ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M.E. COMMUNICATION AND NETWORKING

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 and Networking.
PSO2	Competence to independently undertake research projects involving simulation, measurement, and product development in Communication and Networking-related fields.

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., Communication and Networking **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.	NC25101	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.	NC25201	Advanced Optical Communication Systems	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.	NC25202	Wireless Technology Laboratory	L	0	0	4	4	2	ES(PC)
6.	-	Industry Oriented Course I	-	1	0	0	1	1	SD
7.	NC25203	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.	NC25301	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.	NC25401	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.	EL25C02	Multimedia Compression Techniques	3	0	0	3	3
2.	NC25001	Network Analytics	3	0	0	3	3
3.	NC25002	Advanced Satellite Communication and Navigation Systems	3	0	0	3	3
4.	AP25C05	Signal Integrity for High Speed Design	3	0	0	3	3
5.	NC25003	Server Architecture	3	0	0	3	3
6.	NC25004	High Speed Switching and Networking	3	0	0	3	3
7.	NC25005	Optical Networks	3	0	0	3	3
8.	NC25006	Speech Processing	3	0	0	3	3
9.	CU25C11	Ultra Wide Band Communications	3	0	0	3	3
10.	NC25007	Broadband Networks	3	0	0	3	3
11.	NC25008	Virtual Private Networks	3	0	0	3	3
12.	NC25C01	Telecommunication Switching System Modeling and Simulation	3	0	0	3	3
13.	CU25C13	Image and Video Processing and Analytics	3	0	0	3	3
14.	NC25009	Radar Signal Processing	3	0	0	3	3
15.	NC25010	Network Protocols and Programming	3	0	0	3	3
16.	CU25C12	Signal Detection and Estimation	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.	PO1(3)	2	2
CO4	Design and implement real-time DSP algorithms and architectures.	PO1(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	2
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) PO(2)	2	3

<table>
<tr><td rowspan="2">CU25C05</td><td rowspan="2">Digital Communication Systems Laboratory</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>0</td><td>0</td><td>4</td><td>2</td></tr>
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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) PO(2)	2	3

Semester II

NC25201 **Advanced Optical Communication Systems** L T P C
3 0 0 3

Course Objective:

To provide a comprehensive understanding of modern optical communication systems, components, nonlinear fiber effects, dispersion-management techniques, and optical networking technologies, enabling learners to analyze, design, and optimize high-capacity optical links and networks.

Review of Optical Communications Systems

Optical fibers, dispersion, link budget, Time Division Multiplexing, Sub Carrier Multiplexing and code division multiplexing. Systems: Passive optical Network, Hybrid fiber coax architectures, Radio over fiber technologies, free space optics

Activity 1: Optical Link Budget Analysis

Activity 2: Comparative Study of Optical Communication Systems

Modern Optical Components

VCSEL, QW lasers, Multi section DFB lasers, Tunable lasers, Electro absorption modulator, Integrated transmitters and receivers, optical switches and routers, WDM components, Optical schemes for microwave generation, PCF and PCF components

Activity 1: Characterization of Optical Sources

Activity 2: Study of Modulators and Photonic Devices

Non Linear Fiber Optics and Amplifiers

Nonlinear optics – basics, Brilluion, Raman effects, Four wave mixing, optical phase conjugation, Solitons, Communication using solitons, WDM solitons. Optical Amplifiers- SOA, EDFA, DRFA. Fiber lasers

Activity 1: Analysis of Nonlinear Effects in Optical Fibers

Activity 2: Comparative Study of Optical Amplifiers and Fiber Lasers

Dispersion Compensation Schemes

Pre, post and mixed compensation schemes, Optical filters for compensation, Delay line filters, Dispersion slope compensation, Dispersion and Nonlinearity, Dispersion maps, multi channel compensation schemes.

Activity 1: Evaluation of Dispersion Compensation Techniques

Activity 2: Design of a Dispersion Map for a WDM System

Optical Networks

Optical Network Concepts, Network Topologies, SONET/SDH, IP over DWDM, Optical Ethernet. Modulators for Gigabit networks, Limitations of direct modulation, External modulators - types,

Generation and detection of advanced Modulation Techniques.

Activity 1: Analysis of Optical Network Topologies and Protocols

Activity 2: Study of Modulation Techniques for High-Speed Optical 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. Agarwal, G. P. (2021). *Fiber optic communication system* (5th ed.). John Wiley & Sons.
2. Keiser, G. (2017). *Optical fiber communications* (5th ed.). Tata McGraw-Hill.
3. Agrawal, G. P. (2004). *Lightwave technology: Components and devices*. John Wiley & Sons.
4. Agrawal, G. P. (2013). *Nonlinear fiber optics* (5th ed.). Academic Press.
5. Shivakumar, S., & Jamal Deen, M. (2014). *Fiber optic communications: Fundamentals and applications*. John Wiley & Sons.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamentals of optical communication systems including fibers, dispersion, link budget analysis and multiplexing techniques.	-	-	-
CO2	Analyze modern optical components such as lasers, modulators, WDM devices and integrated photonic systems.	PO1(3), PO2(3), PO3(2)	3	3
CO3	Evaluate nonlinear fiber effects, optical amplifiers and their impact on high-speed optical communication systems.	PO1(3), PO2(3), PO4(3)	2	3
CO4	Design dispersion compensation schemes and analyze optical network architectures for high-capacity transmission systems.	PO1(3), PO2(3), PO3(3), PO5(2)	3	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 including NOMA, V2X, mMTC, and METIS channel models	PO1 (3), PO3 (3)	PSO2 (3), PSO3 (2)

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)

NC25202	Wireless Technology Laboratory	L	T	P	C
		0	0	4	2

Course Objectives:

The Wireless Technology Laboratory aims to provide hands-on experience in modern wireless communication systems and RF technologies. It enables students to analyze, design, and test wireless networks and devices using advanced tools and experimentation.

List of Experiments

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

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	Understand the functioning of various protocols in wireless environment	-	-	-
CO2	Perform real-time experimentation using the existing infrastructure.	PO1(3)	3	2
CO3	knowledge in constructing WLAN, and VLAN	PO1(3) PO(2)	2	3

Programme Elective Courses

EL25C02	Multimedia Compression Techniques	L	T	P	C
		3	0	0	3

Course Objectives:
This course provides a foundational understanding of compression algorithms for multimedia components such as text, speech, audio, image, and video. It covers the principles, standards, and technologies behind these algorithms, emphasizing their applications and performance. Students will also explore the role of compression in multimedia processing and gain practical experience in implementing various compression standards.

Fundamentals of Compression: Introduction To multimedia – Graphics, Image and Video representations – Fundamental concepts of video, digital audio – Storage requirements of multimedia applications – Need for compression – Taxonomy of compression Algorithms - Elements of Information Theory – Error Free Compression – Lossy Compression.

Activity: Comparative Analysis of Compression Techniques

Text Compression: Huffman coding – Adaptive Huffman coding – Arithmetic coding – Shannon-Fano coding – Dictionary techniques – LZW family algorithms.

Activity: Implementing and Comparing Text Compression Algorithms

Image Compression: Image Compression: Fundamentals — Compression Standards – JPEG Standard – Sub-band coding – Wavelet Based compression – Implementation using Filters – EZW, SPIHT coders – JPEG 2000 standards – JBIG and JBIG2 standards.

Activity: Comparative Study of Image Compression Techniques

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

Activity: Implementation and Evaluation of Audio Compression Techniques

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

Activity: Comparative Analysis of Video Compression Standards

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. Sayood, K. (2010). *Introduction to data compression* (3rd ed.). Morgan Kaufmann; Harcourt India.
2. Solomon, D. (2006). *Data compression: The complete reference* (4th ed.). Springer-Verlag.
3. Shi, Y. Q., & Sun, H. (2003). *Image and video compression for multimedia engineering: Algorithms and fundamentals*. CRC Press.
4. Li, Z.-N., & Drew, M. S. (2009). *Fundamentals of multimedia*. PHI Learning.

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Explain multimedia representations, storage requirements, need for compression, information theory concepts, and lossless and lossy compression principles.	**-**	**-**	**-**
CO2	Design and implement some basic compression standards	PO3(3)	3	2
CO3	Apply the various audio,speech compression techniques	PO1(3)	3	2
CO4	Analyze video compression standards and design comparative studies on MPEG, H.261, and emerging compression techniques based on performance metrics.	PO1(3) PO(2)	2	3

NC25001	Network Analytics	L	T	P	C
		3	0	0	3

Course Objectives:
To understand social network structures, relationships, and influence mechanisms; analyze information and web networks using graph and link analysis; mine social network data for communities and patterns; and study network dynamics, diffusion, and cascading behaviors.

Introduction Overview: Social network data-Formal methods- Paths and Connectivity-Graphs to represent social relations-Working with network data- Network Datasets-Strong and weak ties - Closure, Structural Holes, and Social Capital.

Activity: Analysis of a Social Network Dataset

Social Influence Homophily: Mechanisms Underlying Homophily, Selection and Social Influence, Affiliation,Tracking Link Formation in OnLine Data, Spatial Model of Segregation - Positive and Negative Relationships - Structural Balance - Applications of Structural Balance, Weaker Form of Structural Balance.

Activity: Exploring Homophily and Structural Balance in Networks

Information Networks and the World Wide Web The Structure of the Web- World Wide Web- Information Networks, Hypertext, and Associative Memory- Web as a Directed Graph, Bow-Tie Structure of the Web- Link Analysis and Web Search Searching the Web: Ranking, Link Analysis using Hubs and Authorities- Page Rank- Link Analysis in Modern Web Search, Applications, Spectral Analysis, Random Walks, and Web Search.

Activity: Web Graph Analysis and PageRank Computation

Social Network Mining Clustering of Social Network graphs: Betweenness, Girvan newman algorithm-Discovery of communities- Cliques and Bipartite graphs-Graph partitioning methods-Matrices-Eigen valuesSimrank.

Activity: Community Detection in Social Networks

Network Dynamics Cascading Behavior in Networks: Diffusion in Networks, Modeling Diffusion - Cascades and Cluster, Thresholds, Extensions of the Basic Cascade Model-Six Degrees of Separation-Structure and Randomness, Decentralized Search- Empirical Analysis and Generalized Models- Analysis of Decentralized Search.

Activity: Simulation of Diffusion and Cascades in Social 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. Easley, D., & Kleinberg, J. (2010). *Networks, crowds, and markets: Reasoning about a highly connected world*. Cambridge University Press.
2. Hanneman, R. A., & Riddle, M. (2005). *Introduction to social network methods*. University of California.
3. Leskovec, J., Rajaraman, A., & Ullman, J. D. (2014). *Mining of massive datasets* (2nd ed.). Cambridge University Press.
4. Wasserman, S., & Faust, K. (2009). *Social network analysis: Methods and applications*. Cambridge University Press.
5. Borgatti, S. P., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks* (1st ed.). SAGE Publications Ltd.
6. Scott, J. (2000). *Social network analysis: A handbook* (2nd ed.). SAGE Publications

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Apply graph theory concepts to model and analyze social network structures, connectivity, strong/weak ties, and structural properties.	PO1(3), PO2(3)	3	2
CO2	Analyze social influence, homophily, structural balance, and link formation mechanisms using network datasets.	PO1(3), PO2(3), PO4(2)	3	3
CO3	Evaluate information networks and web graphs using link analysis techniques such as PageRank, HITS, spectral methods, and random walks.	PO1(3), PO2(3), PO5(3)	3	3
CO4	Model and simulate community detection, diffusion processes, cascading behavior, and decentralized search in complex networks.	PO2(3), PO3(3), PO4(3), PO5(2)	3	3

NC25002	Advanced Satellite Communication and Navigation Systems	L	T	P	C
		3	0	0	3

Course Objectives: To understand satellite communication fundamentals, M2M/IoT applications, IPv6 implementation, satellite navigation systems, and deep space mission communication subsystems, including link performance and network architecture.

Overview of Satellite Communication Overview of satellite communication and orbital mechanics Link budget Parameters, Link budget calculations, Auxiliary Equations, Performance Calculations.

Activity: Satellite Link Budget Calculation

M2M Developments and Satellite Applications Overview of the Internet of Things and M2M- M2M Applications Examples and Satellite Support- Satellite Roles Context and Applications- Antennas for Satellite M2M Applications- M2M Market Opportunities for Satellite Operators-Ultra HD Video/TV and Satellite Implications-High Throughput Satellites (HTS) and Ka/Ku Spot Beam Technologies-Aeronautical, Maritime and other Mobility Services.

Activity: Analysis of Satellite-Based M2M Applications

Satellite Communication In IPV6 Environment Overview of IPv6 and its benefits for Satellite Networks - Migration and Coexistence--Implementation scenarios and support-Preparations for IPv6 in Satellite communication- Satellite specific Protocol issues in IPv6 – Impact of IPv6 on Satellite Network architecture and services-Detailed transitional plan- IPv6 demonstration over satellites - Key results and recommendations.

Activity: IPv6 Implementation Analysis for Satellite Networks

Satellite Navigation and Global Positioning System Overview of Radio and Satellite Navigation, GPS Principles, Signal model and Codes, Satellite Signal Acquisition, Mathematical model of GPS observables, Methods of processing GPS data , GPS Receiver Operation and Differential GPS. IRNSS, GAGAN, GLONASS and Galileo.

Activity: GPS Data Analysis and Receiver Simulation

Deep Space Networks And Inter Planetary Missions Introduction – Functional description - Design procedure and performance criterion-Mars exploration Rover-Mission and spacecraft summary-Telecommunication subsystem overview-Ground Subsystem-Telecom subsystem and Link performance Telecom subsystem Hardware and software Chandrayaan-1 Mission - Mission and spacecraft summary-Telecommunication subsystem overview-Ground Subsystem-Telecom subsystem and Link performance. Mangalyaan Mission - Mission and spacecraft summary-Telecommunication subsystem overview- Ground Subsystem-Telecom subsystem and Link performance

Activity: Analysis of Deep Space Mission Communication Systems
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. Adimurthy, V. (2015). Concept design and planning of India's first interplanetary mission. *Current Science, 109*(6), 1054. https://www.currentscience.ac.in
2. Maini, A. K., & Agrawal, V. (2014). *Satellite technology: Principles and applications* (3rd ed.). Wiley.
3. Minoli, D. (2015). *Innovations in satellite communication and satellite technology*. Wiley.
4. Minoli, D. (2009). *Satellite systems engineering in an IPv6 environment* (1st ed.). CRC Press.
5. Hofmann-Wellenhof, B., Lichtenegger, H., & Wasle, E. (2008). *Global navigational satellite systems*. Springer-Verlag.
6. Taylor, J. (2016). *Deep space communications*. John Wiley & Sons.
7. Ippolito, L. J., Jr. (2017). *Satellite communications systems engineering: Atmospheric effects, satellite link design and system performance* (2nd ed.). Wiley.
8. Indian Space Research Organisation (ISRO). (n.d.). *PSLV-C25 Mars Orbiter Mission*. http://www.isro.gov.in/pslv-c25-mars-orbiter-mission

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Analyze satellite communication fundamentals including orbital mechanics, link budget design, and performance evaluation of satellite links.	PO1(3), PO2(3), PO4(2)	3	2
CO2	Evaluate satellite-based M2M/IoT applications, High Throughput Satellites (HTS), and mobility services in modern communication systems.	PO1(3), PO2(2), PO3(2), PO5(2)	3	3
CO3	Analyze and implement IPv6 transition strategies and network architecture adaptations for satellite communication environments.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO4	Evaluate satellite navigation systems (GPS, IRNSS, GAGAN, GLONASS, Galileo) and analyze deep space communication subsystems and mission link performance.	PO1(3), PO2(3), PO4(3), PO5(2)	3	3

AP25C05	Signal Integrity for High Speed Design	L	T	P	C
		3	0	0	3

Course Objective:

The objective of this course is to introduce students to the principles and challenges of maintaining signal integrity in high-speed digital designs. It aims to provide a comprehensive understanding of transmission line behavior, impedance control, reflections, crosstalk, differential signaling, and clock distribution. The course emphasizes practical analysis, modeling, and mitigation techniques used in designing robust and reliable high-speed digital systems.

Introduction

Introduction to Signal Integrity, Signal Quality on a Single Net, Cross Talk, Rail-Collapse Noise, Electromagnetic Interference (EMI), Signal-Integrity Solutions in Terms of Impedance: Impedance of ideal resistor, capacitor and inductor in time domain, Impedance in the Frequency Domain, Bulk Resistivity, Resistance per Length, Sheet Resistance, Power and Ground Planes and Decoupling Capacitance, Capacitance per Length, Self-Inductance and Mutual Inductance, Partial Inductance Effective, Total, or Net Inductance and Ground Bounce, Loop Self- and Mutual Inductance, Loop Inductance per Square of Planes, Loop Inductance of Planes and Via Contacts

Activity:

1. **Simulation Assignment:** Use EDA tools like LTspice to simulate impedance mismatch and analyze signal degradation on a PCB trace.
2. **Poster Presentation:** Students prepare a poster explaining impedance behavior in the time vs frequency domain, and the concept of ground bounce and EMI.

Transmission Lines and Reflections

Speed of a Signal in a Transmission Line, Instantaneous Impedance of a Transmission Line, Characteristic Impedance and Controlled Impedance, Return Paths , Frequency Variation of the Characteristic Impedance, Reflections, Reflections from Resistive Loads, Source Impedance, Bounce Diagrams, Reflections from Short Series andShort-Stub Transmission Lines, Reflections from Capacitive End Terminations, Reflections from Capacitive Loads in the Middle of a Trace, Capacitive Delay Adders, Effects of Corners and Vias, Loaded Lines, Reflections from Inductive Discontinuities, Compensation, Losses in Transmission Lines, Sources of Loss: Conductor Resistance and Skin Depth, The Dielectric, Dissipation Factor

Activity:

1. **Flipped Classroom:** Students review pre-recorded videos on reflection and impedance mismatch; classroom used for solving bounce diagram exercises.
2. **Hands-on Lab:**Build and measure signal reflection and delay using a coaxial cable, function generator, and oscilloscope (or simulation-based equivalent).

Crosstalk
Coupling: Capacitance and Inductance, Cross Talk in Transmission Lines, Cross Talk in Uniform Transmission Lines and Saturation Length, Capacitively Coupled Currents, Inductively Coupled Currents, Near-End Cross Talk, Far-End Cross Talk, Decreasing Far-End Cross Talk, Guard Traces, Cross Talk and Dielectric, Cross Talk and Timing, Switching Noise.

Activity:
1. **Case Study Analysis:**Analyze real PCB designs or documented failures where crosstalk affected system reliability (e.g., DDR memory buses, HDMI lines).
2. **Mini Quiz / Diagram Exercis**e: Conduct a quick in-class quiz identifying near-end and far-end crosstalk with diagram-based questions.

Differential Signaling

Differential Signaling, A Differential Pair, Differential Impedance with No Coupling, The Impact from Coupling, Calculating Differential Impedance, The Return-Current Distribution in a Differential Pair, Ideal Coupled Transmission-Line Model or an Ideal Differential Pair, Cross Talk in Differential Pairs, Crossing a Gap in the Return Path.

Activity:
1. **Simulation/Modeling Task:** Use EDA tools to model differential pairs and evaluate the effects of spacing and return path discontinuities.
2. **Group Presentation:** Students present on how differential signaling improves noise immunity and is used in USB, PCIe, or HDMI.

Clock Distribution and Clock Oscillators
Timing margin, Clock slew, low impedance drivers, terminations, Delay Adjustments, canceling parasitic capacitance, Clock jitter.

Activity:
1. Timing Budgeting Exercise: Given a real-world high-speed system, students calculate skew, jitter, and timing margins for clock distribution.
2. Seminar / Tech Talk **:** Students present on advanced clocking techniques (e.g., PLLs, low-jitter buffers) and common clock distribution topologies.

References:

1. Bogatin, E. (Year). *Signal and power integrity simplified* (3rd ed.). Pearson.
2. Johnson, H., & Graham, M. (Year). *High speed digital design*. Prentice Hall.
3. Johnson, H. (Year). *High speed signal propagation*. Prentice Hall.

E-Resources
1. https://www.youtube.com/watch?v=YFwHV2EMB2A
2. https://suddendocs.samtec.com/notesandwhitepapers/samtec-signal-integrity-handbook.pdf
3. https://www.youtube.com/watch?v=KkfKQDnWf20
4. https://onlinecourses.nptel.ac.in/noc24_ee67/preview

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 fundamental concepts of signal integrity and analyze the effects of impedance, capacitance, and inductance on signal quality in high- speed circuits.	-	-	-
CO2	Analyze transmission line behavior, identify causes of signal reflection, and apply impedance matching techniques to minimize reflections and losses.	PO3(3)	3	3
CO3	Examine the sources and effects of crosstalk in high-speed designs and propose methods to mitigate timing and noise-related issues.	PO1(3)	3	3
CO4	Understand and evaluate differential signaling concepts, including impedance calculation, coupling effects, and return current paths.	PO1(3) PO(2)	2	3

NC25003	Server Architectures	L	T	P	C
		3	0	0	3

Course Objectives:
To understand client-server and three-tier database computing models, Oracle database architecture, SQL/PL-SQL programming, database administration, and data storage methods; and to explore system development, performance, and reliability in distributed database environments.

Database Computing Model Client Server Computing: Functions of client, server,middleware components, Advantages and limitations of client server computing
Three Tier Architecture: Overview of thin client, application server, web server, Overview of Distributed Database, Overview of Real Application Clusters, Overview of High Performance Database Computing, Overview of Data Warehousing and Data Mining

Activity: Comparative Study of Database Computing Architectures

Overview of Oracle Database Server Architecture Architecture of Oracle Database and Oracle Instance, Overview of Physical and Logical Structures, Dedicated and Shared Server Configuration, Oracle Server Startup and Shutdown, Creating Database

Activity: Exploring Oracle Database Architecture and Instance Management

Oracle Tools and Utilities SQL - Pl/SQL Procedural Extension, Overview, PL/SQL data types & Control Structures, Cursors, Stored Procedures & Functions, Database Triggers, Package Creation, Dynamic SQL Collections

Activity: Developing and Executing PL/SQL Programs

Database Administration Objects Managing Users, User Configuration Setup, Resource Management, Working with user database account , Backup & Recovery, Database Security, Export & Import Tools, Overview of Grid Based Database

Activity: Hands-On Database Administration and Security Management

Data Storage Magnetic disk, magnetic tape, CD-ROM, WORM, Optical disk, mirrored disk, fault tolerance, RAID, RAID-Disk network interface cards. Network protection devices, Power Protection Devices, UPS, Surge protectors. Client Server Systems Development: Services and Support, system administration, Availability, Reliability, Serviceability, Software Distribution, Performance, Network management, Help Disk, Remote Systems Management Security, LAN and Network Management issues.

Activity: Analysis and Implementation of Storage and Network Management Systems

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	CO Description	PO Mapping	PSO1	PSO2
CO1	Analyze client-server, three-tier, distributed database architectures and evaluate their performance, scalability, and reliability.	PO1(3), PO2(3), PO4(2)	3	2
CO2	Explain Oracle database architecture including physical and logical structures, instance management, and server configurations.	PO1(3), PO2(2), PO5(2)	3	3
CO3	Develop SQL and PL/SQL programs using procedural constructs, cursors, triggers, packages, and dynamic SQL for database applications.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3
CO4	Implement database administration tasks including user management, backup and recovery, security, storage systems (RAID), and network management for reliable server operations.	PO1(3), PO2(3), PO3(2), PO5(3)	3	3

NC25004	High Speed Switching and Networking	L	T	P	C
		3	0	0	3

Course Objectives:
To understand switching architectures, high-performance network design, and quality of service requirements; analyze multimedia networking, packet queues, and delay; and study network security principles, cryptography, and network management frameworks.

Switching Architectures Shared medium switches – Shared memory switches – Space division switches – Cross bar based switching architecture – Input queued, Output queued and Combined input-output queued switches – Non blocking and blocking cross bar switches – Banyan networks – Batcher Banyan networks – Optical switches – Unbuffered and buffered switches – Buffering strategies – Optical packet switches and Optical burst switches – MEMS optical switches

Activity: Comparative Analysis of Switching Architectures

Network Performance Analysis Objectives and requirements for Quality of Service (QoS) in high performance networks. Architecture of high performance networks (HPN), design issues, protocols for HPN, VHF backbone networks, virtual interface architectures, virtual interface for networking, High-speed switching and routing - internet and PSTN IP switching techniques, SRP protocols, SRP authentication, and key exchange, comparison of TCP/IP, FTP, TELNET, queuing systems, network modeling as a graph

Activity: Evaluation of High-Performance Network Architectures and QoS

Multimedia Networking Applications Streaming stored Audio and Video, Best effort service, protocols for real time interactive applications, Beyond best effort, scheduling and policing mechanism, integrated services, RSVP- differentiated services.

Activity: Analysis of Streaming and QoS Mechanisms for Multimedia Networks

Packet Queues and Delay Analysis Littles theorem, Birth and Death process, queueing discipline- Control & stability -, Markovian FIFO queueing system, Non-markovian - PollaczekKhinchin formula and M/G/1, M/D/1, self-similar models and Batch-arrival model, Networks of Queues – Burkes theorem and Jackson Theorem

Activity: Modeling and Analysis of Packet Queues

Network Security and Management Principles of cryptography – Elliptic-AES Authentication – integrity – key distribution and certification– Access control and: fire walls – DoS-attacks and counter measures – security in many layers.Infrastructure for network management – The internet standard management framework – SMI, MIB,SNMP, Security and administration – ASN.1.

Activity: Implementing and Evaluating Network Security and Management Mechanisms
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%).

Reference:

1. Pattavina, A. (2007). *Switching theory: Architectures and performance in broadband ATM networks*. John Wiley & Sons Ltd.
2. Elhanany, I., Hamdi, M., & Mounir, M. (2007). *High performance packet switching architectures*. Springer.
3. Walrand, J., & Varatya, J. (2000). *High performance communication networks* (2nd ed.). Morgan Kaufmann – Harcourt Asia Pvt. Ltd.
4. Halsall, F., & Kulkarni, L. G. (2012). *Computer networking and the Internet* (5th ed.). Pearson Education.
5. Mir, N. F. (2009). *Computer and communication networks*. Pearson Education.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Analyze switching architectures including crossbar, Banyan, optical, buffered/unbuffered switches and evaluate blocking performance and buffering strategies.	PO1(3), PO2(3), PO4(2)	3	2
CO2	Evaluate high-performance network (HPN) architectures, QoS requirements, IP switching techniques, and protocol performance in modern networks.	PO1(3), PO2(3), PO3(2), PO5(2)	3	3
CO3	Model and analyze multimedia networking, packet queuing systems, delay performance, and network traffic using analytical and probabilistic models.	PO1(3), PO2(3), PO4(3), PO5(2)	3	3
CO4	Apply cryptographic principles, security mechanisms, and network management frameworks (SNMP, MIB, SMI) to ensure secure and efficient network operations.	PO1(3), PO2(3), PO3(2), PO5(3)	3	3

NC25005	Optical Networks	L	T	P	C
		3	0	0	3

Course Objectives:
This course provides a comprehensive understanding of optical components and networks, focusing on the design challenges of high-speed, high-bandwidth systems. It covers the architecture and standards of optical networks, explores routing and access mechanisms, and offers in-depth knowledge of the scientific and engineering principles behind photonics technology.

Optical System Components: Light propagation in optical fibers-Loss & Bandwidth, System limitations, Non-Linear effect, Solitons, Optical Network Components- Couplers, Isolators & Circulators, Multiplexers & Filters Optical Amplifiers, Switches, Wavelength Converters.

Activity: Characterization and Analysis of Optical System Components

Optical Network Architectures: Introduction to Optical Networks; WDM networks , SONET / SDH, Metropolitan-Area Networks, Layered Architecture; Broadcast and Select Networks- Topologies for Broadcast Networks, Media- Access Control Protocols, Wavelength Routing Architecture. WOBAN and OTDM networks.
Introduction to ASON.

Activity: Analysis and Design of Optical Network Architectures

Wavelength Routing Networks: The Optical layer, Node Designs, Optical layer cost tradeoff, Routing and Wavelength Assignment algorithms, Virtual Topology design, Architectural variations.

Activity: Routing and Wavelength Assignment in Optical Networks

Packet Switching And Access Networks: Photonic Packet Switching – OTDM , Multiplexing and Demultiplexing, Synchronization, Broadcast OTDM networks, Switch based networks; Access Networks- Network Architecture overview , Future Access Networks, Optical Access Network Architectures.

Activity: Analysis of Photonic Packet Switching and Optical Access Networks

Network Design and Management:Transmission system Engineering-system model, Power penalty-transmitter, receiver, Optical amplifiers, crosstalk, dispersion, wavelength stabilization; overall design consideration; Control and Management-Network management functions, Configuration management, Performance management, Fault management. Optical safety, Service interface.

Activity: Optical Network Design and Management 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. Ramaswami, R., & Sivarajan, K. N. (2004). *Optical networks: A practical perspective* (2nd ed.). Harcourt Asia Pvt Ltd. 2. Moorthy, C. S. R., & Gurusamy, M. (2002). *WDM optical networks: Concept, design and algorithms* (1st ed.). PHI. 3. Green, P. E., Jr. (1993). *Fiber optical networks*. Prentice Hall. 4. Author not specified]. (2002). *Optical networks: Third generation transport systems*. Prentice Hall. 5. Maier, M. (2014). *Optical switching networks*. Cambridge India.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Analyze optical system components including fiber characteristics, nonlinear effects, amplifiers, switches, wavelength converters, and system limitations.	PO1(3), PO2(3), PO4(2)	3	2
CO2	Evaluate optical network architectures such as WDM, SONET/SDH, ASON, broadcast networks, and wavelength routing networks.	PO1(3), PO2(3), PO3(2), PO5(2)	3	3
CO3	Design routing and wavelength assignment (RWA) strategies and analyze node architectures and virtual topology design in wavelength routing networks.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3
CO4	Assess photonic packet switching, optical access networks, and transmission system engineering including network management and performance analysis.	PO1(3), PO2(3), PO4(3), PO5(2)	3	3

NC25006	Speech Processing	L	T	P	C
		3	0	0	3

Course Objectives:
This course introduces the fundamentals of speech production and related parameters, along with various speech signal representation and coding techniques. It explores different speech modeling methods, such as Markov models, and addresses their implementation challenges. Additionally, the course provides knowledge on text analysis and speech synthesis.

Fundamentals of Speech Processing: Introduction – Spoken Language Structure – Phonetics and Phonology – Syllables and Words – Syntax and Semantics – Probability, Statistics and Information Theory – Probability Theory – Estimation Theory – Significance Testing – Information Theory.

Activity: Analysis of Spoken Language and Statistical Models

Speech Signal Representations and Coding: Overview of Digital Signal Processing – Speech Signal Representations – Short time Fourier Analysis – Acoustic Model of Speech Production – Linear Predictive Coding – Cepstral Processing – Formant Frequencies – The Role of Pitch – Speech Coding – LPC Coder, CELP, Vocoders.

Activity: Analysis and Coding of Speech Signals

Speech Recognition: Hidden Markov Models – Definition – Continuous and Discontinuous HMMs – Practical Issues – Limitations. Acoustic Modeling – Variability in the Speech Signal – Extracting Features – Phonetic Modeling – Adaptive Techniques – Confidence Measures – Other Techniques.

Activity: Feature Extraction and Hidden Markov Model Based Speech Recognition

Text Analysis: Lexicon – Document Structure Detection – Text Normalization – Linguistic Analysis – Homograph Disambiguation – Morphological Analysis – Letter-to-sound Conversion – Prosody – Generation schematic – Speaking Style – Symbolic Prosody – Duration Assignment – Pitch Generation.

Activity: Text Processing and Prosody Generation

Speech Synthesis: Attributes – Formant Speech Synthesis – Concatenative Speech Synthesis – Prosodic Modification of Speech – Source-filter Models for Prosody Modification – Evaluation of TTS Systems.

Activity: Implementation and Evaluation of Speech Synthesis Techniques

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. Gold, B., & Morgan, N. (2006). *Speech and audio signal processing: Processing and perception of speech and music* (Wiley-India Edition). Wiley.
2. Becchetti, C., & Prina Ricotti, L. (1999). *Speech recognition*. John Wiley & Sons.
3. Jurafsky, D., & Martin, J. H. (2002). *Speech and language processing: An introduction to natural language processing, computational linguistics, and speech recognition*. Pearson Education.
4. Jelinek, F. (1997). *Statistical methods of speech recognition*. MIT Press.
5. Rabiner, L., & Juang, B.-H. (2003). *Fundamentals of speech recognition*. Pearson Education.
6. Smith, S. W. (1997). *The scientist and engineer's guide to digital signal processing*. California Technical Publishing.
7. Quatieri, T. F. (2004). *Discrete-time speech signal processing: Principles and practice*. Pearson Education.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Analyze the fundamentals of speech production, phonetics, syntax, and probabilistic/statistical models for spoken language understanding.	PO1(3), PO2(3), PO4(2)	3	2
CO2	Apply digital signal processing techniques for speech signal representation, coding, and feature extraction using LPC, CELP, and cepstral methods.	PO1(3), PO2(3), PO3(2), PO5(2)	3	3
CO3	Develop and evaluate speech recognition systems using Hidden Markov Models, acoustic and phonetic modeling, and adaptive techniques.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO4	Implement text analysis and speech synthesis techniques, including formant, concatenative, and prosody-based synthesis, with evaluation of TTS systems.	PO1(3), PO2(3), PO3(3), PO5(3)	3	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) PO(2)	2	3

NC25007	Broadband Networks	L	T	P	C
		3	0	0	3

Course Objectives:.

- To know about uses, applications, disadvantages of broadband networks
- To Understand the Protocols involved in Broadband Networks
- To Know the various evolutions of network
- To elaborate on the Layer level functions

Evolution of Wireless Networks Review of cellular standards, migration and advancement of GSM architecture and CDMA architecture, WLAN – IEEE 802.11and HIPERLAN, Bluetooth.

Activity: Tracing the Evolution of Wireless Networks

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

Activity: Exploring Mobile Network and Transport Layer Protocols

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

Activity: Exploring 3G Network Evolution and Architecture

4G and Beyond Introduction to LTE-A – Requirements and Challenges, network architectures – EPC, E- UTRAN architecture - mobility management, resource management, services, channel -logical and transport channel mapping, downlink/uplink data transfer, MAC control element, PDU packet formats, scheduling services, random access procedure.

Activity: Understanding LTE-A Network Architecture and Data Transfer Mechanisms

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

Activity: Exploring Wireless Channel Functions and MAC/Physical Layer Mechanisms

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. Pahlavan, K. (2008). Principles of wireless networks. Prentice-Hall of India.
2. Garg, V. K. (2013). Wireless network evolution: 2G & 3G. Pearson.
3. Smith, C. P. E., & Collins, D. (2008). 3G wireless networks (2nd ed.). Tata McGraw-Hill.
4. Schiller, J. H. (2014). Mobile communications (2nd ed.). Pearson.
5. Ahmadi, S. (2014). LTE-Advanced: A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies. Elsevier.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Analyze the evolution of wireless networks including GSM, CDMA, WLAN, HIPERLAN, and Bluetooth, understanding their architecture and migration paths.	PO1(3), PO2(3), PO4(2)	3	2
CO2	Evaluate mobile network and transport layer protocols including Mobile IP, IPv4/IPv6, TCP variants, congestion control, and IP mobility management.	PO1(3), PO2(3), PO3(2), PO5(2)	3	3
CO3	Examine 3G and 4G network architectures, including W-CDMA, CDMA2000, UMTS, LTE-A, EPC, UTRAN, and their service, channel, and mobility management mechanisms.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO4	Analyze wireless channel characteristics, physical/MAC layer functions, SC-FDMA, CoMP, carrier aggregation, and multimedia service delivery mechanisms.	PO1(3), PO2(3), PO4(3), PO5(2)	3	3

NC25008	Virtual Private Networks	L	T	P	C
		3	0	0	3

Course Objectives:

- To Understand the purpose and operation of Virtual Private Network
- To identify the business and personal uses of VPN’s.
- To differentiate between a Transport mode VPN and Tunnel mode VPN
- To understand how to manage and maintain the VPN

Introduction and Basics VPN Technologies Security Risks of the Internet , VPNs and Internet Security Issues, VPN Solutions, A Note on IP Address and Domain Name Conventions, Firewall Deployment, Encryption and Authentication , VPN Protocols, Methodologies for Compromising VPNs, Patents and Legal Ramifications

Activity: Understanding VPN Technologies and Internet Security Risks

Implementing, Configuring And Testing Layer 2 Connections General WAN, RAS, and VPN Concepts, VPN Versus WAN, VPN Versus RAS, Differences Between PPTP, L2F, and L2TP, How PPTP Works, Features of PPTP, Installing and Configuring PPTP on a Windows NT RAS Server, Configuring PPTP for Dialup Networking on a Windows NT Client, Using PPTP with Other Security Measures

Activity: Implementing and Testing a Layer 2 VPN Connection Using PPTP

Implementing The Alta Vista Tunnel 98 Advantages of the AltaVista Tunnel System, AltaVista Tunnel Limitations , working of AltaVista Tunnel Works, VPNs and AltaVista , Installing the AltaVista Tunnel, Configuring the AltaVista Tunnel Extranet and Telecommuter Server, Configuring the AltaVista Telecommuter Client, Troubleshooting Problems

Activity: Installing and Configuring the AltaVista Tunnel

Creating A VPN and the CISCO PIX Firewall The SSH Software, Building and Installing SSH , SSH Components , Creating a VPN with PPP and SSH, Troubleshooting Problems , A Performance Evaluation , The Cisco PIX Firewall, The PIX in Action , Configuring the PIX as a Gateway, Configuring the Other VPN Capabilities

Activity: Building a VPN with PPP and SSH and Configuring the Cisco PIX Firewall

Managing and Maintaining VPN and Its Scenario Choosing an ISP, Solving VPN Problems , Delivering Quality of Service , Security Suggestions , Keeping Yourself Up-to-Date, A VPN Scenario: The Topology , Central Office Large Branch Office, Small Branch Offices, Remote Access Users.

Activity: Managing, Maintaining, and Optimizing a VPN Network

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%).
Reference 1. Scott, C., Wolfe, P., & Erwin, M. (1999). *Virtual private networks* (2nd ed.). O'Reilly.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamentals of VPN technologies, internet security risks, encryption, authentication, and VPN protocols.	-	-	-
CO2	Implement, configure, and test Layer 2 VPN connections using PPTP, L2F, and L2TP protocols in secure network environments.	PO1(3), PO2(3), PO3(2), PO5(2)	3	3
CO3	Configure and deploy advanced VPN solutions including AltaVista Tunnel, SSH-based VPNs, PPP, and Cisco PIX Firewall with performance evaluation.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO4	Manage, maintain, and optimize VPN networks for multiple branch offices, remote users, and ensure QoS, security, and reliability in operational scenarios.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3

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%).
References 1. Tranter, W. H., Shanmugam, K. S., Rappaport, T. S., & Kosbar, K. L. (2004). *Principles of communication systems simulation*. Pearson Education (Singapore) Pvt. Ltd. 2. Jeruchim, M. C., Balaban, P., & Shanmugam, K. S. (2001). *Simulation of communication systems: Modeling, methodology and techniques*. Plenum Press. 3. Law, A. M., & Kelton, W. D. (2000). *Simulation modeling and analysis* (3rd ed.). McGraw-Hill. **4.** Gordon, G. (2007). *System simulation* (2nd ed.). Prentice Hall of India.

	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) PO(2)	2	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) PO(2)	2	3

NC25009	Radar Signal Processing	L	T	P	C
		3	0	0	3

Course Objectives:. To understand the fundamentals and history of radar systems, signal models, and radar waveforms; analyze sampling, quantization, and Doppler processing techniques; and study advanced radar signal processing methods for detection and target analysis.

Introduction to Radar Systems History and application of radar, basic radar function, elements of pulsed radar,review of signal processing concepts and operations, A preview of basic radar signal processing, radar system components, advanced radar signal processing

Activity: Basics of Radar Systems and Signal Processing

Signal Models Components of a radar signal, amplitude models, types of clutters, noise model and signal-to noise ratio, jamming, frequency models: the doppler shift, spatial models, spectral model

Activity: Modeling Radar Signals, Noise, Clutter, and Doppler Effects

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

Activity: Sampling and Quantization of Pulsed Radar Signals

Radar Waveforms Introduction, The waveform matched filter, Matched filtering of moving targets, The ambiguity function, The pulse burst waveform, frequency-modulated pulse compression waveforms, Range sidelobe control for FM waveforms, the stepped frequency waveform, Phase-modulated pulse compression waveforms, COSTAS Frequency Codes.

Activity: Radar Waveforms, Matched Filtering, and Pulse Compression

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

Activity: Doppler Processing, MTI, and Moving Target 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. Kolawole, M. O. (2003). *Radar systems, peak detection and tracking*. Elsevier.
2. Skolnik, M. I. (2017). *Introduction to radar systems* (3rd ed.). McGraw Hill.
3. Peebles, P. Z. (2009). *Radar principles*. Wiley India.
4. Cohen, M. N., & Nathanson, F. E. (2006). *Radar design principles: Signal processing and the environment* (2nd ed.). PHI Learning.

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain the fundamentals of radar systems, signal components, system architecture, and basic radar signal processing concepts.	-	-	-
CO2	Model radar signals including amplitude, frequency, Doppler, spatial, and spectral characteristics along with noise, clutter, and jamming effects.	PO1(3), PO2(3), PO3(2)	3	3
CO3	Apply sampling and quantization techniques to pulsed radar signals, considering fast-time, slow-time, spatial, and Doppler dimensions.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO4	Analyze radar waveforms, matched filtering, pulse compression, and Doppler processing techniques including MTI, pulse-Doppler, and adaptive moving target detection.	PO1(3), PO2(3), PO3(3), PO5(3)	3	3

NC25010	Network Protocols and Programming	L	T	P	C
		3	0	0	3

Course Objectives:. To understand communication models, protocol development, and layered architectures; explore protocol specification, verification, and validation techniques; and study performance testing, synthesis, and implementation methods for reliable network protocols.

Introduction Communication Model, Software, Subsystems, Protocol, Communication protocol development methods, Protocol Engineering Process, Layered Architecture, Network services and interfaces, Protocol functions, OSI, TCP/IP, Wireless Protocol Challenges, Application Protocols.

Activity: Understanding Communication Protocols and Layered Architectures

Protocol Specification Components, Services, Protocol Entity, Interface, Interactions, Multimedia, Internet. Protocol Specification Languages, SDL, SPIN, Estelle, E-Lotus, CPN, Uppal, UML.

Activity: Protocol Specification and Using Specification Languages

Protocol Verification and Validation Finite State Machines, Design Errors, Approaches, SDL based, Communication Protocol Conformance Test Principle, Test Execution, Methodology and Framework, Architectures, Generation Methods

Activity: Protocol Verification and Validation Using FSMs and SDL

Protocol Performance Testing Protocol Performance Testing, SDL based TCP and OSPF, Interoperability, SDL based CSMA/CD and CSMA/CA, Scalability, Protocol Synthesis, Interactive and Automatic, SDL from MSC, Re-synthesis

Activity: Protocol Performance Testing and SDL-Based Analysis

Implementation Protocol implementation, requirement, Object based, compilers, Tool or Protocol Engineering

Activity: Implementing a Communication Protocol Using Object-Oriented 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%).

CO	CO Description	PO Mapping	PSO1	PSO2
CO1	Explain communication models, layered architectures (OSI, TCP/IP), network services, and protocol engineering principles.	-	-	-
CO2	Specify network protocols using formal specification languages such as SDL, SPIN, Estelle, UML, and evaluate protocol interactions and services.	PO1(3), PO2(3), PO3(2), PO5(2)	3	3
CO3	Verify and validate protocol behavior using finite state machines, SDL-based conformance testing, and protocol validation frameworks.	PO1(3), PO2(3), PO3(3), PO5(2)	3	3
CO4	Analyze protocol performance, perform synthesis, and implement reliable network protocols using object-oriented and SDL-based approaches.	PO1(3), PO2(3), PO3(3), PO5(3)	3	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 TheoryWeb 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) PO(2)	2	3