconstruction techniques.	K3
CO5	Evaluate signal compression techniques using transform coding, subband coding, wavelet coding, and video compression methods.	K4

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 - TreeStructured 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.	

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Nandha College of Technology (Autonomous)
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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 PERIODS	45

REFERENCES:

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

E-resources:

1. https://www.math.purdue.edu/~lucier/692/DJL-image-compression.pdf
2. https://nptel.ac.in/courses/117101123
3. https://onlinecourses.nptel.ac.in/noc20_ee51/preview
4. https://archive.nptel.ac.in/courses/108/101/108101093/

MappingofCOswithPOs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	2	2	2	3	2
3	3	2	3	3	2
4	3	3	2	2	3
5	3	3	3	2	3
CO (W.A)	2.8	2.4	2.2	2.4	2.2

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Erode - 638 052.

EL25C03-WIRELESS SENSOR NETWORKS AND WBAN	L	T	P	C
	3	0	0	3

Course Objective:	This course aims to equip students with a comprehensive understanding of wavelets and subband coding, enabling them to analyze and differentiate various signal representation techniques, master the fundamentals of multirate signal processing, and design and evaluate digital filter banks for perfect reconstruction. Furthermore, students will gain proficiency in implementing the Discrete Wavelet Transform (DWT) using Multiresolution Analysis (MRA) and ultimately allowing them to critically assess the performance of different wavelet and subband coding schemes.

Course Outcomes The Student will be able to		**Cognitive Level**
CO1	Explain the fundamentals, characteristics, enabling technologies, and applications of Wireless Sensor Networks (WSNs).	K2
CO2	Explain the architecture of sensor nodes, network architecture, and energy-efficient design considerations in WSNs	K2
CO3	Apply MAC protocols, IEEE 802.15.4, ZigBee, and routing protocols for efficient wireless sensor network communication.	K3
CO4	Analyze topology control, clustering, synchronization, localization, and data management techniques in WSNs.	K4
CO5	Evaluate the architecture, protocols, energy management, and performance of Wireless Body Area Networks (WBANs).	K5

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 – INFRASTRUCTURE ESTABLISHMENT AND DATA MANAGEMENT	**(9)**

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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 PERIODS	45

REFERENCES:

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

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	2	2	2	2
3	3	2	3	3	2
4	3	3	3	2	3
5	3	3	3	2	3
CO (W.A)	3.0	2.4	2.4	2.2	2.2

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Nandha College of Technology (Autonomous)
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CU25C11-ULTRA WIDE BAND COMMUNICATIONS	L	T	P	C
	3	0	0	3

Course Objective:	1. To understand UWB fundamentals, technologies, regulations, and benefits in wireless communication systems. 2. To analyze UWB antenna design, performance, and compatibility with multiband and MIMO systems. 3. To model and evaluate UWB channels for path loss, delay, and interference. 4. To explore UWB signal processing, modulation, access methods, and receiver architectures. 5. To examine UWB applications in radar, positioning, healthcare, automotive, and future trends.

Course Outcomes The Student will be able to		**Cognitive Level**
CO1	Explain the concepts, technologies, standards, regulations, and applications of Ultra-Wideband (UWB) wireless communication systems.	K2
CO2	Explain the design requirements, radiation mechanisms, and performance characteristics of UWB antennas and MIMO-based UWB systems.	K2
CO3	Apply UWB channel models and interference analysis techniques to evaluate wireless communication performance.	K3
CO4	Analyze UWB signal processing techniques, modulation schemes, multiple access methods, and receiver architectures.	K4
CO5	Evaluate UWB applications, emerging trends, and future challenges in wireless communication systems.	K5

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.	

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Electronics and Communication Engineering
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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 ModulationUniform Pulse Train Spacing-Pseudorandom Time Hopping-Direct Sequence UWB (DSUWB)- 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 & 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 PERIODS	**45**

REFERENCES:

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

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Mapping of COs with POs / PSOs					
COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	2	2	3	2
3	3	2	3	3	2
4	3	3	3	2	3
5	3	3	3	2	3
CO (W.A)	3.0	2.4	2.4	2.4	2.2

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Erode - 638 052.

VL25C01-VLSI FOR WIRELESS COMMUNICATION	L	T	P	C
	3	0	0	3

Course Objective:	This Course Explores the principles and design methodologies for implementing wireless communication systems using VLSI. It focuses on rf front-end architectures, mixers, amplifiers, ADCS, and synthesizers, considering power, noise, and non-idealities. Emphasis is placed on practical implementation using modern VLSI techniques in CMOS technologies.

Course Outcomes The Student will be able to		Cognitive Level
CO1	Explain the fundamentals of wireless communication systems, multiple access techniques, modulation schemes, and wireless channel models.	K2
CO2	Explain receiver architectures, RF front-end components, and low-noise amplifier (LNA) design principles.	K2
CO3	Apply active and passive mixer design concepts to analyze conversion gain, noise, and non-idealities in wireless receivers.	K3
CO4	Analyze analog-to-digital converter (ADC) architectures, sigma-delta modulators, and I/Q mismatch in wireless systems.	K4
CO5	Evaluate frequency synthesizers, PLL-based transmitter architectures, power amplifiers, and transmitter performance.	K5

UNIT I – COMMUNICATION SYSTEMS & 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 LowPass ΣΔ Modulators. Implementation With Switched-Capacitor Circuits. I/Q Mismatch.	
UNIT V – FREQUENCY SYNTHESIZERS AND TRANSMITTERS	**(9)**
PLL-Based Frequency Synthesizers, Phase Detectors, VCOS, Loop Filters. Phase Noise and Spur Analysis.	

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Electronics and Communication Engineering
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Transmitter Architectures – Quadrature Lo Generation, Pa Design (Class A, B, E), Linearity, Output Control.	
TOTAL PERIODS	45

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. SSSSSAndreas F. Molisch, Wireless Communications: From Fundamentals to beyond 5G, Third edition, IEEE Press, 2022.

E-Resources

1. https://nptel.ac.in/courses/108106157 (RFIC Design)
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/
3. https://www.coursera.org/learn/rfic-design • https://www.keysight.com (Design guides for ADS)
4. https://www.ti.com/lit/ml/slyp173/slyp173.pdf (RF Design for Wireless Communication)

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	2	2	3	2
3	3	2	3	3	2
4	3	3	3	2	3
5	3	3	3	2	3
CO (W.A)	3.0	2.4	2.4	2.4	2.2

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25002-COGNITIVE RADIO COMMUNICATIONS	L	T	P	C
	3	0	0	3

Course Objective:	To understand the principles, architectures, functions, and performance limits of software-defined and cognitive radios, including spectrum sensing, cognitive behavior, and user cooperative communication strategies for efficient and adaptive wireless networks.

Course Outcomes The Student will be able to		Cognitive Level
CO1	Explain the concepts, architecture, functions, and components of Software Defined Radio (SDR).	K2
CO2	Explain the principles, architecture, cognition cycle, and resource optimization techniques of Cognitive Radio (CR).	K2
CO3	Apply spectrum sensing and spectrum opportunity detection techniques for cognitive radio networks.	K3
CO4	Analyze cognitive radio network behaviors, spectrum sharing techniques, and information-theoretic limits.	K4
CO5	Evaluate user cooperative communication techniques, relay channels, and cooperative wireless network architectures.	K5

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)

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

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 PERIODS	**45**

REFERENCES:

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

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	3	3	2	3
4	3	3	3	3	3
5	2	3	3	2	3
CO (W.A)	2.8	2.8	2.4	2.2	2.4

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Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25C08-QUANTUM COMMUNICATION AND NETWORKING	L	T	P	C
	3	0	0	3

Course Objective:	To develop foundational understanding of quantum information, communication, cryptography, and networking by enabling learners to analyze quantum states and qubit systems, simulate core quantum communication and cryptography protocols,

Course Outcomes The Student will be able to		**Cognitive Level**
CO1	Explain the fundamental concepts of quantum information, including qubits, quantum states, superposition, quantum gates, and quantum circuits.	K2
CO2	Explain the principles of quantum communication, quantum channels, density matrices, noise, decoherence, and quantum error models.	K2
CO3	Apply quantum communication protocols such as quantum teleportation, superdense coding, and entanglement-based communication	K3
CO4	Analyze quantum cryptographic techniques, including Quantum Key Distribution (QKD), BB84 and E91 protocols, and security mechanisms.	K4
CO5	Evaluate quantum networking concepts, including entanglement distribution, quantum repeaters, routing, network architectures, and future quantum internet technologies.	K5

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 -FUNDAMENTALS OF QUANTUM COMMUNICATION	(9)
Classical vs quantum communication, Quantum channels, Density matrices, Noise and decoherence, Quantum error models, Holevo bound.	
UNIT III -QUANTUM COMMUNICATION PROTOCOLS	(9)
Quantum teleportation, Superdense coding, Entanglement-based communication, Bell states.	
UNIT IV – QUANTUM CRYPTOGRAPHY	(9)
Introduction to cryptography, Quantum Key Distribution (QKD), BB84 protocol, E91 protocol, Security analysis, Eavesdropping strategies, Practical QKD implementations.	
UNIT V – QUANTUM NETWORKING	(9)
Entanglement distribution, Quantum repeaters, Quantum routing and switching, Quantum network architectures, Hybrid classical–quantum networks, Quantum internet vision, Challenges and future directions.	
TOTAL PERIODS	45

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Nandha College of Technology (Autonomous)
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REFERENCES:

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

Mapping of Cos with POs/PSOs					
COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	2	3
4	2	3	3	2	3
5	3	3	3	3	3
CO (W.A)	2.8	2.6	2.4	2.2	2.4

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

NC25C01-TELECOMMUNICATION SYSTEM MODELING AND SIMULATION	L	T	P	C
	3	0	0	3

Course Objective:	• 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 Student will be able to		**Cognitive Level**
CO1	Explain the principles of simulation methodology, performance estimation, sampling techniques, and simulation models for communication systems.	K2
CO2	Explain random signal generation, random number generation techniques, and random signal processing methods.	K2
CO3	Apply Monte Carlo simulation techniques for performance evaluation of communication systems.	K3
CO4	Analyze advanced simulation models for nonlinear, time-varying, waveform, and channel modeling in communication systems.	K4
CO5	Evaluate efficient simulation techniques, including importance sampling and performance estimation of cellular radio systems.	K5

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 & PROCESSING	**(9)**
Uniform random number generation, Mapping uniform random variables to an arbitrary pdf, Correlated and Uncorrelated Gaussian random number generation, PN sequence generation, Random signal processing, Testing of random number generators.	
UNIT III – MONTE CARLO SIMULATION	**(9)**
Fundamental concepts, Application to communication systems, Monte Carlo integration, Semi-analytic techniques, Case study: Performance estimation of a wireless system.	

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

UNIT IV – ADVANCED MODELS & SIMULATION TECHNIQUES	(9)
Modeling and simulation of nonlinearities: 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 PERIODS	**45**

REFERENCES:

1. Tranter, W. H., Shanmugan, K. S., Rappaport, T. S., & Kosbar, K. L. (2004). *Simulation of communication systems: Modeling, methodology and techniques*. Springer Science & Business Media.
2. Jeruchim, M. C., Balaban, P., & Shanmugan, K. S. (2006). *Simulation of communication systems: Modeling, methodology and techniques*. Kluwer Academic Publishers.
3. Guasselli, M. (2018). *Principles of communication systems simulation with wireless applications*. CRC Press.
4. Gentle, J. E. (2006). *Random number generation and Monte Carlo methods*. Springer Science & Business Media.
5. Kroese, D. P., Taimre, T., & Botev, Z. I. (2013). *Handbook of Monte Carlo methods*. John Wiley & Sons.

Mapping of COs with POs / PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	1
3	3	3	3	2	2
4	2	3	3	3	2
5	2	3	3	3	3
CO (W.A)	2.6	2.8	2.4	2.4	1.8

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Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25C09 -MASSIVE MIMO AND MMWAVE SYSTEMS	L	T	P	C
	3	0	0	3

Course Objective:	To enable students to understand the concepts, challenges, and design of massive MIMO and millimeter-wave systems for next-generation wireless communication.

Course Outcomes The Student will be able to		Cognitive Level
CO1	Explain the fundamentals of Massive MIMO, Millimeter Wave (mmWave) communication, system architecture, and their applications in 5G and beyond.	K2
CO2	Explain mmWave propagation characteristics and channel modeling techniques for Massive MIMO communication systems.	K2
CO3	Apply beamforming and precoding techniques for efficient signal transmission in Massive MIMO and mmWave systems.	K3
CO4	Analyze signal processing techniques, channel estimation methods, detection algorithms, and performance optimization in Massive MIMO systems.	K4
CO5	Evaluate the design, standards, resource management, and real-world applications of Massive MIMO and mmWave communication systems in 5G and beyond.	K5

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.	

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

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 PERIODS	45

REFERENCES:

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

NPTEL Courses:

Massive MIMO for 5G: https://nptel.ac.in/courses/108104113

MOOCPlatforms:

Coursera – Millimeter Wave Wireless Communication (https://www.coursera.org/learn/millimeter-wave-wireless).

Mapping of Cos with Pos / PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	2
2	3	3	2	2	2
3	3	2	3	3	2
4	3	3	3	3	3
5	2	3	3	2	3
CO (W.A)	2.8	2.6	2.4	2.4	2.4

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25C10 -ADVANCED SATELLITE BASED SYSTEMS	L	T	P	C
	3	0	0	3

Course Objective:	This course introduces satellite concepts and different navigation systems. It covers various remote sensing concepts for safety of life services. Students will design and simulate Image and Satellite based Ipv6 networks using open-source tools.

Course Outcomes The Student will be able to		**Cognitive Level**
CO1	Explain the fundamentals of satellite communication, GPS architecture, satellite orbits, and Global Navigation Satellite Systems (GNSS)	K2
CO2	Explain the principles of inertial navigation systems, differential GPS techniques, and augmentation systems.	K2
CO3	Apply remote sensing techniques, satellite imaging systems, sensors, and image processing methods for Earth observation.	K3
CO4	Analyze satellite-based broadcast systems, multimedia communication services, and Direct-to-Home (DTH) technologies.	K4
CO5	Evaluate the implementation of IPv6 in satellite communication networks, including protocol issues, migration strategies, and future network architectures.	K5

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 GPSLADGPSWADGPS-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.	

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

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 PERIODS	45

REFERENCES:

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

E-Resources :

1. https://archive.nptel.ac.in/courses/117/105/117105131
2. https://link.springer.com/article/10.1007/BF03655018

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	2
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	2	3
5	3	3	3	2	3
CO (W.A)	2.8	2.6	2.4	2.2	2.4

CU25003-COMMUNICATION NETWORK DESIGN	L	T	P	C
	3	0	0	3

Course Objective:	To understand and apply quantitative modeling, multiplexing, switching, and routing principles for the analysis, design, and simulation of wired and wireless telecommunication networks.

Course Outcomes The Student will be able to		Cognitive Level
CO1	Explain the fundamentals of telecommunication networks, networking elements, and the evolution of wired and wireless communication systems.	K2
CO2	Explain multiplexing techniques, traffic models, network performance measures, and scheduling mechanisms in communication networks.	K2
CO3	Apply switching techniques and queueing models to evaluate the performance of packet and circuit-switched networks.	K3
CO4	Analyze routing algorithms, routing protocols, QoS routing, and MPLS for efficient network communication.	K4
CO5	Evaluate the design and simulation of wired and wireless communication networks using network simulation tools.	K5

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 Problemminimum interference Routing, MPLS, QoS Routing, Non-additive and Additive metrics	
UNIT V – CASE STUDIES	(9)

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Erode - 638 052.

Design of a wireless network and a wired network, prototype implementation to be simulated in a network simulator.	
TOTAL PERIODS	45

REFERENCES:

1. Kumar, A., Manjunath, D., & Joy, J. (2005). Communication networking. Morgan Kaufmann Publishers.
2. Lean Garcia, A., & Widjaja, I. (2004). Communications networks. Tata McGrawHill.
3. Robertazzi, T. G. (2006). Computer networks and systems (3rd ed.). Springer.
4. Keshav, S. (1999). An engineering approach to computer networking. Addison– Wesley.

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	3	2
5	2	3	3	3	3
CO (W.A)	2.6	2.6	2.4	2.6	2.0

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25004 -DIGITAL COMMUNICATION RECEIVERS	L	T	P	C
	3	0	0	3

Course Objective:	• 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 Student will be able to		Cognitive Level
CO1	Explain the fundamentals of digital communication receivers, receiver architectures, signal space representation, and performance metrics.	K2
CO2	Explain carrier and timing synchronization techniques used in digital communication receivers.	K2
CO3	Apply channel estimation and equalization techniques for mitigating channel impairments in digital communication systems.	K3
CO4	Analyze advanced receiver architectures, including ML/MAP receivers, MIMO receivers, and iterative decoding techniques.	K4
CO5	Evaluate simulation and hardware implementation aspects of digital communication receivers using MATLAB/Simulink, FPGA, and SDR platforms.	K5

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)**

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

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 PERIODS	**45**

REFERENCES:

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

Online Resources:

1. MATLAB Communication Toolbox Documentation – https://www.mathworks.com/help/comm/

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	3	3
5	2	3	3	3	3
CO (W.A)	2.6	2.6	2.4	2.6	2.2

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25005-CO-OPERATIVE COMMUNICATION	L	T	P	C
	3	0	0	3

Course Objective:	To study and develop cooperative communication techniques and green radio strategies that enhance energy efficiency, resource allocation, and overall performance in modern wireless networks

	Course Outcomes The Student will be able to	Cognitive Level
CO1	Explain the fundamentals of cooperative communication, green radio concepts, and energy-efficient wireless network architectures.	K2
CO2	Explain cooperative communication techniques, antenna architectures, and LTE-Advanced technologies for energy-efficient cellular networks.	K2
CO3	Apply relay-based cooperative communication techniques, resource optimization, and network coding in cellular wireless networks.	K3
CO4	Analyze green radio network techniques, including power management, spectrum management, and cooperative multicell processing.	K4
CO5	Evaluate access techniques, resource allocation strategies, and standardization approaches for energy-efficient green radio networks.	K5

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; Turbo base stations; 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)**

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

Cross-layer design of adaptive packet scheduling for green radio networks; Energy efficient relaying for cooperative cellular wireless networks; Energy performance in TDDCDMA multi hop cellular networks; Resource allocation for green communication in relay- based cellular networks; Green Radio Test-Beds and Standardization.	
TOTAL PERIODS	45

REFERENCES:

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

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	2
2	3	3	2	3	2
3	3	2	3	3	3
4	2	3	3	2	3
5	2	3	3	2	3
CO (W.A)	2.6	2.6	2.4	2.4	2.6

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25006-SECURITY FOR WIRELESS COMMUNICATION NETWORKS	L	T	P	C
	3	0	0	3

Course Objective:	To understand and analyze security goals, cryptographic techniques, key management, and security protocols, along with addressing modern wireless network security challenges in advanced communication systems.

		Cognitive Level
CO1	Explain the fundamentals of information security, cryptographic techniques, security goals, attacks, and security mechanisms.	K2
CO2	Explain symmetric and asymmetric cryptographic algorithms, including AES, RC4, and public-key cryptography.	K2
CO3	Apply integrity, authentication, digital signature, hash function, and key management techniques to secure communication systems.	K3
CO4	Analyze security protocols for IP, e-mail, and web-based communication systems, including IPsec, PGP, S/MIME, SSL, TLS, and SET.	K4
CO5	Evaluate security challenges, threats, and countermeasures in broadband, 4G, and 5G wireless networks, including side-channel attacks.	K5

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 & 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 PERIODS	45

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

REFERENCES:

1. Forouzan, B. A. (2011). Cryptography and network security. McGraw-Hill.
2. Stallings, W. (2002). Cryptography and network security: Principles and practice (2nd ed.). Prentice Hall of India.
3. Kahate, A. (2008). Cryptography and network security (2nd ed.). Tata McGraw-Hill.
4. Nichols, R. K., & Lekkas, P. C. (2001). Wireless security: Models, threats, and solutions. McGraw-Hill.
5. Yang, H., et al. (2004). Security in mobile ad hoc networks: Challenges and solutions. IEEE Wireless Communications, February 2004. https://doi.org/10.1109/MWC.2004.1274245
6. IEEE Network Magazine. (1999). Securing ad hoc networks. IEEE Network Magazine, 13(6), 24–30.
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. (2008). Securing wireless sensor networks – Security architecture. Journal of Networks, 3(1), 65–76.
9. Perrig, A., Stankovic, J., & Wagner, D. (2004). Security in wireless sensor networks. Communications of the ACM, 47(6), 53–57. https://doi.org/10.1145/990680.990707

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	2	3	3	2	3
4	2	3	3	3	3
5	2	2	3	2	3
CO (W.A)	**2.4**	**2.6**	**2.4**	**2.2**	**2.4**

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25C12 -SIGNAL DETECTION AND ESTIMATION	L	T	P	C
	3	0	0	3

Course Objective:	This course aims to equip students with a solid foundation in the principles and methods of signal detection and estimation, emphasizing both theoretical understanding and practical applications. It seeks to develop the ability to design, analyze, and implement detection and estimation algorithms for signals in noisy environments commonly encountered in communications, radar, and related fields. The course also fosters hands-on proficiency with open-source tools and simulation techniques to solve real-world problems.

Course Outcomes The Student will be able to		Cognitive Level
CO1	Explain the fundamentals of random processes, statistical concepts, Gaussian processes, and Hilbert space principles used in signal processing.	K2
CO2	Explain hypothesis testing, detection theory, likelihood ratio tests, matched filters, and performance analysis of signal detectors.	K2
CO3	Apply parameter estimation techniques, including Maximum Likelihood Estimation (MLE), least squares estimation, and Bayesian estimation methods.	K3
CO4	Analyze Bayesian signal detection and estimation techniques, including MAP, MMSE, Wiener filtering, and Kalman filtering.	K4
CO5	Evaluate advanced detection and estimation techniques for radar and communication systems, including adaptive and machine learning-based approaches.	K5

UNIT I – RANDOM PROCESSES AND STATISTICAL PRELIMINARIES	**(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 –HYPOTHESIS TESTING AND DETECTION THEORY	**(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 –PARAMETER ESTIMATION THEORY	**(9)**
Principles of parameter estimation – Minimum variance unbiased estimators – CramérRao lower bound – Maximum Likelihood Estimation (MLE) techniques – Method of moments – Bayesian estimation fundamentals – Linear models and least squares estimation – Properties of estimators: consistency,	

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

sufficiency, and efficiency – Applications in signal parameter estimation.	
UNIT IV – BAYESIAN SIGNAL DETECTION AND ESTIMATION (IPR)	**(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 – ADVANCED TOPICS AND APPLICATIONS	**(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 PERIODS	**45**

REFERENCES:

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

E-Resources:

1. Course Type: NPTEL Course Title: Detection and Estimation Theory
   Web Link: https://nptel.ac.in/courses/117105085
2. Course Type: NPTEL Course Title: Statistical Signal Processing
   Web Link:https://nptel.ac.in/courses/117104117
3. Course Type: Online Course (Coursera) Title: Digital Signal Processing
   Web Link:https://www.coursera.org/learn/dsp
4. Course Type:OpenCourseWare (MIT OCW) Title: Estimation and Detection Theory
   WebLink:https://ocw.mit.edu/courses/6-432-stochastic-processesdetection-and-estimation-fall-2004/
5. Course Type: Tutorial Resource Title: Introduction to Signal Detection and Estimation (Tutorials Point)

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

Mapping of Cos with POs/PSOs					
COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	3	3
5	3	3	3	2	3
CO (W.A)	2.8	2.6	2.4	2.4	2.2

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25007 - SOLID STATE DEVICE MODELING AND SIMULATION	L	T	P	C
	3	0	0	3

Course Objective:	This course aims to apply device physics in the modeling of integrated diodes and MOS capacitors. It enables students to analyze and model advanced semiconductor devices such as MOSFETs, FINFETs, UTBs, MESFETs, HBTs, HEMTs, and MODFETs. Additionally, it provides a comprehensive understanding of the analysis and modeling of optoelectronic devices.

Course Outcomes The Student will be able to		Cognitive Level
CO1	Explain the fundamentals of semiconductor physics, diode characteristics, transport equations, and SPICE modeling of PN junction and Schottky diodes.	K2
CO2	Explain the operating principles of MOS capacitors, threshold voltage, C–V characteristics, and integrated MOS capacitance.	K2
CO3	Apply MOS transistor models and analyze device characteristics, scaling effects, short-channel effects, and compact modeling techniques.	K3
CO4	Analyze the operating principles and characteristics of advanced semiconductor devices such as MESFETs, HBTs, HEMTs, and MOSFETs.	K4
CO5	Evaluate the characteristics and applications of optoelectronic devices, including LEDs, lasers, photodiodes, avalanche photodiodes, and solar cells.	K5

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 –INTEGRATED MOS TRANSISTOR	**(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. Technology scaling for cost, speed and power consumption, Sub threshold Current –Sub threshold Swing, Threshold voltage Roll Off-Short Channel Leakage, reducing gate insulator electrical thickness And Tunneling Leakage, Short Channel Effects. Ultra Thin body, SOI and Multi gate MOSFET - FINFET. Compact Model for Circuit Simulation using Verilog A.	

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

UNIT IV – ADVANCED SEMICONDUCTOR DEVICES	(9)
MESFETs, HBTs, HEMTs, MOSFETs.	
UNIT V – OPTOELECTRONICS DEVICES	**(9)**
Light Emitting Diodes, Lasers, Photoconductors, Junction Photodiodes, Avalanche Photodiodes, Solar Cells.	
TOTAL PERIODS	45

REFERENCES:

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

MappingofCOswithPOs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	3	3
5	3	3	3	2	3
CO (W.A)	2.8	2.6	2.4	2.4	2.2

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

EL25C04 -RF INTEGRATED CIRCUIT DESIGN	L	T	P	C
	3	0	0	3

Course Objective:	To study CMOS transceiver design, noise analysis, impedance matching, amplifier and feedback system design, mixers, oscillators, and frequency synthesizers for high performance communication systems.

	Course Outcomes The Student will be able to	**Cognitive Level**
CO1	Explain CMOS device physics, transceiver architectures, noise mechanisms, and RF receiver/transmitter specifications.	K2
CO2	Explain impedance matching techniques, amplifier design principles, and low-noise amplifier (LNA) architectures for RF systems.	K2
CO3	Apply feedback principles and power amplifier design techniques to improve the performance and efficiency of RF communication systems.	K3
CO4	Analyze the operation and performance of RF mixers, oscillators, and phase noise characteristics in communication circuits.	K4
CO5	Evaluate PLLs and frequency synthesizer architectures, including Integer-N and Direct Digital Frequency Synthesizers, for RF communication applications.	K5

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	

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

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 PERIODS	45

REFERENCES:

1. Lee, T. (2004). Design of CMOS RF integrated circuits. Cambridge University Press.
2. Razavi, B. (2013). RF microelectronics (2nd ed.). Pearson Education.
3. Crols, J., & Steyaert, M. (1997). CMOS wireless transceiver design. Kluwer Academic Publishers.
4. Razavi, B. (2017). Design of analog CMOS integrated circuits (2nd ed.). McGraw-Hill Education.
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

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	3	3
5	3	3	3	2	3
CO (W.A)	2.8	2.6	2.4	2.4	2.2

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25C13-IMAGE AND VIDEO PROCESSING AND ANALYTICS	L	T	P	C
	3	0	0	3

Course Objective:	This course aims to provide students with a comprehensive understanding of image processing and video analytics techniques, focusing on feature extraction, motion analysis, object detection, and high-level interpretation. It equips learners with the skills to apply open-source tools for developing practical solutions in domains such as surveillance, smart cities, and human activity recognition. By integrating foundational concepts with project-based and research-oriented activities, the course prepares students for advanced study and real-world applications in computer vision and video intelligence.

Course Outcomes The Student will be able to		Cognitive Level
CO1	Explain the fundamentals of computer vision, visual perception, image representation, color models, and image analytics.	K2
CO2	Explain feature extraction, feature descriptors, machine perception techniques, and dimensionality reduction methods used in vision analytics.	K2
CO3	Apply intelligent video processing techniques, including motion analysis, video segmentation, key frame extraction, and camera calibration.	K3
CO4	Analyze object detection, tracking, recognition, and action recognition techniques using modern computer vision algorithms.	K4
CO5	Evaluate video analytics applications, deployment tools, real-world datasets, ethical issues, and emerging trends in intelligent vision systems.	K5

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)**

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

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 PERIODS	**45**

REFERENCES:

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

E-Resources

1. NPTEL Online Course – Digital Image Processing by Prof. P. K. Biswas, IIT Kharagpur – https://nptel.ac.in/courses/117105079
2. NPTEL Online Course – Computer Vision by Prof.Shanmuganathan Raman, IIT Gandhinagar – https://nptel.ac.in/courses/106106228
3. Web Resource – OpenCV-Python Tutorials – https://docs.opencv.org/master/d6/d00/tutorial_py_root.html
4. Online Learning (Coursera) – Computer Vision Basics by University at Buffalo – https://www.coursera.org/learn/computer-vision-basics
5. 5. Dataset/API Resource – COCO Dataset: Common Objects in Context – https://cocodataset.org/#home

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

Mapping of Cos with POs/PSOs					
COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	3	3
5	3	3	3	2	3
CO (W.A)	2.8	2.6	2.4	2.4	2.2

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

VL25C02-MEMS & NEMS	L	T	P	C
	3	0	0	3

Course Objective:	• 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 Student will be able to		**Cognitive Level**
CO1	Explain the fundamentals of MEMS technology, silicon processing, fabrication techniques, and semiconductor materials.	K2
CO2	Explain photolithography, pattern transfer techniques, mask alignment, and MEMS fabrication processes.	K2
CO3	Apply the principles of Nano-Electro-Mechanical Systems (NEMS) and nanofabrication techniques for nanoscale device development.	K3
CO4	Analyze nanomaterials, carbon nanotubes, deposition, lithography, and etching processes used in NEMS fabrication.	K4
CO5	Evaluate the design and applications of MEMS/NEMS devices, including sensors, RF MEMS, resonators, gyroscopes, and case study-based systems.	K5

UNIT I – FUNDAMENTALS OF MEMS	**(9)**
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)**

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

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 PERIODS	45

Mapping of Cos with POs/PSOs					
COs	**POs**			**PSOs**	
	1	**2**	**3**	**1**	**2**
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	3	3
5	2	3	3	2	3
CO (W.A)	2.6	2.6	2.4	2.4	2.2

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25008 -IMAGE PROCESSING AND PATTERN RECOGNITION	L	T	P	C
	3	0	0	3

Course Objective:	To understand and apply fundamental imaging concepts—including acquisition, enhancement, restoration, segmentation, compression, watermarking, and feature extraction—using mathematical transforms, filtering techniques, statistical models, and modern computer vision descriptors for effective analysis and processing of digital images.

Course Outcomes The Student will be able to		Cognitive Level
CO1	Explain the fundamentals of digital image processing, image acquisition, image formation, and image transformation techniques.	K2
CO2	Explain image enhancement and restoration techniques, including spatial and frequency domain filtering, histogram processing, and Wiener filtering.	K2
CO3	Apply image segmentation techniques, including edge detection, thresholding, region-based methods, and morphological segmentation.	K3
CO4	Analyze image compression, watermarking techniques, and image/video compression standards for efficient multimedia storage and transmission.	K4
CO5	Evaluate feature extraction methods, including boundary descriptors, SIFT, SURF, PCA, and texture analysis for image recognition applications.	K5

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 PERIODS	45

Chairman - Board of Studies
Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

REFERENCES:

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

Mapping of Cos with POs/PSOs

COs	POs			PSOs	
	1	2	3	1	2
1	3	2	1	2	1
2	3	3	2	2	2
3	3	2	3	3	2
4	2	3	3	3	3
5	3	3	3	2	3
CO (W.A)	2.8	2.6	2.4	2.4	2.2

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Electronics and Communication Engineering
Nandha College of Technology (Autonomous)
Erode - 638 052.

CU25C14- ANALOG AND MIXED SIGNAL VLSI DESIGN	L	T	P	C
	3	0	0	3

Course Objective:	• 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.

CourseOutcomes TheStudentwillbeableto		**Cognitive Level**
CO1	Describe the integration of analog and digital subsystems in electronic system design.	K1
CO2	Analyze and design CMOS analog and digital building blocks using device-level models.	K4
CO3	Analyze and design CMOS digital building blocks for electronic system applications.	K4
CO4	Develop and simulate mixed-signal circuits using appropriate simulation tools for real-time applications.	K4
CO5	Evaluate the performance parameters of analog, digital and mixed-signal subsystems through simulation and laboratory experiments.	K4

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 PERIODS	45

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

Mapping of Cos with POs/PSOs					
COs	PO			PSO	
	1	2	3	1	2
1	1	2	3	1	1
2	2	1	3	3	2
3	2	1	3	3	2
4	3	2	3	3	3
5	3	3	3	2	3
CO (W.A)	**2.2**	**1.8**	**3.0**	2.4	2.2

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