ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

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.

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

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**	

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**	

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

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.

Basics of Radio Frequency System Design

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

Activity: Measurement of Gain and Noise Figure in an RF System

Amplifier Modeling and Analysis

Noise: Noise equivalent model for Radio frequency device, amplifier noise model, cascade performance, minimum detectable signal, performance of noisy systems in cascade.

Non-Linearity: Amplifier power transfer curve, gain compression, AM-AM, AM-PM, polynomial approximations, Saleh model, Wiener model and Hammerstein model, intermodulation, Single and two tone analyses, second and third order distortions and measurements, SOI and TOI points, cascade performance of nonlinear systems.

Activity: Characterization of Amplifier Noise and Non-Linearity Using Single- and Two-Tone Tests

Mixer And Oscillator Modeling and analysis

Mixers: Frequency translation mechanisms, frequency inversion, image frequencies, spurious calculations, principles of mixer realizations.

Oscillators: phase noise and its effects, effects of oscillator spurious components, frequency accuracy, oscillator realizations: Frequency synthesizers, NCO.

Activity: Analysis of Mixer Frequency Translation and Oscillator Phase Noise in RF Systems

Radio Architectures and Design Considerations

Superheterodyne architecture, direct conversion architecture, Low IF architecture, band-pass sampling radio architecture

Activity: Comparative Study of Superheterodyne, Direct Conversion, and Low-IF Radio Architectures

Case Study: Applications of Systems Design Multimode and multiband Superheterodyne transceiver: selection of frequency plan, receiver system and transmitter system design – Direct conversion transceiver: receiver system and transmitter system design. **Activity**: Design and Analysis of Multimode and Multiband Transceivers Using Superheterodyne and Direct Conversion Architectures
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. 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.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain RF system parameters, digital baseband signaling concepts, and performance metrics such as noise figure, S-parameters, EVM, BER, and dynamic range.	-	-	-
CO2	Analyze RF amplifier behavior including noise modeling, nonlinear characteristics, intermodulation distortion, and cascade performance.	PO3(3)	3	3
CO3	Develop and simulate mixer and oscillator models, frequency translation effects, phase noise, and spurious responses in RF systems.	PO1(3)	3	3
CO4	Design and evaluate RF receiver and transmitter architectures including superheterodyne, direct conversion, and low-IF systems for multimode and multiband applications.	PO1(3) PO3(2)	2	3

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.

Introduction To machine Learning and Communication Systems

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.

Activity Flipped Classroom: Students will *review online tutorials and curated open-source datasets* related to modulation recognition and signal processing *before class*. In-class sessions will focus on *group discussions and demonstrations* of basic data preprocessing workflows for communication signals. Tools Used: Python, Scikit-learn, NumPy, Matplotlib.

Supervised Learning Methods and Applications

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.

Activity Project-Based Learning: Students will *design and implement a supervised learning model* (e.g., SVM or Random Forest) to classify modulation schemes from provided datasets. They will *document their workflow and evaluate performance metrics*. Tools Used: Python, Jupyter Notebook, Scikit-learn.

Unsupervised Learning and Dimensionality Reduction

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

Activity Type: Seminar and Code Reproduction :Each student will *select a research paper* on unsupervised learning applications in communication (e.g., blind source separation), *present key ideas*, and *reproduce core algorithms* from the paper using open-source libraries. Tools Used: Python, scikit-learn, SciPy.

Deep Learning Techniques in Communication Systems

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.

Activity Seminar and Code Reproduction: Each student will *select a research paper* on unsupervised learning applications in communication (e.g., blind source separation), *present key ideas*, and *reproduce core algorithms* from the paper using open-source libraries. Tools Used: Python, scikit-learn, SciPy.

Reinforcement Learning and Emerging Trends

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.

Activity Type: Capstone Mini-Project: Teams will develop and demonstrate a reinforcement learning prototype for dynamic spectrum access simulation. They will present their methodology and code in class, integrating ethical considerations discussed during lectures. Tools Used: OpenAI Gym, Python, NumPy.

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. Goodfellow, 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 TensorFlow* (3rd ed.). O’Reilly Media.

4. Simeone, O. (2022). *Machine learning for engineers* (1st ed.). Cambridge University Press.
5. Hastie, T., Tibshirani, R., & Friedman, J. (2020). *The elements of statistical learning: Data mining, inference, and prediction* (3rd ed.). Springer.

E-Resources

1. Course Type: NPTEL CourseTitle: Machine LearningWeb Link: https://nptel.ac.in/courses/106/106/106106202
2. Course Type: NPTEL CourseTitle: Deep LearningWeb Link: https://nptel.ac.in/courses/106/105/106105215
3. Course Type: Online CourseTitle: Introduction to Machine Learning (Coursera)Web Link: https://www.coursera.org/learn/machine-learning
4. Course Type: Web ResourceTitle: Scikit-learn User GuideWeb Link: https://scikit-learn.org/stable/user_guide.html
5. Course Type: Web ResourceTitle: TensorFlow TutorialsWeb Link: https://www.tensorflow.org/tutorials

CO No.	Course Outcome Description	PO Mapping	PSO Mapping
CO1	Explain the fundamental concepts of machine learning and summarize their significance in communication systems applications.	-	-
CO2	Apply supervised learning algorithms to solve classification and regression problems in communication signal analysis.	PO1 (3), PO3 (3)	PSO2 (3), PSO3 (2)
CO3	Analyze unsupervised learning techniques and demonstrate their use in clustering and dimensionality reduction of communication data.	PO1 (3), PO3 (3)	PSO2 (3), PSO3 (2)
CO4	Design and implement deep learning models, including convolutional and recurrent neural networks, for advanced signal processing tasks.	PO1 (3), PO3 (3)	PSO2 (3), PSO3 (3)
CO5	Develop reinforcement learning strategies and propose innovative solutions for dynamic resource management in communication systems.	PO1 (3), PO3 (3)	PSO2 (3), PSO3 (3)

CU25C07	Advanced Wireless Communication Networks	L	T	P	C
		3	0	2	4

Course objectives:

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.

4G Architecture:

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.

5G Architecture and Millimeter Wave Communications:

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.

5G Waveforms and Channel Models:

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.

Networking in 5G:

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.

Evaluation of 5G And 5G Applications:

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

Activities:

1: Modeling of 4G LTE – A System
2: Design of Radio Network Access for 4G Networks
3: Modeling of 5G Networks
4: Design of Radio Network Access for 5G Systems
5: Design of Smart Antenna System

Practicals:

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

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. 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.

CO No.	Course Outcome Description	PO Mapping	PSO Mapping
CO1	Explain the architecture and protocols of 4G LTE systems including E-UTRAN, EPC, and LTE air interface and 5G architecture, use cases, millimeter-wave communication principles, and massive MIMO concepts.	-	-
CO2	Analyze LTE air interface protocol stack, channel structures, resource grid, and bearer management mechanisms and5G radio access technologies	PO1 (3), PO3 (3)	PSO2 (3), PSO3 (2)

	including NOMA, V2X, mMTC, and METIS channel models		
CO3	Design and evaluate coordinated multi-point transmission, relaying techniques, and massive MTC systems using simulation tools.	PO1 (3), PO3 (3)	PSO2 (3), PSO3 (2)
CO4	Implement and test 4G/5G network models, D2D communication, and smart antenna systems in laboratory environments.	PO1 (3), PO3 (3) PO1(4)	PSO2 (3), PSO3 (3)

CU25202	Advanced Communication Systems Laboratory	L	T	P	C
		0	0	4	2

Course Objective:

This course introduces

- To study & measure the performance of digital communication systems.
- To provide a comprehensive knowledge of Wireless Communication.
- To learn about the design of digital filter and its adaptive filtering algorithms.

List of experiments (matlab/scilab/cabview)

Use appropriate simulation tools for the following experiments

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.

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

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

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.

	CO description	PO Mapping	PSO1	PSO2
CO1	Implement and demonstrate binary digital modulation and demodulation techniques and analyze their performance under ideal and noisy channel conditions.	PO3(3)	2	2
CO2	Design and implement channel coding and decoding schemes including linear, cyclic, convolutional, and turbo codes for error control.	PO1(3)	3	2

CO3	Design and simulate advanced communication systems such as DSSS, CDMA, OFDM, synchronization modules, and channel equalizers.	PO1(3) PO3(2)	2	3
CO4	Evaluate wireless channel characteristics and adaptive algorithms such as LMS and RLS for noise and echo cancellation using simulation tools.	PO3(3)	3	3

Programme Elective Courses

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.

Introduction to Signal Decompositions

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

Activity: Exploration of Signal Decomposition Using Fourier Transform and Orthonormal Basis in Hilbert Spaces

Discrete-Time Bases and Filter Banks

Series Expansions of Discrete - Time Signals - Two-Channel Filter Banks - Tree-Structured Filter Banks - Multichannel Filter Banks - Pyramids and Over complete Expansions - Multidimensional Filter Banks - Tran multiplexers and Adaptive Filtering in Subbands

Activity: Design and Analysis of Two-Channel and Tree-Structured Filter Banks for Discrete-Time Signal Decomposition

Multiresolution Analysis and Construction of Wavelets

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

Activity: Construction and Analysis of Wavelets Using Multiresolution Techniques and Filter Bank Methods

Continuous Wavelet and Frames

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

Activity: Implementation and Analysis of Continuous Wavelet Transform and Short-Time Fourier Transform Using Frame Theory

Signal Compression and Sub Band Coding
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

Activity: Design and Evaluation of Subband and Wavelet-Based Compression Techniques for Audio, Image, and Video Signals

References:

1. Vetterli, M., & Kovačević, J. (1995). *Wavelets and subband coding*. Prentice Hall.
2. Soman, K. P., & Ramachandran, K. I. (2013). *Insight into wavelets – From theory to practice* (3rd ed.). PHI Learning Private Limited.
3. Rao, R. M., & Bopardikar, A. S. (2012). *Wavelet transforms: Introduction to theory and applications* (3rd ed.). Prentice Hall PTR.
4. Strang, G., & Nguyen, T. (1996). *Wavelets and filter banks* (2nd ed.). Wellesley-Cambridge Press.
5. 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/

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

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Understand the vector spaces, signal spaces and explain the theoretical foundations and limitations of time-frequency analysis methods	-	-	-
CO2	Analyze and design the two-channel and multi-channel filter banks	PO3(3)	3	3

CO3	Apply the principles of Multiresolution Analysis (MRA) to derive and interpret the properties of scaling functions and wavelet functions, linking them to filter bank coefficients.	PO1(3)	3	3
CO4	Analyze the properties and reconstruction of continuous wavelets, Short-time Fourier Transform and Frames	PO1(3) PO3(2)	2	3

EL25C03	Wireless Sensor Netwoks 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.

Overview of Wireless Sensor Networks
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

Activity: Analysis and Case Study of Wireless Sensor Network Applications and Enabling Technologies

Mac and Routing
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

Activity: Evaluation of Sensor Node Architecture, Energy Consumption, and Network Design Scenarios

Architectures
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.

Activity: Analysis and Simulation of MAC Protocols and Energy-Efficient Routing in Wireless Sensor Networks

Infrastructure Establishment and Data Management
Topology Control, Clustering, Time Synchronization, Localization and Positioning-Data management in WSN, Storage and indexing in sensor networks, Query processing in sensor, Data aggregation.

Activity: Implementation and Evaluation of Topology Control, Clustering, and Data Aggregation in Wireless Sensor Networks

Wireless Body Area Network
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. **Activity**: Simulation and Performance Analysis of WBAN Architecture, MAC Protocols, and Energy Management
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. 4. Li, H.-B., Yekeh Yazdandoost, K., & Bin-Zhen. (2010). Wireless body area networks. River Publishers. 5. Thotahewa, K. M. S., Redoute, J.-M., & Yuce, M. R. (2016). Ultra wideband wireless body area networks. Springer.
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%).

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamentals, challenges, enabling technologies, and application scenarios of Wireless Sensor Networks and Wireless Body Area Networks.	-	-	-
CO2	Analyze sensor node architecture, energy consumption models, network architectures, and physical layer design considerations for WSN and WBAN.	PO3(3)	3	3
CO3	Evaluate MAC and routing protocols for WSN including IEEE 802.15.4, ZigBee, low-duty-cycle protocols, and energy-efficient routing schemes.	PO1(3)	3	3
CO4	Design and evaluate infrastructure and data management solutions for WSN and WBAN including topology control, clustering, synchronization, localization, and data aggregation using simulation tools.	PO1(3) PO3(2)	2	3

CU25C11	Ultra Wide Band Communications	L	T	P	C
		3	0	0	3

Course Objectives:

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.

Introduction about UWB For Wireless Communications

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.

UWB Antennas

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.

UWB Wireless Channels and Interference

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.

UWB Signal Processing

Data Modulation schemes and their comparison-UWB Multiple Access Modulation-Uniform Pulse Train Spacing-Pseudorandom Time Hopping-Direct Sequence UWB (DS-UWB)- BER of Modulation Schemes- Rake Receiver- Transmit-Reference (T-R) Technique-UWB Range- Data Rate Performance-UWB Channel Capacity.

Applications And Recent Trends in UWB

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

Activity:

1. Generation of UWB signals using Matlab
2. Spectral Characteristics of UWB Signals using Matlab
3. Simulate and design UWB receivers using Matlab
4. Simulate and test Pulse shaping using Matlab
5. Experiments with the Decawave DWM1001-DEV

Group Projects :

1. Design and Simulation of an Ultra-Wideband (UWB) Based Indoor Positioning System
2. Design of a UWB Transmitter-Receiver Pair for Low-Power IoT Applications
3. Implement Vehicle-to-Vehicle (V2V) Communication Using UWB

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.

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%).

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain UWB concepts, technologies, regulations, standards, advantages, challenges, and application domains in wireless communication systems.	**-**	**-**	**-**
CO2	Analyze UWB antennas, wireless channel models, interference mechanisms, and performance metrics such as link budget, BER, and channel capacity.	PO3(3)	3	3
CO3	Evaluate UWB signal processing techniques including modulation schemes, multiple access methods, receiver architectures, and interference mitigation strategies.	PO1(3)	3	3
CO4	Design, simulate, and evaluate UWB-based systems for applications such as indoor positioning, IoT, vehicular communication, and radar using MATLAB and hardware platforms.	PO1(3) PO3(2)	2	3

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.

Communication Systems & Wireless Channel Models

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.

Activity (Simulation):
(I) Simulation of Wireless Channel and Modulation Schemes Using MATLAB.
(Ii) Ber Vs Snr Analysis Under AWGN And Fading Conditions.

Receiver Architectures and LNA Design

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.

Activity (EDA Tools):
(I) Simulation AND Analysis of Gain, NF of A CMOS LNA.
(Ii) Impedance Matching Using Smith Chart.

Mixer Design – Active and Passive

Gilbert Cell Mixer, Conversion Gain, Distortion, Noise Figure, Lo-Rf Isolation. Switching Mixers, Sampling Mixers – Non-Idealities and Noise Analysis.

Activity (Eda Tools):
(I) Design and Simulation of Active Gilbert Mixer.
(Ii) Conversion Gain and NF Evaluation Using Spice.

A/D Converters in Wireless Systems

Demodulators And ADC Types: Flash, Pipeline, And Sigma-Delta. Band Pass Vs Low-Pass ΣΔ Modulators. Implementation With Switched-Capacitor Circuits. I/Q Mismatch.

Activity (Simulation):
(I) Modeling Of 1-Bit ΣΔ ADC In MATLAB/Simulink.
(Ii) System-Level Ber Analysis of ADC Output.

Frequency Synthesizers and Transmitters

PLL-Based Frequency Synthesizers, Phase Detectors, VCOS, Loop Filters. Phase Noise and Spur Analysis. Transmitter Architectures – Quadrature Lo Generation, Pa Design (Class A, B, E), Linearity, Output Control.

Activity (Eda Tools):

(I) Design And Simulation of Ring Oscillator.
(Ii) Efficiency and Output Power Analysis of A Class E Pa.

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

E-Resources

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

	CO description	PO Mapping	PSO1	PSO2
CO1	Understand the Wireless System Blocks and Their Circuit-Level Implications.	-	-	-
CO2	Analyze and Design Front-End Receiver Components Like LNA And Mixers.	PO3(3)	3	3
CO3	Implement ADC Architectures AND Assess Their Performance for Wireless Systems.	PO1(3)	3	3
CO4	Develop And Simulate PLLS And Transmitter Components Including Pas.	PO1(3) PO3(2)	2	3

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.

Software Defined Radio and its Architecture

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.

Activity: Exploring SDR Architecture Through Modular Simulation

Cognitive Radios and its Architecture

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

Activity: Designing a Cognitive Radio Prototype on SDR Platform

Spectrum Sensing and Identification

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.

Activity: Implementing and Comparing Spectrum Sensing Techniques

Information Theoretical Limits on CR Networks

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.

Activity: Analyzing Cognitive Radio Network Performance under Different Interference Behaviors

User Cooperative Communications

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 **Activity:** Simulating Cooperative Communication in Wireless Networks
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.
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%).

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Explain the principles, architecture, evolution, and functional components of Software Defined Radio (SDR) and its hardware–software interfaces.	-	-	-
CO2	Analyze the architecture and operation of Cognitive Radio systems including cognition cycle, resource optimization, and integration with SDR platforms.	PO3(3)	3	3
CO3	evaluate spectrum sensing and identification techniques such as energy detection, cyclostationary detection, matched filtering, and cooperative sensing.	PO1(3)	3	3
CO4	Design and simulate cognitive and cooperative wireless communication systems considering spectrum sharing strategies and interference behaviors.	PO1(3) PO3(2)	2	3

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,

Fundamentals of Quantum Information

Quantum carriers Qubits and quantum states, Superposition and measurement, Bloch sphere, Multi-qubit systems, Tensor products, Quantum gates and circuits, No-cloning theorem.

Activities: Exploring Qubits and Quantum Gates Using the Bloch Sphere

Quantum Communication Principles

Classical vs quantum communication, Quantum channels, Density matrices, Noise and decoherence, Quantum error models, Holevo bound, protocols: Quantum teleportation, Superdense coding, Entanglement-based communication, Bell states.

Activities: Simulate teleportation circuit and verify fidelity

Quantum Cryptography

Introduction to cryptography, Quantum Key Distribution (QKD), BB84 protocol, E91 protocol, Security analysis, Eavesdropping strategies, Practical QKD implementations.

Activities: Simulate eavesdropping scenarios and observe QBER impact

Quantum Networking

Entanglement distribution, Quantum repeaters, Quantum routing and switching, Quantum network architectures, Hybrid classical–quantum networks, Quantum internet vision, Challenges and future directions.

Activities: Implement entanglement distribution and routing between nodes

Tools: Netsquid, Qiskit

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.

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%).

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamental principles of quantum communication qubits, photons, polarization, quantum channels, error correction, teleportation and super dense coding	-	-	-
CO2	Apply quantum cryptography algorithm and security key exchange and message encryption.	PO1(3)	3	3
CO3	Analyze hybrid secure communication systems combining QKD,PQC and AES.	PO2(3)	2	2
CO4	Develop quantum network architectures with real world deployment.	PO3(3) PO11(2)	2	2

NC25C01	Telecommunication Switching System Modeling and Simulation	L	T	P	C
		3	0	0	3

Course Objectives:

- To enable the student to understand the various aspects of simulation methodology and performance, appreciate the significance of selecting sampling frequency and modelling different types of signals and processing them.
- To expose the student to the different simulation techniques, their pros and cons and enable him to understand and interpret results using case studies.

Simulation Methodology 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

Activity: Simulating a Multicarrier Communication System and Analyzing Performance

Random Signal Generation & Processing 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.

Activity: Generating and Processing Random Signals

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

Activity: Monte Carlo Simulation for Wireless System Performance Estimation

Advanced Models & Simulation Techniques Modeling and simulation of non-linearities : Types, Memoryless non-linearities, Non-linearities with memory, Modeling and simulation of Time varying systems : Random process models, Tapped delay line model, Modelling and simulation of waveform channels, Discrete memoryless channel models, Markov model for discrete channels with memory.

Activity: Modeling and Simulating Non-linear and Time-Varying Communication Systems

Efficient Simulation Techniques Tail extrapolation, pdf estimators, Importance Sampling methods, Case study: Simulation of a Cellular Radio System.

Activity: Efficient Simulation of a Cellular Radio System Using Importance Sampling

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%).

	CO description	PO Mapping	PSO1	PSO2
CO1	Understand the different signal generation and processing methods	-	-	-
CO2	Mathematically model a physical phenomena	PO3(3)	3	3
CO3	Simulate a phenomena so as to depict the characteristics that may be observed in a real experiment.	PO1(3)	3	3
CO4	Apply knowledge of the different simulation techniques for designing a communication system or channel	PO1(3) PO3(2)	2	3

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.

Introduction to Massive MIMO And MMWAVE Communication

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.

Activity: Introduction to Massive MIMO and MMWAVE Communication in 5G and Beyond Technologies

Propagation and Channel Modeling

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.

Activity: Exploring Propagation and Channel Modeling for MMWAVE and Massive MIMO Systems

Beamforming and Precoding Techniques

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.

Activity: Understanding Beamforming and Precoding Techniques for MMWAVE and Massive MIMO Systems

Signal Processing in Massive MIMO Systems

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.

Activity: Signal Processing Techniques in Massive MIMO Systems

System Design, Standards, and Applications

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.)

Activity: System Design, Standards, and Applications of Massive MIMO and MMWAVE in 5G and Beyond

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

MOOC Platforms:

Coursera – Millimeter Wave Wireless Communication

(https://www.coursera.org/learn/millimeter-wave-wireless).

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%).

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Understand the architecture, benefits, and challenges of Massive MIMO and MMWAVE systems.	-	-	-
CO2	Analyze system capacity, spectral efficiency, and propagation characteristics at MMWAVE frequencies.	PO3(3)	3	3
CO3	Apply signal Processing techniques for channel estimation, beamforming, and detection in MIMO.	PO1(3)	3	3
CO4	Evaluate system performance under different fading, mobility, and interference conditions.	PO1(3) PO3(2)	2	3

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.

Introduction to Satellite and GPS

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).

Activity (Flipped classroom and Quiz):
Flipped classroom followed by a quiz where students learn Satellite and GPS through pre-class study.

Inertial Navigation and Differential GPS

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.

Activity (Seminar Presentation):
Technical seminar presentation on different GPS systems.

Remote Sensing Systems and Techniques

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.

Activity (Model Making):
Design and simulation of Image Processing.

Broadcast Systems

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.

Activity (Seminar Presentation):
Technical seminar presentation on Broadcast Systems.

Satellite Communication in IPV6 Environment

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

Activity (Model Making):
Design and simulation of IPv6 based networks using network simulator tools.

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. 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

	CO description	PO Mapping	PSO1	PSO2
CO1	Understand Satellite navigation and Global Positioning System	-	-	-
CO2	Demonstrate an understanding of the different communication, sensing and navigational applications of satellite.	PO3(3)	3	2
CO3	Analyze the different Remote sensing systems and techniques.	PO1(3)	3	3
CO4	Familiar with the implementation aspects of existing satellite based systems	PO1(3) PO3(2)	2	3

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.

Introduction: Importance of Quantitative Modeling in Engineering of Telecommunication Networks, The Functional Elements of Networking, Evolution of Networking in the Wired and Wireless Domain.

Activity: Exploring Quantitative Modeling and the Evolution of Telecommunication Networks

Multiplexing: 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.

Activity: Analyzing Network Performance and Multiplexing in Wired and Wireless Networks

Switching: 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.

Activity: Evaluating Switching Performance and Queuing in Packet and Circuit Networks

Routing: Algorithms for Shortest Path Routing - Dijkstra‘s Algorithm, Bellman Ford Algorithm, Generalized Dijkstra‘s Algorithm, Optimal Routing, Routing Protocols-Distance Vector, Link State and Exterior gateway protocols, Formulations of the Routing Problem-minimum interference Routing, MPLS, QoS Routing, Non-additive and Additive metrics

Activity:Implementing and Analyzing Routing Algorithms and Protocols in Telecommunication Networks

Case Studies
Design of a wireless network and a wired network, prototype implementation to be simulated in a network simulator.

Activity: Case Study on Designing and Simulating Wired and Wireless Networks

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

	CO description	PO Mapping	PSO1	PSO2
CO1	Familiar with the multiplexing, switching and routing related issues, solutions and performance metrics	-	-	-
CO2	Able to understand the wired and wireless network design process	PO3(3)	3	3
CO3	Analyse the various aspects of a protocol and implement it using a network simulation tool.	PO1(3)	3	3
CO4	Able to break up the communication network design problem into a number of sub-problems, identify suitable protocol solutions, implement using any simulator tool and carryout performance characterization	PO1(3) PO3(2)	2	3

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.

Introduction to Digital Communication Receivers: 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

Carrier and Timing Synchronization: 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

Channel Estimation and Equalization: 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

Advanced Receiver Architectures: 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

Simulation and Implementation Aspects: 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

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Activity:

1. Simulate a digital baseband receiver using MATLAB (BPSK/QPSK)
2. Implement timing recovery using Gardner algorithm
3. Evaluate BER for different SNR using matched filter
4. Design and simulate a Costas loop in Simulink

Group Projects :

1. Design and simulation of a QAM receiver with carrier and timing recovery

2. Performance analysis of equalizers under fading channels
3. FPGA prototype for real-time signal detection (baseband receiver)
4. Comparative study of ML and MMSE receivers for MIMO systems

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/

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%).

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the structure and operation of digital communication receivers, including noise models, channel impairments, signal space representation, and matched filter receivers.	-	-	-
CO2	Analyze carrier and timing synchronization techniques such as PLL, Costas loop, early-late gate, and Gardner algorithm under practical impairments.	PO3(3)	3	3
CO3	evaluate channel estimation and equalization techniques using adaptive algorithms (LMS, RLS) and assess their performance trade-offs.	PO1(3)	3	3
CO4	Design, simulate, and implement advanced digital receiver architectures including ML/MAP detection, MIMO receivers, and SDR-based implementations using MATLAB/Simulink.	PO1(3) PO3(2)	2	3

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.

Cooperative Communications and Green Concepts

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.

Activity: Study of Cooperative Communication Architectures and Green Radio Concepts

Cooperative Techniques

Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbobasestations; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying and Coordinated multi-point transmission in LTE-Advanced.

Activity: Exploration of Cooperative Techniques for Energy-Efficient Cellular Wireless Networks

Relay-Based Cooperative Cellular Networks

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.

Activity: Analysis of Relay-Based Cooperative Cellular Network Techniques and Resource Optimization Strategies

Green Radio Networks

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.

Activity: Evaluation of Power-Management and Energy-Efficient Techniques for Green Radio Networks

Access Techniques for Green Radio Networks

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

Activity: Investigation of Access Techniques and Resource Optimization for Green Radio Networks

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. 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-over-fibre 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.

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain cooperative communication architectures and green radio concepts, including energy-efficient modulation, coding schemes, and fundamental design trade-offs in cellular wireless networks.	-	-	-
CO2	Analyze cooperative techniques such as base station cooperation, antenna architectures, coordinated multipoint transmission, and partial information relaying in LTE-Advanced networks.	PO3(3)	3	3
CO3	evaluate relay-based cooperative cellular networks, including distributed space–time coding, NOMA-based cooperative relaying, network coding, and cross-layer resource optimization strategies	PO1(3)	3	3
CO4	Design and assess energy-efficient green radio network solutions using power-management, adaptive scheduling, and cooperative multicell processing techniques.	PO1(3) PO3(2)	2	3

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.

Introduction on Security

Security goals, cryptographic attacks, security services and mechanisms, techniques: cryptography and steganography, traditional symmetric key ciphers, mathematics of cryptography.

Activity: Study of Security Goals, Cryptographic Attacks, and Fundamental Cryptographic Techniques

Symmetric & Asymmetric Key Algorithms

Introduction to block and stream ciphers, advanced encryption standard (AES), RC4, principle of asymmetric key algorithms.

Activity: Exploration of Symmetric and Asymmetric Key Encryption Algorithms

Integrity, Authentication and Key Management

Message integrity, hash functions, digital signatures: digital signature standards. Authentication: entity authentication: biometrics, key management techniques..

Activity: Study of Message Integrity, Authentication Methods, and Key Management Techniques

Security Protocols

Ip security, e-mail security :pgp, s/mime, web security: ssl, tls and set.

Activity: Analysis of Security Protocols for IP, Email, and Web Communications

Wireless Network Security

Security for broadband networks: security challenges in 4g and 5g deployments, introduction to side channel attacks and their counter measures.

Activity: Investigation of Wireless Network Security Challenges in 4G and 5G and Countermeasures

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. 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

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Explain security goals, cryptographic attacks, security services, and fundamental cryptographic techniques including symmetric ciphers and mathematical foundations of cryptography.	**-**	**-**	**-**
CO2	Analyze and compare symmetric and asymmetric key algorithms such as AES, RC4, and public key cryptosystems with respect to security, performance, and application requirements.	PO3(3)	3	3
CO3	Develop and simulate security protocols and wireless network security mechanisms for IP, email, web, and 4G/5G networks, including side-channel attack countermeasures.	PO1(3)	3	3
CO4	Evaluate integrity, authentication, and key management mechanisms including hash functions, digital signatures, biometrics, and key distribution techniques.	PO1(3) PO3(2)	2	3

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.

Random Processes and Statistical Preliminaries

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.

Activity Type: Simulation Assignment - Description: Students will implement and simulate random processes and Gaussian noise generation to visualize properties like autocorrelation and power spectral density. They will analyze how these characteristics impact signal models.Tools Used: Python with NumPy and Matplotlib libraries.

Hypothesis Testing and Detection Theory

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.

Activity Type: Flipped Classroom Exercise - Description: Before class, students will watch curated video lectures and study example Jupyter notebooks on binary hypothesis testing and likelihood ratio tests. In class, they will collaboratively solve detection problems and interpret ROC curves.Tools Used: Jupyter Notebook, SciPy, and Open Courseware video content.

Parameter Estimation Theory

Principles of parameter estimation – Minimum variance unbiased estimators – Cramér-Rao lower bound – Maximum Likelihood Estimation (MLE) techniques – Method of moments – Bayesian estimation fundamentals – Linear models and least squares estimation – Properties of estimators: consistency, sufficiency, and efficiency – Applications in signal parameter estimation.

Activity Type: Mini Project Description: Students will develop parameter estimation algorithms (e.g., maximum likelihood estimators) for synthetic signals embedded in noise, compare estimators, and validate Cramér-Rao bounds through simulations. **Tools Used:** GNU Octave or Python (NumPy, SciPy).

Bayesian Signal Detection and Estimation (IPR)

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.

Activity Type: Seminar Presentation Description: Each student will prepare and present a seminar on Bayesian estimation methods, demonstrating practical examples such as Kalman filtering with live-coded demonstrations. Tools Used: Python with pykalman library and presentation slides using LibreOffice Impress.

Advanced Topics and Applications

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.

Activity: Reproduction of Research Paper, Reproduce a simplified research or innovation project using open-source code, **GitHub, Overleaf (LaTeX), Python Notebooks.**

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. 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**Web Link:** https://ocw.mit.edu/courses/6-432-stochastic-processes-detection-and-estimation-fall-2004/
5. **Course Type:** Tutorial Resource **Title:** Introduction to Signal Detection and Estimation (Tutorials Point) **Web Link:**

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamental concepts of random variables, random processes, and statistical preliminaries relevant to signal models. (Level 2 – Understand)	-	-	-
CO2	Apply hypothesis testing frameworks and detection criteria to analyze and design detectors for known signals in noise. (Level 3 – Apply)	PO3(3)	3	3
CO3	Develop parameter estimation techniques and evaluate estimator performance using theoretical bounds such as the Cramér-Rao lower bound. (Level 5 – Evaluate)	PO1(3)	3	3
CO4	Construct Bayesian detection and estimation algorithms, including MAP, MMSE estimators, and recursive filters for dynamic systems. (Level 4 – Analyze)	PO1(3) PO3(2)	2	3

CU25007	Solid State Device Modeling and Simulation	L	T	P	C
		3	0	0	3

Course objectives:
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.

Introduction to Semiconductor physics and Diode Modelling: 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.

Integrated MOS Capacitance: 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.

Integrated MOS Transistor: 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, Subthreshold Current –Subthreshold Swing, Threshold voltage Roll Off-Short Channel Leakage, reducing gate insulator electrical thickness And Tunneling Leakage, Short Channel Effects. Ultra Thin body, SOI and Multigate MOSFET - FINFET. Compact Model for Circuit Simulation using Verilog A.

Advanced Semiconductor Devices: MESFETs, HBTs, HEMTs, MOSFETs.

Optoelectronics Devices: Light Emitting Diodes, Lasers, Photoconductors, Junction Photodiodes, Avalanche Photodiodes, Solar Cells

Activities:
1: Expert Lectures from the Faculty guiding in the area of Device Modelling
2: Using facilities in https://nanohub.org/ for online simulation of devices
3. Usage of Synopsis/ Silvaco TCAD is required

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. 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.

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Acquire the knowledge of modelling of integrated diode	-	-	-
CO2	Model and simulate MOS capacitor for different values of process and operating parameters	PO3(3)	3	3
CO3	Model and simulate SPICE, EKV and BSIM model of MOSFETs	PO1(3)	3	3
CO4	Acquire the knowledge of modelling SoI, multigate MOSFET, UT Band FINFET devices	PO1(3) PO3(2)	2	3

EL25C04	RF Integrated Circuit Design	L	T	P	C
		3	0	0	3

Course Objectives:

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

CMOS Physics, Transceiver Specifications and Architectures

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.

Activity: Analysis of CMOS Transceiver Architectures and Noise Performance in Communication Systems

Impedance Matching and Amplifiers

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.

Activity: Design and Analyze a Source-Degenerated Common-Source LNA Using S-Parameters and Smith Chart–Based Impedance Matching

Feedback Systems and Power Amplifiers

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

Activity: Analyze Stability, Efficiency, and Linearity in Class A–F Power Amplifiers Using Gain/Phase Margin, Root-Locus, and ACPR Evaluation

Mixers and Oscillators

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.

Activity: Analyze and Compare Mixer Architectures and Oscillator Designs Using Nonlinear Characteristics, Describing Functions, and Phase-Noise Evaluation

PLL and Frequency Synthesizers

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

Activity: Model and Evaluate a PLL-Based Integer-N Frequency Synthesizer Using Linearized Loop Analysis, Noise Characterization, and Phase-Detector/Charge-Pump Design

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. 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/

	CO description	PO Mapping	PSO1	PSO2
CO1	understand user specifications for RF systems	-	-	-
CO2	design RF low noise amplifiers,power amplifiers,RF mixers and oscillators	PO3(3)	3	3
CO3	Analyze PLL for RF applications	PO1(3)	3	3

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.

Vision and Perception Fundamentals for Analytics

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.

Activity Type: is *Flipped Classroom*, where students will watch pre-recorded tutorials on color models and human visual perception before the session. During the class, they will perform hands-on exercises to convert and visualize color spaces (RGB, HSV, YCbCr) using real images. Tools Used include OpenCV (Python) and Google Colab.

Feature Descriptors and Machine Perception

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).

Activity Type: is a *Mini Project*. Students will implement and compare classical image feature descriptors such as SIFT, SURF, and ORB on benchmark datasets, visualize keypoints, and analyze performance differences. Tools Used are OpenCV, scikit-image, and matplotlib.

Intelligent Video Processing

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.

Activity Type: is Reproduction of Research, where students select a lightweight research paper or open-source code related to optical flow or scene segmentation and reproduce the results using public video datasets. They will document observations and discuss challenges. Tools Used include OpenCV, Jupyter Notebook, and the DAVIS video dataset.

Object Detection, Tracking, and Recognition

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).

Activity Type:is a *Seminar/Demo*. Student groups will prepare and demonstrate real-time object detection using YOLO or object tracking using Kalman Filter or Mean-shift algorithms. They will explain the workflow and algorithm basics during a peer seminar. Tools Used are YOLOv5 (PyTorch), OpenCV, and Streamlit.

Applications and Tools in Video Analytics

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.

Activity Type:*Case Study and Presentation*. Students will explore open-source datasets like COCO or Cityscapes, select a real-world video analytics application (e.g., smart surveillance or people counting), perform analysis, and present insights using visualizations and result interpretation. Tools Used are COCO API, MediaPipe, and Python Notebooks.

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. 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. **Dataset/API Resource** – COCO Dataset: Common Objects in Context – https://cocodataset.org/#home

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	understand the fundamentals of color perception, image representation, and basic visual features relevant to analytics, corresponding to the Understand level (Level 2) of Bloom's Taxonomy.	-	-	-
CO2	apply and compare classical and advanced feature extraction techniques to represent and analyze images for various pattern recognition tasks, aligning with the Apply level (Level 3).	PO3(3)	3	3
CO3	analyze motion in videos using techniques such as optical flow and scene segmentation, thereby interpreting temporal patterns effectively, which maps to the Analyze level (Level 4).	PO1(3)	3	3
CO4	create end-to-end object detection, tracking, and recognition pipelines using suitable algorithms and open-source tools, falling under the Create level (Level 6).	PO1(3) PO3(2)	2	3

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.

Fundamentals of MEMS

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.

Activity:

- **Case Study**: Analyze the evolution and cost benefits of MEMS in healthcare diagnostics.
- **Hands-on**: Silicon wafer orientation and doping simulation using open tools (e.g., NanoHUB).

Pattern Transformation of Mems

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

Activity:

- Lab Demo / Video Simulation: Lithography and mask alignment procedure
- Assignment: Design a basic mask layout for a MEMS pattern

Introduction of NEMS

Introduction – Basic properties - Benefits of Nanomachines – Miniaturization - NEMS Memory – Importance of AFM - Top-Down Approach - NEMS devices - NEMS Advantages.

Activity:

- Seminar: Benefits and miniaturization challenges in NEMS
- Simulation: NEMS memory modeling using nano-electronics simulator (NanoHub toolkit)

Feedback Amplifiers and Waveform Generators Materials – Carbon Allotropes - Carbon Based Materials - Metallic Carbon Nanotubes – Difficulties – Simulations - Current Challenges and future of NEMS – Deposition processes – Lithography – Etching processes. **Activity:** • Group Project: Design and simulate a carbon nanotube-based NEMS device • Quiz: On lithography types and carbon-based nanomaterials
Power Amplifiers 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 **Activity:** • Case Study Presentation: Comparison of MEMS gyroscope and accelerometer • Assignment: Technical report on emerging RF MEMS switches.
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%).

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Explain the fundamentals of MEMS including materials, silicon substrates, fabrication processes, scaling concepts, and applications in sensing and actuation.	-	-	-
CO2	apply photolithographic and pattern transfer processes for MEMS device fabrication, including mask design and resist processing.	PO3(3)	3	2
CO3	Analyze the principles, materials, fabrication challenges, and performance of NEMS devices including carbon-based nanomaterials and feedback-based nanodevices.	PO1(3)	3	2
CO4	Design and evaluate MEMS/NEMS-based sensors, actuators, and RF/optical MEMS devices using simulations and case studies.	PO1(3) PO3(2)	2	3

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.

Imaging Preliminaries

Image Acquisition, Sensors, Image formation, Image transformations: 2D-DFT, DCT, DST, Hadamard, Walsh, Hotelling transformation, 2D-Wavelet transformation, Wavelet packets.

Image Enhancement and Restoration

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.

Image Segmentation

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.

Image Compression and Water Marking

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.

Feature Extraction

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

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. 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.

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	apply a variety of introductory digital image processing techniques	**-**	**-**	**-**
CO2	apply the combinations of enhancement/restoration methods in cases where a single approach is insufficient	PO3(3)	3	3
CO3	identify the suitable image segmentation techniques for image analysis	PO1(3)	3	3
CO4	familiar with the understanding of various lossless and lossy image compression techniques	PO1(3) PO3(2)	2	3

CU25C14	Analog and Mixed Signal VLSI Design	L	T	P	C
		3	0	0	3

Course Objectives:

- To understand the fundamentals of Analog IC design, MOSFET models, and device-level noise behavior.
- To analyze and design CMOS analog building blocks including amplifiers, current mirrors, references, and op-amps.
- To explore mixed-signal design concepts and implement circuits like data converters, comparators, and PLLs.

Introduction

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.

CMOS Amplifiers

Single stage amplifiers: CS, CG and CD stages, Small Signal Models, Input Output Impedances, and Frequency Response. Differential Amplifier, Cascode Amplifiers, Current Amplifiers.

CMOS Sub-Circuits

Current Sinks and Sources, Simple and Cascode current Mirrors, Wilson Current Mirror, and High Swing Current Mirror. Current and Voltage References, Band gap Reference.

CMOS Operational Amplifiers

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.

Mixed Signal Design Fundamentals

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.

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.

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%).

	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