ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M.E. ELECTRONICS AND COMMUNICATION ENGINEERING

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

ANNA UNIVERSITY, CHENNAI

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., Electronics and Communication Engineering **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.	EL25101	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.	EL25201	FPGA Based System Design	T	3	0	0	3	3	ES(PC)
2.		Programme Elective I	T	3	0	0	3	3	ES(PE)
3.	CU25C06	Machine Learning	T	3	1	0	4	4	ES(PC)
4.	CU25C07	Advanced Wireless Communication Networks	LIT	3	0	2	5	4	ES(PC)
5.	EL25202	FPGA Based System Design Laboratory	L	0	0	4	4	2	ES(PC)
6.	-	Industry Oriented Course I	-	1	0	0	1	1	SD
7.	EL25203	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.	EL25301	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.	EL25401	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.	CU25C08	Quantum Communication and Networking	3	0	0	3	3
2.	CU25C09	Massive MIMO and MMWAVE System	3	0	0	3	3
3.	EL25C05	Electromagnetic Interference and Compatibility	3	0	0	3	3
4.	EL25001	Optical Communication and Photonics	3	0	0	3	3
5.	EL25C01	Cryptography and Network Security	3	0	0	3	3
6.	EL25002	5G and Beyond Wireless Networks	3	0	0	3	3
7.	EL25C02	Multimedia Compression Techniques	3	0	0	3	3
8.	EL25003	Smart Antennas and Intelligent Surfaces	3	0	0	3	3
9.	AP25C06	Hardware/ Software Co-design	3	0	0	3	3
10.	EL25004	Design and Optimization for mixed signal PCBs	3	0	0	3	3
11.	EL25005	Edge Computing and AI-Optimized Hardware	3	0	0	3	3
12.	EL25006	Nano electronics and Nano photonics	3	0	0	3	3
13.	AP25C05	Signal Integrity for High Speed Design	3	0	0	3	3
14.	EL25007	Flexible and Wearable Electronics	3	0	0	3	3
15.	VL25C01	VLSI for Wireless Communication	3	0	0	3	3
16.	EL25C03	Wireless Sensor Networks and WBAN	3	0	0	3	3
17.	CU25C10	Advanced Satellite Based Systems	3	0	0	3	3
18.	EL25C04	RF Integrated Circuit Design	3	0	0	3	3
19.	VL25C02	MEMS and NEMS	3	0	0	3	3

Semester I

MA25C05	Advanced Mathematical Methods	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–OperationsResearch, 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

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

Course Objectives:

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

list of experiments(MATLAB/Scilab/Labview)

use appropriate simulation tools for the following experiments:

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

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

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

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

Semester II

EL25201	FPGA Based System Design	L	T	P	C
		3	0	0	3

Course Objectives:

This course introduces the different programming elements, logic blocks, I/O blocks, and interconnects in various types of FPGAs. It helps students understand the processes of synthesis, simulation, and system testing. Additionally, the course focuses on designing and implementing circuits, subsystems, and complete systems using FPGAs and I/O boards.

FPGA Architectures:

FPGA-Based Systems: Basic Concepts - Digital Design and FPGAs - The Role of FPGAs - FPGA Types - FPGAs vs. Custom VLSI - FPGA-Based System Design - Goals and Techniques - Hierarchical Design - Design Abstraction- Methodologies. FPGA Basics: Components of an FPGA - Programming Technology - Antifuse Technology - Logic Circuit Representation of FPGA. FPGA Structure: Logic Block - Logic Cluster – Adaptive LUT - Routing Part - Switch Block - Connection Block - I/O Block - DSP Block - Hard Macros - Embedded Memory - Configuration Chain - PLL and DLL.

FPGA Design Flow:

Design Flow and Design Tools: Design Flow - Design Flow by HDL - HLS Design - IP-Based Design - Design with Processor. Design Methodology: FPGA Design Flow - Technology Mapping - Clustering - Place and Route - Low Power Design Tools. Simulation and Synthesis Concepts - Place and Route – Technology Mapping.

FPGA Based Subsystem Design:

Combinational Circuits: Basic Gates - Majority Logic and Concatenation - Shift Operations - Multiplexers - Demultiplexer - Full Adder - Magnitude Comparator. Sequential Circuits: D Flip-flop- Registers - Shift Registers - Counters - Finite State Machines - Pattern Sequence Detector. Arithmetic Circuit Designs: Digital Pipelining - Partitioning of a Design - Signed Adder Design - Multiplier Design.

FPGA Based System Design:

Design of Memories: On-chip Dual Address ROM Design - Single Address ROM Design - On- Chip Dual RAM Design - External Memory Controller Design. System Designs: Discrete Cosine Transform and Quantization Processor - FOSS Motion Estimation Processor - DCTQ Processor.

FPGA Based Project Design:

Project Designs: Traffic Light Controller - Real Time Clock - Digital Signal Processor - PCI Bus Arbiter - DCTQ Processor - Electrostatic Precipitator Controller - JPEG/H.263/MPEG 1/ MPEG 2 Codec.

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. Wolf, W. (2004). *FPGA-based system design*. PTR Prentice Hall.
2. Amano, H. (2018). *Principles and structures of FPGAs*. Springer.
3. Ramachandran, S. (2007). *Digital VLSI systems design: A design manual for implementation of projects on FPGAs and ASICs using Verilog*. Springer.
4. Wilson, P. R. (2008). *Design recipes for FPGAs*. Springer.
5. Churiwala, S. (2017). *Designing with Xilinx FPGAs using Vivado*. Springer.

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Explain the fundamental concepts of FPGA and its structures	**-**	**-**	**-**
CO2	Analyze the steps involved in synthesis, simulation, and testing of systems	PO1(3) PO3(3)	2	2
CO3	Apply the FPGA for the real time applications	PO3(3)	3	3
CO4	Design combinational and arithmetic circuits using FPGA board	PO1(3)	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)

EL25202	FPGA Based System Design Laboratory	L	T	P	C
		0	0	4	2

Course Objectives

This course aims to provide a thorough understanding of Verilog and VHDL for modeling digital circuits and systems. It also covers the principles of simulation, synthesis, and implementation using FPGAs and I/O boards.

List of Experiments

1. **Combinational Circuits:** Basic Gates - Majority Logic and Concatenation - Shift Operations - Multiplexers - Demultiplexer - Full Adder - Magnitude Comparator.
2. **Sequential Circuits:** D Flip-flop - Registers - Shift Registers - Counters - Finite State Machines - Pattern Sequence Detector.
3. **Arithmetic Circuit Designs**: Signed Adder - Multiplier - 8/16 Bit MAC – 16 Bit ALU - 8x64 FIFO Buffer
4. **System Designs**: Traffic Light Controller - Real Time Clock – 4 Bit Slice Processor

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 model, analyze, and evaluate combinational and sequential circuits	PO3(3)	2	2
CO2	design and implement various arithmetic circuits using FPGA boards	PO1(3)	3	2
CO3	Create and import logic modules into FPGA, synthesize and analyze the module with FPGA and I/O boards	PO1(3) PO4(2)	2	3

Programme Elective Courses

CU25C08	Quantum Communication and Networking	L	T	P	C
		3	0	0	3

Course Objective:

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

Fundamentals of Quantum Information

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

Activities: Exploring Qubits and Quantum Gates Using the Bloch Sphere

Quantum Communication Principles

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

Activities: Simulate teleportation circuit and verify fidelity

Quantum Cryptography

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

Activities: Simulate eavesdropping scenarios and observe QBER impact

Quantum Networking

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

Activities: Implement entanglement distribution and routing between nodes

Tools: Netsquid, Qiskit

References:

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

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

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

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

CU25C09	Massive MIMO and MMWAVE Systems	L	T	P	C
		3	0	0	3

Course Objective:

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

Introduction to Massive MIMO And MMWAVE Communication

Overview of 5G and Beyond Technologies- Introduction to Massive MIMO: Concept, evolution, and significance- Motivation for MMWAVE communication- MIMO vs. Massive MIMO- Basic architecture and key features of MMWAVE systems- Use cases and applications: 5G, IoT, vehicular, indoor.

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

Propagation and Channel Modeling

MMWAVE propagation characteristics: path loss, blockage, and reflection- Channel modeling for MMWAVE: LOS and NLOS scenarios- Spatial characteristics and sparsity in MMWAVE channels- Frequency selectivity and time variance- Massive MIMO channel modeling: Rayleigh, Rician, and geometry-based stochastic models-Channel correlation and estimation challenges.

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

Beamforming and Precoding Techniques

Fundamentals of beamforming: analog, digital, and hybrid beamforming- Directional transmission and beam management- Codebook-based beamforming- Precoding techniques: MRT, ZF, MMSE- Hybrid precoding for MMWAVE MIMO- Beam training and feedback strategies.

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

Signal Processing in Massive MIMO Systems

Uplink and downlink processing- Channel estimation methods: TDD reciprocity, pilot contamination- Detection techniques: linear detectors, MMSE, successive interference cancellation-Power control and scheduling in large antenna systems- Spectral and energy efficiency optimization-Hardware impairments and mitigation.

Activity: Signal Processing Techniques in Massive MIMO Systems

System Design, Standards, and Applications

5G NR and beyond physical layer overview-Integration of Massive MIMO and MMWAVE in 5G architecture- Antenna array design considerations for MMWAVE- Resource allocation and mobility management- Massive MIMO and MMWAVE in vehicular and industrial applications- Case studies and simulation platforms (MATLAB, ns-3, etc.)

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

References:

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

NPTEL Courses:

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

MOOC Platforms:

Coursera – Millimeter Wave Wireless Communication

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

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

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

	CO description	PO Mapping	PSO1	PSO2
CO1	Understand the architecture, benefits, and challenges of Massive MIMO and MMWAVE systems.	-	-	-
CO2	Apply signal Processing techniques for channel estimation, beamforming, and detection in MIMO.	PO3(3)	3	3
CO3	Analyze system capacity, spectral efficiency, and propagation characteristics at MMWAVE frequencies.	PO1(3)	3	3
CO4	Evaluate system performance under different fading, mobility, and interference conditions.	PO1(3) PO(2)	2	3
CO5	Design and simulate components of Massive MIMO/MMWAVE systems using software tools.	PO4(3)	2	2

EL25C05	Electromagnetic Interference and Compatibility	L	T	P	C
		3	0	0	3

Course Objective:

This course aims to equip students with a comprehensive understanding of Electromagnetic Interference (EMI) and Electromagnetic Compatibility (EMC), enabling them to identify and analyze EMI sources and coupling mechanisms, apply effective mitigation techniques like shielding, grounding, and filtering, comprehend relevant national and international EMC standards and regulations, and gain practical knowledge of EMI/EMC test methods and instrumentation, ultimately allowing them to design electromagnetically compatible electronic systems and PCBs.

Introduction to EMI & EMC

Definitions and Concepts – EMC Environment - EMC Testing Categories - Basic Electromagnetic Theory: Maxwell's equations and their application in EMC, Near-field and far-field approximations, Concepts of impedance

Activity 1: EMI Source Identification & Classification
Activity 2: Near-Field vs Far-Field Exploration Using Simple Calculations

EMI Coupling Mechanisms

Coupling Paths - basic coupling mechanisms: Conducted Coupling, Capacitive Coupling, Inductive/Magnetic Coupling, Radiative / Electromagnetic Coupling – Crosstalk - Transient Sources - Automotive transients.

Activity 1: Identify and Classify EMI Coupling Mechanisms in Real Devices
Activity 2: Hands-On Demonstration of Crosstalk and Transient Effects

EMI Mitigation Techniques & EMC Standards

Shielding – Grounding – Filtering – Cabling – Bonding - Need for Standards - National and International EMC Standardizing Organizations: IEC, FCC, CISPR, ANSI, BSI, CENELEC, ETSI - Key Standards and Specifications: MIL-STD, Electro Magnetic Emission and Susceptibility standards.

Activity 1: EMI Mitigation Hands-On Experiment
Activity 2: EMC Standards Research & Presentation

EMI Test Methods and Instrumentation

Fundamental Considerations - Emission Testing: Conducted Emissions, Radiated Emissions - Immunity/Susceptibility Testing: Conducted Immunity, Radiated Immunity, ESD Testing, Transient Immunity - Test Equipment

Activity 1: Emission Testing Demonstration
Activity 2: Immunity and ESD Testing Simulation

PCB Design for EMC Compliance

PCB Layout and Stack-up - Signal Integrity Considerations - Mixed-Signal PCB Layout: Grounding and power distribution for mixed-signal systems, Isolation of sensitive circuits - Component Placement for EMC

Activity 1: Analyzing PCB Layout for EMC Issues
Activity 2: Design a Simple EMC-Compliant PCB Section

References:

1. Ott, H. W. (1988). *Electromagnetic compatibility engineering* (2nd ed.). John Wiley & Sons.
2. Paul, C. R. (2010). *Introduction to electromagnetic compatibility* (2nd ed.). Wiley Interscience.
3. Ott, H. W. (1988). *Noise reduction techniques in electronic systems* (2nd ed.). John Wiley & Sons.
4. Keiser, B. (1989). *Principles of electromagnetic compatibility* (3rd ed.). Artech House.
5. Kodali, V. P. (2001). *Engineering electromagnetic compatibility: Principles, measurements, and technologies with computer models* (2nd ed.). IEEE Press.

E-Resources:

1. http:// www.ewh.ieee.org/soc/emcs/
2. https://archive.nptel.ac.in/courses/108/106/108106138/
3. https://nptel.ac.in/courses/108106138
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	Identify, categorize, and explain various sources of electromagnetic interference and EMC testing categories and EMI/EMC test methods, recognize the associated instrumentation, and critically evaluate test results for compliance.	-	-	-
CO2	Analyze and classify the coupling mechanisms (conducted, radiated, capacitive, inductive), and their impact on electronic systems.	PO3(3)	3	2
CO3	Integrate EMC principles into the design process of electronic circuits and printed circuit boards (PCBs), optimizing layouts, component placement, and power/ground distribution to ensure inherent electromagnetic compatibility.	PO1(3) PO2(2)	2	3

EL25001	Optical Communication and Photonics	L	T	P	C
		3	0	0	3

Course Objective:

To provide learners with a comprehensive understanding of photonics principles and optical communication systems by enabling them to analyze light–matter interactions, design and evaluate optical fibers, sources, detectors, and communication links, and explore advanced photonic technologies and applications in modern sensing, networking, and communication systems.

Fundamentals of Photonics

Nature of light: wave–particle duality Electromagnetic spectrum and optical bands Basic principles of photonics- Optical materials: refractive index, dispersion- Reflection, refraction, Snell's law - Total internal reflection and light guiding mechanism

Optical Fibers and Waveguides

Optical fiber structure and classification- Step-index and graded-index fibers Modes in optical fibers Numerical aperture and acceptance angle Attenuation and loss mechanisms- Dispersion: material, waveguide, and modal dispersion

Optical Sources and Detectors

Light sources: LED and Laser Diodes- Characteristics of optical sources- semi conductor laser principles- Optical detectors: PIN and APD photodiodes- Detector characteristics and noise- Optical coupling and efficiency

Optical Communication Systems

Basic optical communication system block diagram- Optical transmitters and receivers Modulation techniques in optical communication= Optical amplifiers: EDFA, SOA Power budget and rise time budget analysis- Digital optical communication systems

Advanced Photonics and Applications

Wavelength Division Multiplexing (WDM)- Optical networking concepts- Photonic integrated circuits- Nonlinear optical effects- Applications of photonics in sensing, medicine, and communication- Introduction to fiber optic sensors

References:

1. Keiser, G. (2013). Optical fiber communications (5th ed.). McGraw-Hill.
2. Senior, J. M., & Jamro, M. Y. (2009). Optical fiber communications: Principles and practice (3rd ed.). Pearson Education.
3. Saleh, B. E. A., & Teich, M. C. (2007). Fundamentals of photonics (2nd ed.). Wiley.
4. Agrawal, G. P. (2010). Fiber-optic communication systems (4th ed.). Wiley.

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 fundamental concepts of photonics and optical communication systems	-	-	-
CO2	Analyze optical fiber characteristics including losses and dispersion	PO1(3)	3	3
CO3	Evaluate performance of optical sources and detectors	PO2(3)	2	2
CO4	Design and analyze optical communication systems	PO3(3) PO11(2)	2	2
CO5	Apply photonic principles to advanced communication and sensing applications	PO3(2)	2	2

EL25C01	Cryptography and Network Security	L	T	P	C
		3	0	0	3

Course Objectives:

This course aims to provide an understanding of the importance and objectives of communication network and information security, along with an overview of various types of attacks. It introduces different security approaches and algorithms used to ensure data integrity and authenticity. The course also emphasizes the practical design and implementation of security features in both wired and wireless networking environments.

Introduction on Security: Security Goals, Cryptographic attacks, Security services and
mechanisms Techniques: Cryptography and Steganography, Traditional Symmetric-Key Ciphers: Substitution Ciphers and Transposition Ciphers, Mathematics for Cryptography.

Symmetric & Asymmetric Key Algorithms: Introduction to Block Ciphers and Stream Ciphers, Data Encryption Standards (DES), Advanced Encryption Standard (AES), RC4, Principle of asymmetric key algorithms, RSA Cryptosystem.

Integrity, Authentication and Key Management: Message Integrity, Hash functions: SHA 512, Whirlpool, Digital signatures: Digital signature standards. Authentication: Entity Authentication: Biometrics, Key management Techniques.

Network Security, Firewalls and Web Security: Introduction on Firewalls, Types of Firewalls, IP Security, E-mail security: PGP- S/MIME, Web security: SSL-TLS, SET.

Wireless Network Security: Security Attack issues specific to Wireless systems: Worm hole, Tunneling, DoS. Security for WLAN, Security for Broadband networks: Security challenges in 4G and 5G deployments, Introduction to side channel attacks and their counter measures.

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. Behrouz A. Forouzan ,"Cryptography and Network security", McGraw- Hill, 2011
2. William Stallings, "Cryptography and Network security: principles and practice", Prentice Hall of India, New Delhi, 2nd Edition,2002
3. AtulKahate ,"Cryptography and Network security", Tata McGraw-Hill,2nd Edition, 2008.
4. R.K.Nichols and P.C. Lekkas ,"Wireless Security: Models , threats and Solutions", McGraw- Hill, 2001.
5. H. Yang et al., "Security in Mobile Ad Hoc Networks: Challenges and Solution", IEEE Wireless Communications, Feb. 2004.
6. "Securing Ad Hoc Networks", IEEE Network Magazine, vol. 13, no. 6, pp. 24-30, December 1999.

7. "Security of Wireless Ad Hoc Networks," http://www.cs.umd.edu/~aram/wireless/survey.pdf
8. David Boelet.al,"Securing Wireless Sensor Networks – Security Architecture", Journal of networks , Vol.3. No. 1. pp. 65 -76, Jan 2008.
9. Perrig, A., Stankovic, J., Wagner, D., "Security in Wireless Sensor Networks", Communications of the ACM, 47(6), 53-57, 2004.
10. Introduction to side channel attacks – http://gauss.ececs.uc.edu/Courses/c653/lectures/SideC/intro.pdf.

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Explain security goals, cryptographic attacks, security services, mechanisms, and classical cryptographic techniques including symmetric-key ciphers and cryptographic mathematics.	**-**	**-**	**-**
CO2	Apply symmetric and asymmetric key algorithms such as DES, AES, RC4, and RSA with respect to confidentiality and performance.	PO1(3)	3	3
CO3	Evaluate integrity, authentication, hashing algorithms, digital signature schemes, and key management techniques for secure communication.	PO23)	3	3
CO4	Analyze and design security mechanisms for network, web, and wireless systems including firewalls, IPsec, SSL/TLS, WLAN security, and 4G/5G security challenges.	PO3(3) PO4(2)	2	3

EL25002 **5G and Beyond Wireless Networks** **L T P C**
3 0 0 3

Introduction to 5G and Beyond

5G characteristics and requirements, Applications, Case studies, 5G channel models: METIS channel models, Map-based model, stochastic model, Comparison of Models

5G Architecture

Introduction, NFV and SDN, Basics about RAN architecture, High –level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional Split Alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfill 5G requirements, Enhanced Multi-RAT Coordination features, Physical architecture and 5G deployment.

Multi-Carrier waveforms for 5G

Filter-bank based multi-carrier (FBMC)- Principles, Transceiver block diagram, Frame structure, Resource structure, allocation, mapping.Universal filtered multi carrier (UFMC)- Principles, Transceiver structure, Frame and Resource structure, allocation, mapping. Generalized frequency division multicarrier (GFDM) —Principles, Transceiver Block diagram, Frame structure, Resource structure, allocation, mapping, MIMO-GFDM

Multiple Access Techniques in 5G

Challenges in OFDM- NOMA — Principle- Superposition Coding, Successive Interference Cancellation, Power Domain NOMA, Sparse Code NOMA - types, Power Domain Sparse Code NOMA, Cooperative NOMA – Benefits and Challenges.

Cooperative Communication

Machine Type Communication (MTC), Device to Device Communication (D2D), 5G Narrowband IoT, Cloud Computing architecture and Protocols**, Relaying:** Cooperative NOMA- Benefits and Challenges, Half duplex relaying, Full duplex relaying, Amplify and forward relaying, Decode and forward relaying, Decode and forward relaying with PLNC, BER Analysis, Capacity Analysis.

References

1. AfifOsseiran, Jose.F.Monserrat and Patrick Marsch, “5G Mobile and Wireless Communications Technology”, Cambridge University Press, 2016.
2. Robert W. Heath Jr., Nuria González-Prelcic, SundeepRangan, WonilRohand Akbar M. Sayeed, “An Overview of Signal Processing Techniques for Millimeter Wave MIMO Systems”, IEEE Journal of Selected Topics in Signal Processing, Vol. 10, No. 3, April 2016.
3. Min ChulJu and Il-Min Kim, “Error Performance Analysis of BPSK Modulation in Physical- Layer Network-Coded Bidirectional Relay Networks”, IEEE Transactions on Communications,Vol. 58, No. 10, October 2010.
4. Shengli Zhang, Soung-Chang Liew, Patrick P.Lam, “Physical Layer Network Coding”, Mobicom ‗06, Proceeding of the 12th International Conference on Mobile Computing and Networking, pp.358-365, Los Angeles, CA, USA, Sep.23-29,2006.

5. ThomasL.Marzetta, ErikG.Larsson,HongYang, HienQuocNgo,“Fundamentals of Massive MIMO”, Cambridge University Press, 1stEdition, 2016.
6. AfifOsseiran, Jose F. Monserrat, Patrick Marsch, “ 5G Mobile and Wireless Communications Technology”, Cambridge University Press, 2nd edition, 2011
7. Erik Dahlman, Stefan Parkvall, Johan Sköld, “5G NR: The Next Generation Wireless Access Technology”, Elsevier, 1stEdition, 2016.
8. Jonathan Rodriguez.” Fundamentals of 5G Mobile Networks”, Wiley, 1stEdition, 2010.

	CO description	**PO Mapping**	**PSO1**	**PSO2**
CO1	Explain 5G characteristics, requirements, applications, case studies, and 5G channel models including METIS, map-based, and stochastic models.	**-**	**-**	**-**
CO2	Apply the concepts of 5G functional and physical architecture including SDN, NFV, RAN architecture, functional splits, and multi-RAT integration in % G networks	PO3(3)	3	3
CO3	Analyze and compare multi-carrier waveforms and multiple access techniques for 5G including FBMC, UFMC, GFDM, and NOMA schemes.	PO1(3)	3	3
CO4	Design and evaluate cooperative communication techniques for 5G systems including MTC, D2D, NB-IoT, relaying strategies, and performance metrics.	PO1(3) PO4(2)	2	3

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

EL25003	Smart Antennas and Intelligent Surfaces	L	T	P	C
		3	0	0	3

Course Objective:

The objective of this course is to provide postgraduate students with a strong theoretical and analytical foundation in smart antenna systems and intelligent reflecting surfaces for modern wireless communications. The course develops understanding of adaptive antenna arrays, beamforming, MIMO systems, and intelligent surfaces for next-generation wireless networks.

Fundamentals of Smart Antennas

Introduction to smart antennas, antenna array theory, radiation patterns, beam steering, switched beam and adaptive array systems, and applications in wireless communication.

Array Signal Processing

Spatial sampling, signal and noise models, direction of arrival estimation, Bartlett, Capon, and MUSIC algorithms, and performance metrics

Adaptive Beamforming Techniques

Adaptive beamforming concepts, LMS, RLS, SMI algorithms, interference suppression, convergence, and implementation issues.

MIMO and Massive MIMO Systems

MIMO channel models, diversity and multiplexing, capacity analysis, space–time coding, massive MIMO architectures, and 5G applications.

Intelligent Reflecting Surfaces

Metasurface principles, IRS-assisted channel modeling, phase shift design, beam control, and wireless performance enhancement.

Advanced Topics and Applications

Smart antennas and IRS for mmWave and 6G, machine learning–based beamforming, joint optimization, and future research directions.

References:

1. Balanis, C. A. (2016). *Antenna theory: Analysis and design* (4th ed.). Wiley.
2. Godara, L. C. (2004). *Smart antennas*. CRC Press.
3. Goldsmith, A. (2005). *Wireless communications*. Cambridge University Press.
4. Björnson, E., Sanguinetti, L., Hoydis, J., & Debbah, M. (2017). *Massive MIMO networks: Spectral, energy, and hardware efficiency*. *Foundations and Trends in Signal Processing, 11*(3–4), 154–655. https://doi.org/10.1561/2000000093
5. Wu, Q., & Zhang, R. (2019). Intelligent reflecting surface enhanced wireless network. *IEEE Transactions on Wireless Communications, 18*(11), 5394–5409. https://doi.org/10.1109/TWC.2019.2937425
6. Rappaport, T. S., & Liberti, J. C. (1999). *Smart antennas for wireless communications: IS-95 and third generation CDMA applications*. Prentice Hall PTR.
7. Janaswamy, R. (2001). *Radio wave propagation and smart antennas for wireless communications*. Kluwer Academic Publishers.
8. Bronzel, M. J. (2004). *Smart antennas*. Wiley.

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 and explain the antenna theory and antenna parameters	-	-	-
CO2	analyze smart antenna fundamentals,	PO1(3)	3	3
CO3	apply adaptive beamforming algorithms,	PO2(3)	2	2
CO4	evaluate MIMO system performance, model intelligent reflecting surfaces, design smart antenna–based systems, and interpret current research literature.	PO3(3) PO11(2)	2	2

AP25C06	Hardware / Software Co-Design	L	T	P	C
		3	0	0	3

Course Objectives:

The objective of this course is to acquire the knowledge about system specification and modeling and to learn the formulation of partitioning. This course also deals with the different technical aspects about prototyping, emulation and verification.

System Specification and Modelling

Embedded Systems, Hardware/Software Co-Design, Co-Design for System Specification And Modeling, Co-Design for Heterogeneous Implementation - Processor Synthesis, Single-Processor Architectures With One ASIC, Single-Processor Architectures With Many ASICs, Multi-Processor Architectures, Comparison of Co-Design Approaches, Models of Computation, Requirements for Embedded System Specification.

Hardware/Software Partitioning

The Hardware/Software Partitioning Problem, Hardware-Software Cost Estimation, Generation of the Partitioning Graph, Formulation of the HW/SW Partitioning Problem, Optimization, HW/SW Partitioning Based On Heuristic Scheduling, HW/SW Partitioning Based On Genetic Algorithms.

Hardware/Software Co-Synthesis

The Co-Synthesis Problem, State-Transition Graph, Refinement and Controller Generation, Distributed System Co-Synthesis – Hardware/software co-synthesis algorithms: hardware – software partitioning, distributed system co-synthesis.

Prototyping and Emulation

Introduction, Prototyping And Emulation Techniques, Prototyping and Emulation Environments, Future Developments In Emulation and Prototyping, Target Architecture, Architecture Specialization Techniques, System Communication Infrastructure, Target Architectures and Application System Classes, Architectures for Control-Dominated Systems, Architectures for Data-Dominated Systems, Mixed Systems and Less Specialized Systems.

Design Specification and Verification

Concurrency, Coordinating Concurrent Computations, Interfacing Components, Verification, Languages for System-Level Specification and Design: System-Level Specification, Design Representation for System Level Synthesis, System Level Specification Languages, Heterogeneous Specification and Multi-Language Co-Simulation

References:

1. Schaumont, P. (2010). A practical introduction to hardware/software codesign. Springer.
2. Niemann, R. (1998). Hardware/software co-design for data flow dominated embedded systems. Kluwer Academic Publishers.

3. Staunstrup, J., & Wolf, W. (1997). Hardware/software co-design: Principles and practice. Kluwer Academic Publishers.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

	CO description	PO Mapping	PSO1	PSO2
CO1	Describe the broad range of system architectures and design methodologies that currently exist and define their fundamental attributes.	-	-	-
CO2	Apply the dataflow models as a state-of-the-art methodology to solve co-design problems and to optimize the balance between software and hardware	PO3(3)	3	3
CO3	Develop co-design solutions to problems using modern hardware/software tools for building prototypes.	PO1(3)	3	3
CO4	Identify the concurrent specification from an algorithm, analyze its behavior and partition the specification into software and hardware components	PO1(3) PO(2)	2	3

EL25004	Design and Optimization for mixed signal PCBs	L	T	P	C
		3	0	0	3

Course Objectives:

This course provides an understanding of the importance of PCB design and the steps involved in its design and fabrication process. It familiarizes students with schematic and layout design using Electronic Design Automation (EDA) tools, and covers key concepts such as transmission lines, crosstalk, and thermal issues. Students will also learn to design PCBs for analog, digital, and mixed-signal circuits, along with schematic creation and interpretation.

Introduction to Printed Circuit Board:

Introduction to Printed circuit board: fundamental of electronic components, basic electronic circuits, Basics of printed circuit board designing: Layout planning, general rules and parameters, ground conductor considerations, thermal issues, check and inspection of artwork.

Design Rules For PCB:

Design rules for PCB: Design rules for Digital circuit PCBs, Analog circuit PCBs, high frequency and fast pulse applications, Power electronic applications, Microwave applications, PCB Technology Trends: Multilayer PCBs. Multiwire PCB, Flexible PCBs, Surface mount PCBs, Reflow soldering, Introduction to High-Density Interconnection (HDI) Technology.

Introduction to electronic design Automation(EDA) Tools for PCB Designing:

Introduction to Electronic design automation(EDA) tools for PCB designing: Brief Introduction of various simulators,SPICE and PSPICE Environment, Selecting the Components Footprints as per design, Making New Footprints, Assigning Footprint to components, Net listing, PCB Layout Designing, Auto routing and manual routing. Assigning specific text (silkscreen) to design, Creating report of design, creating manufacturing data (GERBER) for design.

Introduction Printed Circuit Board Production Techniques:

Introduction printed circuit board production techniques: Photo printing, film-master production, reprographic camera, basic process for double sided PCBs photo resists, Screen printing process, plating, relative performance and quality control, Etching machines, Solders alloys, fluxes, soldering techniques, Mechanical operations.

PCB Design for EMI/EMC:

PCB design for EMI/EMC: Subsystem/PCB Placement in an enclosure, Filtering circuit placement, decoupling and bypassing, Electronic discharge protection, Electronic waste; Printed circuit boards Recycling techniques, Introduction to Integrated Circuit Packaging and footprints,
NEMA and IPC standards.

Activities:

1. Using any Electronic design automation (EDA) software, Practice following PCB Design steps (Open source EDA Tool KiCad Preferable or equivalent) Example circuit: Basic RC

Circuit Schematic Design: Familiarization of the Schematic Editor, Schematic creation, Annotation, Netlist generation Layout Design: Familiarization of Footprint Editor, Mapping of components, Creation of PCB layout Schematic Create new schematic components Create new component footprints.

2. Fabricate single-sided PCB, mount the components and assemble in a cabinet for any one of the circuits mentioned below.
3. Regulator circuit using 7805.
4. Astable or Monostable multivibrator using IC555
5. RC Phase-shift or Wein-bridge Oscillator using transistor.
6. 4 bit binary /MOD N counter using D-Flip flops.
7. Design a 8051 Development board having Power section consisting of IC7805, capacitor, resistor, headers, LED,Serial communication section consisting of MAX 232, Capacitors,DB9 connector, Jumper, LEDs, Reset & Input/ output sections consisting of89C51 Microcontroller, Electrolytic Capacitor, Resistor, Jumper, Crystal Oscillator, Capacitors.
8. Touch plate switches – transistorized or 555 based
9. Doorbell/cordless bell 10.Clapping switch and IR switch 11.Blinkers

12.Cell charger, battery charger, mobile charger 13.Fire/smoke/intruder alarm

14.Liquid level controller

15. Audio amplifiers

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. Printed circuit board design ,fabrication assembly and testing By R. S. Khandpur, Tata McGraw Hill 2006
2. Printed Circuits Handbook, Sixth Edition,by Clyde F. Coombs, Jr, Happy T. Holden,Publisher: McGraw-Hill Education Year: 2016
3. Complete PCB Design Using OrCAD Capture and PCB Editor,Kraig Mitzner Bob Doe Alexander Akulin Anton Suponin Dirk Müller, 2nd Edition 2009.
4. Introduction to System-on-Package, Rao R ,Tummala,&MadhavanSwaminathan, McGraw Hill, 2008
5. EMC and Printed circuit board ,Design theory and layout, Mark I Montrose IEEE compatibility society
6. Electronic Product Design Volume-I by S D Mehta, S Chand Publications
7. Open source EDA Tool KiCad Tutorial: http://kicad-pcb.org/help/tutorials/
8. PCB Fabrication user guide page: http://www.wikihow.com/Create-Printed-Circuit-Boards http://www.siongboon.com/projects/2005-09-07_home_pcb_fabrication/ ,

9. http://reprap.org/wiki/MakePCBInstructions#Making_PCBs_yourself 10. PCB Fabrication at home(video): https://www.youtube.com/watch?v=mv7Y0A9YeUc, 11. https://www.youtube.com/watch?v=imQTCW1yWkg

	CO description	PO Mapping	PSO1	PSO2
CO1	Understand the steps involved in schematic, layout, fabrication and assembly process of PCB design.	**-**	**-**	**-**
CO2	Apply advanced techniques, skills and modern tools for designing and fabrication of PCBs.	PO3(3)	3	3
CO3	Design (schematic and layout) and fabricate PCB for simple circuits.	PO1(3)	3	3

EL25005	Edge Computing and AI-Optimized Hardware	L	T	P	C
		3	0	0	3

Course Objective:

The objective of this course is to provide students with fundamental and applied knowledge of Artificial Intelligence, Machine Learning, and Edge Computing. The course develops programming skills using Python, introduces modern ML and deep learning techniques, and enables learners to design and analyze AI solutions for edge and IoT-based systems.

Introduction to AI, Edge Computing, and Python

Overview of Artificial Intelligence and its evolution toward Edge Computing, relationship between AI, ML, IoT, and Edge AI, Cloud AI versus Edge AI, introduction to TinyML. Basics of Python programming, Python internals, and machine learning libraries.

Machine Learning Fundamentals

Machine learning concepts and workflow, data preparation, supervised learning principles, regression and classification algorithms, and model evaluation.

Unsupervised and Reinforcement Learning

Clustering and dimensionality reduction techniques including K-Means, DBSCAN, and PCA. Fundamentals of reinforcement learning, model-based and model-free approaches.

Neural Networks and Deep Learning

Neural network fundamentals, multilayer perceptron models, gradient descent and backpropagation, overfitting and regularization. Introduction to CNNs and RNNs with applications.

IoT, Edge Computing, and TinyML

IoT architecture, edge and fog computing models, TinyML concepts, model compression, TensorFlow Lite, and edge hardware platforms.

Applications and Emerging Trends

Applications of AI in healthcare, manufacturing, power systems, transportation, oil and gas, civil engineering, ethics in AI, and emerging trends.

References:

1. Russell, S. J., & Norvig, P. (2021). *Artificial intelligence: A modern approach* (4th ed.). Pearson.
2. Géron, A. (2022). *Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow* (3rd ed.). O’Reilly Media.
3. Murphy, K. P. (2022). *Machine learning: A probabilistic perspective*. MIT Press.
4. Bishop, C. M. (2006). *Pattern recognition and machine learning*. Springer.
5. Sutton, R. S., & Barto, A. G. (2018). *Reinforcement learning: An introduction* (2nd ed.). MIT Press.
6. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep learning*. MIT Press.
7. McKinney, W. (2022). *Python for data analysis* (3rd ed.). O’Reilly Media.
8. Shi, W., Cao, J., Zhang, Q., Li, Y., & Xu, L. (2016). Edge computing: Vision and challenges. *IEEE Internet of Things Journal, 3*(5), 637–646.

9. Warden, P., & Situnayake, D. (2020). *TinyML: Machine learning with TensorFlow Lite on Arduino and ultra-low-power microcontrollers*. O'Reilly Media.
10. Floridi, L. (2019). *The ethics of artificial intelligence*. Oxford University Press.
11. Topol, E. J. (2019). *Deep medicine: How artificial intelligence can make healthcare human again*. Basic Books.

Activities: real time application Mini project

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 fundamentals of Artificial Intelligence, Edge Computing, and their integration.	-	-	-
CO2	Apply Python programming and ML libraries for data analysis and prediction tasks.	PO1(3)	2	2
CO3	Analyze supervised, unsupervised, and reinforcement learning algorithms.	PO2(3)	2	2
CO4	Design neural network and deep learning models for real-world problems.	PO3(3)	2	2
CO5	Evaluate real-time and industrial applications of AI across engineering domains.	PO4(3)	2	2

EL25006	Nano Electronics and Nano photonics	L	T	P	C
		3	0	0	3

Course Objectives:

This course aims to provide an understanding of transistor design at the nanoscale and explore various types of nano devices. It also covers the properties and applications of different nano sensors.

Semiconductor and Nanodevices: Single-Electron Devices; Nano scale MOSFET – Resonant Tunneling Transistor - Single-Electron Transistors; Nanorobotics and Nanomanipulation; Mechanical Molecular Nanodevices; Nano Computers: Optical Fibers for Nanodevices; Photochemical Molecular Devices; DNA-Based Nanodevices; Gas-Based Nanodevices**.**

Electronics and Photonic Molecular Materials: Preparation – Electroluminescent Organic materials - Laser Diodes - Quantum well lasers:- Quantum cascade lasers- Cascade surface-emitting photonic crystal laser- Quantum dot lasers - Quantum wire lasers:- White LEDs - LEDs based on nanowires - LEDs based on nanotubes - LEDs based on nanorods - High Efficiency Materials for OLEDs- High Efficiency Materials for OLEDs - Quantum well infrared photo detectors.

Thermal Sensors: Thermal energy sensors -temperature sensors, heat sensors - Electromagnetic sensors - electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors, magnetism sensors - Mechanical sensors - pressure sensors, gas and liquid flow sensors, position sensors - Chemical sensors - Optical and radiation sensors.

Gas Sensor Materials: Criteria for the choice of materials - Experimental aspects – materials, properties, measurement of gas sensing property, sensitivity; Discussion of sensors for various gases, Gas sensors based on semiconductor devices.

Biosensors:

Principles - DNA based biosensors – Protein based biosensors – materials for biosensor applications - fabrication of biosensors - future potential.

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. K.E. Drexler, “Nano systems”, Wiley, 1992
2. M.C. Petty, “Introduction to Molecular Electronics”, 1995.
3. W. Ranier, “Nano Electronics and Information Technology”, Wiley, 2003

	CO description	PO Mapping	PSO1	PSO2
CO1	Explain the principles, operation, and applications of semiconductor nanodevices including single-electron devices, nanoscale MOSFETs, molecular nanodevices, and nano-computing concepts.	**-**	**-**	**-**
CO2	Analyze electronic and photonic molecular materials and devices such as quantum well, quantum dot, quantum cascade lasers, LEDs, OLED materials, and infrared photodetectors.	PO3(3)	3	2
CO3	Design and evaluate gas sensors and biosensors based on material selection, fabrication techniques, sensitivity, and future application requirements	PO1(3)	3	3
CO4	evaluate thermal, electromagnetic, mechanical, chemical, and optical sensor principles with respect to performance parameters and applications.	PO1(3) PO(2)	2	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

EL25007	Flexible and Wearable Electronics	L	T	P	C
		3	0	0	3

Course Objective:

- To introduce the fundamentals of flexible and wearable electronics.
- To understand materials and fabrication techniques for flexible systems.
- To analyze flexible electronic devices and system integration.
- To explore applications in healthcare, IoT, and smart systems.
- 5. To familiarize students with reliability, packaging, and future trends.

Introduction to Flexible and Wearable Electronics

Evolution of electronics, rigid vs flexible electronics, flexible, stretchable and wearable electronics, mechanical deformation modes, overview of applications.

Materials for Flexible Electronics

Flexible substrates, conductive materials, semiconducting materials, dielectric materials, biocompatible and biodegradable materials.

Fabrication and Printing Techniques

Thin-film deposition, photolithography on flexible substrates, printing techniques, roll-to-roll processing.

Flexible Devices and Components

Flexible sensors, flexible transistors, flexible energy storage devices, energy harvesting, flexible displays.

Wearable Electronics Systems and Applications

Wearable system architecture, healthcare wearables, smart textiles, IoT integration, data acquisition.

Reliability, Packaging and Future Trends

Mechanical reliability, testing methods, packaging techniques, standards, challenges and future trends.

References:

1. Someya, T. (Ed.). (2012). *Stretchable electronics*. Wiley-VCH.
2. Wong, W. S., & Salleo, A. (Eds.). (2009). *Flexible electronics: Materials and applications*. Springer.
3. Tao, X. (Ed.). (2005). *Wearable electronics and photonics*. Woodhead Publishing.
4. Huang, Y., Su, Y., & Jiang, S. (2023). *Flexible electronics: Theory and method of structural design*. Springer Singapore.

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 principles of flexible and wearable electronics.	-	-	-
CO2	Identify suitable materials and substrates.	PO1(3)	3	3
CO3	Analyze fabrication and printing techniques.	PO2(3)	2	2
CO4	Design basic flexible electronic devices.	PO3(3) PO11(2)	2	2
CO5	Evaluate applications and challenges of wearable systems.	PO4(2)	2	2

VL25C01	VLSI For Wireless Communication	L	T	P	C
		3	0	0	3

Course Objective:

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

Communication Systems & Wireless Channel Models

Overview of Wireless Systems and Standards. TDMA, FDMA, CDMA, OFDMA. Modulation Schemes (BPSK, QPSK, MSK, OFDM). Classical And Wireless Channel Models – Path Loss, Multipath Fading, Doppler Spread, Coherence Bandwidth.

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

Receiver Architectures and LNA Design

Receiver Types: Heterodyne, Homodyne, And Low-If. RF Front-End: Bandpass Filters, Noise Figure, Linearity, Gain. Wideband And Narrowband Lna Design, Matching Networks, NF Vs Power Trade-Off.

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

Mixer Design – Active and Passive

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

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

A/D Converters in Wireless Systems

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

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

Frequency Synthesizers and Transmitters

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

Activity (Eda Tools):

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

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

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

References:

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

E-Resources

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

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

EL25C03	Wireless Sensor Netwoks and WBAN	L	T	P	C
		3	0	0	3

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

Overview of Wireless Sensor Networks
Challenges for Wireless Sensor Networks-Characteristics requirements-required mechanisms, Difference between mobile ad-hoc and sensor networks, Applications of sensor networks- case study, Enabling Technologies for Wireless Sensor Networks

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

Mac and Routing
Single-Node Architecture - Hardware Components, Energy Consumption of Sensor Nodes, Operating Systems and Execution Environments, Network Architecture - Sensor Network Scenarios, Optimization Goals and Figures of Merit, Gateway Concepts. Physical Layer and Transceiver Design Considerations

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

Architectures
MAC Protocols for Wireless Sensor Networks, IEEE 802.15.4, ZigBee, Low Duty Cycle Protocols and Wakeup Concepts - S-MAC, The Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols- Energy Efficient Routing, Geographic Routing.

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

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

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

Wireless Body Area Network
Introduction to WBAN Standard-Architecture-WBAN layers- Network and MAC Protocol Design for WBAN-Energy Management in WBAN-Performance Analysis of WBAN-Miniaturized Antennas Implanted Antennas- PHY layer for UWB WBAN. Case study using Simulation Tools.

Activity: Simulation and Performance Analysis of WBAN Architecture, MAC Protocols, and Energy Management
References: 1. Karl, H., & Willig, A. (2005). Protocols and architectures for wireless sensor networks. John Wiley. 2. Akyildiz, I. F., & Vuran, M. C. (2010). Wireless sensor networks. John Wiley. 3. Li, Y., Thai, M. T., & Wu, W. (2008). Wireless sensor networks and applications. Springer. 4. Li, H.-B., Yekeh Yazdandoost, K., & Bin-Zhen. (2010). Wireless body area networks. River Publishers. 5. Thotahewa, K. M. S., Redoute, J.-M., & Yuce, M. R. (2016). Ultra wideband wireless body area networks. Springer.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

	CO description	PO Mapping	PSO1	PSO2
CO1	understanding of the different components of WSN and WBAN	-	-	-
CO2	design and implement protocols suitable to sensor communication scenario using design tools and characterize them	PO3(3)	3	3
CO3	apply designing energy efficient sensor nodes and protocols for prolonging network lifetime.	PO1(3)	3	3
CO4	evaluate practical design issues and find out different implementation tools for improving the overall performance of body area network.	PO1(3) PO(2)	2	3

CU25C10	Advanced Satellite Based Systems	L	T	P	C
		3	0	0	3

Course Objective:

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

Introduction to Satellite and GPS

Origin of satellite communication, Development, Space segment, Ground segment, Types of orbit, Evolution of satellite communications, Development of service Global Navigation Satellite Systems – Basic concepts of GPS and its segments, GPS constellation, GPS measurement characteristics, selective availability (AS), Anti spoofing (AS).

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

Inertial Navigation and Differential GPS

Systems Introduction to Inertial Navigation- Inertial Sensors - Navigation Coordinates- System Implementations- System-Level Error Models- Introduction to Differential GPSLADGPSWADGPS-WAAS - GEO Uplink Subsystem (GUS) - GEO Uplink Subsystem (GUS) Clock Steering Algorithms - GEO Orbit Determination – Problems.

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

Remote Sensing Systems and Techniques

Introduction - Commercial Imaging - Digital Globe – GeoEye - Meteorology – Meteosat – Land Observation – Landsat- Remote Sensing Data- Sensors- Overview - Optical Sensors: Cameras- Non-Optical Sensors- Image Processing - Image Interpretation- System Characteristics.

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

Broadcast Systems

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

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

Satellite Communication in IPV6 Environment

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

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

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

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

References:

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

E-Resources

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

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

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

Course Objectives:

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

CMOS Physics, Transceiver Specifications and Architectures

Introduction to MOSFET Physics, Noise: Thermal, shot, flicker, popcorn noise, Two port Noise theory, Noise Figure, THD, IP2, IP3, Sensitivity, SFDR, Phase noise - Specification distribution over a communication link, Homodyne Receiver, Heterodyne Receiver, Image reject, Low IF Receiver Architectures Direct up conversion Transmitter, Two step up conversion Transmitter**.**

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

Impedance Matching and Amplifiers

S-parameters with Smith chart, Passive IC components, Impedance matching networks, Common Gate, Common Source Amplifiers, OC Time constants in bandwidth estimation and enhancement, High frequency amplifier design, Power match and Noise match, Single ended and Differential LNAs, Terminated with Resistors and Source Degeneration LNAs.

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

Feedback Systems and Power Amplifiers

Stability of feedback systems: Gain and phase margin, Root-locus techniques, Time and Frequency domain considerations, Compensation, General model — Class A, AB, B, C, D, E and F amplifiers, Power amplifier Linearization Techniques, Efficiency boosting techniques, ACPR metric, Design considerations

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

Mixers and Oscillators

Mixer characteristics, Non-linear based mixers, Quadratic mixers, Multiplier based mixers, Single balanced and double balanced mixers, subsampling mixers, Oscillators describing Functions, Colpitts oscillators Resonators, Tuned Oscillators, Negative resistance oscillators, Phase noise.

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

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

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

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

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

References

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

	CO description	PO Mapping	PSO1	PSO2
CO1	understand user specifications for RF systems	-	-	-
CO2	design RF low noise amplifiers,power amplifiers,RF mixers and oscillators	PO3(3)	3	3
CO3	Analyze PLL for RF applications	PO1(3)	3	2

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

Course Objective:

- To understand MEMS fundamentals and fabrication processes.
- To impart knowledge of the photolithographic process, photo resist and pattern transfer.
- To provide a fundamental of NEMS and its fabrication methods.
- To explore carbon-based NEMS materials and fabrication challenges.
- To learn about the diverse applications of MEMS and NEMS.

Fundamentals of MEMS

MEMS Introduction - Low Cost - Redundancy and Disposability – Scaling – Made – Substrates –Processing – Mask – Developing – Etching - Road Map and Perspective Silicon Substrate – Silicon Growth – Crystal - Miller Indices – Semiconductor – Doping - Additive Techniques.

Activity:

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

Pattern Transformation of Mems

Photolithographic Process - Clean room - Photo Resist - Positive Resist - Negative Resist –Working with Resist – Applying Photo Resist - Exposure and Pattern Transfer - Printing Methods – Contact Proximity – Projection Printing - Development and Post Treatment -Masks – Resolution –Sensitivity and Resist Profiles – Mask Alignment - Permanent Resists

Activity:

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

Introduction of NEMS

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

Activity:

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

Feedback Amplifiers and Waveform Generators

Materials – Carbon Allotropes - Carbon Based Materials - Metallic Carbon Nanotubes – Difficulties – Simulations - Current Challenges and future of NEMS – Deposition processes – Lithography – Etching processes.

Activity:

- Group Project: Design and simulate a carbon nanotube-based NEMS device
- Quiz: On lithography types and carbon-based nanomaterials

Power Amplifiers Pressure sensor - Piezoresistive sensor - Capacitive sensor – RF applications – Gyroscope – Optical MEMS - Optical Data - Switching - RF MEMS - MEMS switches - MEMS Resonators. Case study: Cantilever piezoelectric actuator, Capacitive accelerometer, Piezoresistive pressure sensor **Activity:** • Case Study Presentation: Comparison of MEMS gyroscope and accelerometer • Assignment: Technical report on emerging RF MEMS switches.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (5%), Assignments (10%), Review of Question Papers (IES, GATE, SSC Questions) (20%), Projects (20%), Flipped Class (5%), Internal Examinations (40%).

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