CURRICULUM AND SYLLABI

for

B.Tech Programme in ECE

(Applicable to 2023 admission onwards)

Department of Electronics and Communication Engineering

Sarabhai Complex

National Institute of Technology Goa

Kottamoll Plateau, Cuncolim,

South Goa, Goa – 403 703

Table of Contents

Department Vision and Mission

Vision

To emerge as one of the nation's unrivalled academic center of excellence in the area of Electronics and Communication and its allied fields of Engineering.

Mission

- To impart a quality teaching and learning process
- Inculcate and ignite the research culture through innovation ideas.
- Implementation of Ideas into practical outcome based solutions.
- To interact and tie-up with R&D industry to bridge the academia industry gap.
- To have strong and continued interaction with alumni, top ranked universities and similar set ups to have sustained global growth.
- To serve and support the Goan/National society in enhancing the quality and standard through make in India and other social development schemes.

Curriculum

The total credits for completing B.Tech. in ***Electronics and Communication Engineering*** is ***168***. The structure of B.Tech. programmes shall have the following course classifications as listed in Table 1.

Table 1: Course classifications of the B.Tech. programmes

Sl. No.	Classifications	Course Type	Credits For CGPA	Courses
1	Basic Sciences	**BS**	21	MA→11, PH→5, CY→5
2	Basic Engineering Sciences and Technical Arts	**ES**	21	EM→3, BMC→3, BES→6, CPPS→4, ED→3, WP→2
3	Humanities and Social Sciences	**HU & HS**	7	PC →4, ECO→ 3
4	Indian Knowledge Systems	**IKS**	5	HH→2 and an Open Elective Course →3
5	Others: Liberal Arts, Innovation & Entrepreneurship	**OT**	2	LA→1, IE→1
6	Mandatory Learning Courses	**MLC**	2	PE→0, ES→ 1, PEHV→ 1
7	Department Core	**DC**	83 - 86	Core Theory and Lab courses, Comprehensive Examination →1, Seminar→1, Summer Internship→1, Project Work→5
8	Department Elective (including MOOCs or any other as approved by the Institute)	**DE**	21-27	7-9 Electives
9	Open Elective (including MOOCs or any other as approved by the Institute)	**OE**	0-6	Upto 2 Open Electives
Total Credits			**168**	
10	Minor Program	**MR**	**18**	

Course abbreviations used in Table 1 are as below:

MA	:	Mathematics	CPPS	:	Computer Programming and Problem Solving	LA	:	Liberal Arts
PH	:	Physics	ED	:	Engineering Drawing	IE	:	Innovation & Entrepreneurship
CY	:	Chemistry	WP	:	Workshop Practices	PE	:	Physical Education
EM	:	Engineering Mechanics	PC	:	Professional Communication	ES	:	Environmental Studies
BMC	:	Basics of Mechanical and Civil Engineering	ECO	:	Economics	PEHV	:	Professional Ethics and Human Values
BES	:	Basic Electrical Engg. / Basic Electronics Engg.	HH	:	Health and Happiness	MOOCs	:	Massive Open Online Courses

Programme Outcomes (POs)

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Semester-wise courses from III Semester Onwards

III Semester

Sl. No.	Course Code	Name of the Course	Type	L-T-P	Credits
1	MA202	Mathematical Methods for Communication Engineering	BS	2-1-0	3
2	EC200	Electromagnetic Theory	DC	3-1-0	4
3	EC201	Network Theory and Synthesis	DC	3-1-0	4
4	EC202	Digital System Design	DC	3-0-0	3
5	EC203	Signals & Systems	DC	3-0-0	3
6	EC204	Digital System Design Laboratory	DC	0-0-3	2
7	EC205	Signals & Systems Laboratory	DC	0-0-3	2
Total Credits					21

IV Semester

Sl. No.	Course Code	Name of the Course	Type	L-T-P	Credits
1	IE250	Innovation & Entrepreneurship	OT	1-0-0	1
2	EC250	Numerical Methods for ECE	DC	3-0-2	4
3	EC251	Analog Electronics	DC	3-0-0	3
4	EC252	Principle of Communication Systems	DC	3-1-0	4
5	EC253	Sensor Technologies	DC	3-0-0	3
6	EC254	Semiconductor Devices	DC	3-1-0	4
7	EC255	Analog Electronics Laboratory	DC	0-0-3	2
8	EC256	Communication Systems Laboratory	DC	0-0-3	2
Total Credits					23

V Semester

Sl. No.	Course Code	Name of the Course	Type	L-T-P	Credits
1	IE250	Professional Ethics and Human Values	MLC	1-0-0	1
2	EC300	Control System	DC	3-1-0	4
3	EC301	Digital Signal Processing	DC	3-0-0	3
4	EC302	Microprocessor and Microcontroller	DC	3-0-0	3
5	EC303	Linear Integrated Circuits	DC	3-0-0	3
6	ECXXX	Elective – I	DE/OE$	3-0-0	3
7	EC304	Digital Signal Processing Laboratory	DC	0-0-3	2
8	EC305	Microprocessor and Microcontroller Laboratory	DC	0-0-3	2
9	EC306	Linear Integrated Circuits Laboratory	DC	0-0-3	2
Total Credits					23

VI Semester

Sl. No.	Course Code	Name of the Course	Type	L-T-P	Credits
1	ES300	Environmental Studies	MLC	1-0-0	1
2	HS353	Industrial Economics	HU&HS	3-0-0	3
3	EC350	Digital Communication	DC	3-0-0	3
4	EC351	Principles of Antenna and Measurements	DC	3-1-0	4
5	EC352	VLSI Circuit Design	DC	3-0-0	3
6	ECXXX	Elective – II	DE/OE$	3-0-0	3
7	EC353	Digital Communication Laboratory	DC	0-0-3	2
8	EC354	High Frequency Laboratory	DC	0-0-3	2
9	EC355	VLSI Circuit Design Laboratory	DC	0-0-3	2
10	EC356	Seminar	DC	0-0-2	1
Total Credits					24

VII Semester

Sl. No.	Course Code	Name of the Course	Type	L-T-P	Credits
1	ECXXX	Elective (IKS)	IKS	3-0-0	3
2	ECXXX	Elective – III	DE/OE$	3-0-0	3
3	ECXXX	Elective – IV	DE/OE$	3-0-0	3
4	ECXXX	Elective – V	DE/OE$	3-0-0	3
5	ECXXX	Elective – VI	DE/OE$	3-0-0	3
6	EC400	Major Project – I	DC	0-0-3	2
7	EC401	Summer Project/Industrial Training	DC	0-0-2	1
8	EC402	Comprehensive Examination	DC	0-0-0	1
Total Credits					19

VIII Semester

Sl. No.	Course Code	Name of the Course	Type	L-T-P	Credits
1	ECXXX	Elective – VII	DE/OE$	3-0-0	3
2	ECXXX	Elective – VIII	DE/OE$	3-0-0	3
3	ECXXX	Elective – IX	DE/OE$	3-0-0	3
4	EC450	Major Project – II	DC	0-0-6	3
Total Credits					12

$ A student can register only one open elective (OE) per semester and a maximum of two OE in the B.Tech tenure. This is excluding the Indian Knowledge System (IKS) course offered in 7th Semester. Since IKS is a mandatory OE, students are not allowed to register for an OE in that semester.

Detailed Syllabi of Core Courses

Course Code	Course Name	L	T	P	Credits
MA202	Mathematical Methods for Communication Engineering	2	1	0	3

Course Objective

This course is crafted to provide engineers and scientists with a comprehensive grasp of probability, random variables, statistics and complex analysis. Further, with a focus on key principles such as probability, complex variables and their practical applications, students will develop a deep understanding of applied mathematics and its real-world implications.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability

CO1. Acquire a solid comprehension of probability distributions and apply them to address challenging engineering problems.

CO2. Comprehend the significance and analytical solving methods for statistical and their applications in communication engineering problems.

CO3. Grasp the fundamentals of complex variables, complex functions, and the processes of complex differentiation and integration.

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	M	M			L	L	M		H
CO2	H	H	H	H	H			L	L	M		H
CO3	H	H	H	H	H			L	L	M		H

Syllabus

Module 1: Elements of Probability

Introduction to Probability; Sample Space and Events; Probabilities Defined on Events; Conditional Probabilities; Independent Events; Total Probability; Bayes' Formula.

Module 2: Random Variables and Distribution

Random Variables: Concept of Random Variables; Distribution and Density Function; Jointly Distributed Random of Variables; Conditional and Joint Density Distribution function; Function of Random Variables; Expected Value: Mean, Variance and moments of random variable; Joint moments, conditional expectation; covariance and correlation; Some special distributions: Uniform and Gaussian distributions; Bernoulli, Binomial, and Poisson distributions**.**

Module 3: Statistics

The Sample Mean; The Central Limit Theorem; The Sample Variance; Sampling Distributions from a Normal Population; Sampling from a Finite Population; Parameter Estimation; Maximum Likelihood Estimators; Interval Estimates; Significance Levels; Tests Concerning the Mean of a Normal Population; Testing the Equality of Means of Two Normal Populations; Hypothesis Tests Concerning the Variance of a Normal Population.

Module 4: Complex Analysis

Complex Numbers, geometric representation, powers and roots of complex numbers, Functions of a complex variable, Analytic functions, Cauchy-Riemann equations; elementary functions, Conformal mapping (for linear transformation); Contours and contour integration, Cauchy's theorem, Cauchy integral formula; Power Series and properties, Taylor series, Laurent series, Zeros, singularities, poles, essential singularities, Residue theorem, Evaluation of real integrals and improper integrals.

Text/Reference Books:

1. E. Kreyszig, "Advanced engineering mathematics", 8th Edition, John Wiley (1999).
2. Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", 5th Edition, Academic Press.
3. Sheldon M. Ross, "Introduction to Probability Models", 11th Edition, Academic Press.
4. Athanasios Papoulis, and S. Unnikrishna Pillai, "Probability, Random Variables, and Stochastic Processes", McGraw-Hill, 2002.

Course Code	Course Name	L	T	P	Credits
EC200	**Electromagnetic Theory**	**3**	**1**	**0**	**4**

Course Objectives

1. Understand electromagnetic fields and wave propagation.
2. Explore vector calculus, electrostatic and magneto static fields.
3. Analyze electromagnetic systems.
4. Learn about transmission lines and wave propagation in different media.
5. Apply Maxwell's Equations and use boundary conditions to solve problems in electromagnetics.

Course Outcomes

CO1. Grasp fundamental electromagnetic principles, including vector calculus, electrostatic and magnetostatic fields.

CO2. Apply Maxwell's Equations effectively to analyze and solve practical problems in electromagnetic fields and wave propagation.

CO3. Develop adept problem-solving skills for diverse electromagnetism scenarios.

CO4. Gain practical insight into transmission lines, including parameters, equations, and design considerations.

CO5. Cultivate critical thinking for evaluating and applying electromagnetic principles to various real-world scenarios.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	L	M	H	L	M	L	M	L	L	H
CO2	M	H	L	M	H	L	M	L	M	L	L	M
CO3	M	H	H	L	M	L	M	L	M	L	M	L
CO4	L	M	L	H	M	L	M	L	M	L	L	M
CO5	M	H	H	L	M	L	M	L	M	L	M	L

Syllabus

Module 1: Vector Calculus (10 hours)

Coordinate Systems and Transformation, Vector Calculus: Line, Surface, and Volume Integrals, Gradient of a Scalar, Divergence of a Vector and Divergence Theorem, Curl of a Vector and Stokes's Theorem, Laplacian of a Scalar.

Module 2: Electrostatic Fields (16 hours)

Electrostatic Fields: Coulomb's Law and Field Intensity, Electric Fields due to Continuous Charge Distributions, Electric Flux Density, Gauss's Law, An Electric Dipole, Flux Lines.

Electric Fields in Material Space: Convection and Conduction Currents, Dielectric Constant and Strength, Continuity Equation and Relaxation Time, Boundary Conditions, Electrostatic Boundary- Value Problems: Poisson's and Laplace's Equations, Uniqueness Theorem.

Module 3: Magnetostatic Fields (12 hours)

Biot-Savart's Law, Ampere's Circuit Law, Magnetic Flux Density, Maxwell's Equations for Static EM Fields, Magnetic Scalar and Vector Potentials, Magnetic Forces: Forces due to Magnetic Fields, Magnetic Torque and Moment, A Magnetic Dipole, Magnetic Boundary Conditions.

Module 4: Wave Propagation and Transmission Lines (18 hours)

Faraday's Law, Transformer and Motional EMFs, Displacement Current, Maxwell's Equations in Final Forms, Time-Varying Potentials, Time-Harmonic Fields, Wave Propagation in Lossy Dielectrics, Plane Waves in Lossless Dielectrics, Plane Waves in Free Space, Plane Waves in Good Conductors, Skin effect, Power and the Poynting Vector, Reflection of a Plane Wave at Normal Incidence, Reflection of a Plane Wave at Oblique Incidence.

Introduction, Transmission Line Parameters, Transmission Line Equations, Input Impedance, SWR, and Power.

Text/Reference Books:

1. Matthew N. O. Sadiku, "Principles of Electromagnetics", 4th Edition, oxford university press, 2010.
2. David k. Cheng, "Field and Wave Electromagnetics", 2nd Edition, Pearson Education India, 2014.
3. W. H. Hayt, J A Buck and M Jaleel Akthar, "Engineering Electromagnetics", 8th Edition, McGraw Hill Education, 2017.
4. David J. Griffith, "Introduction to Electrodynamics", 4th Edition, Pearson Education India Learning Private Limited, 2015.

Course Code	Course Name	L	T	P	Credits
EC201	**Network Theory and Synthesis**	**3**	**1**	**0**	**4**

Course Objectives

1. To expose the students to the basic concepts of electric circuits and its use
2. To understand the analysis of electrical circuits in time domain
3. Use of Laplace transform in network analysis for frequency domain analysis
4. To expose the students to the use of two-port networks and its applications
5. To introduce the techniques of network realizability and synthesis

Course Outcomes

CO1. Understanding the basic concepts of electrical circuits and their analysis in time domain

CO2. Analyze the circuit in frequency domain by using Laplace transform.

CO3. Understanding the network functions and their stability. Analyzing the concepts of resonance and impedance matching.

CO4. Understanding the elementary theory of realizability of a network function.

CO5. Understanding the concept of network synthesis with given network functions.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	H	M	M	H	M	M	M	L	L	M
CO2	M	H	H	M	H	M	M	M	M	L	L	M
CO3	H	M	H	L	M	M	M	L	M	L	L	M
CO4	M	H	H	M	H	M	M	L	M	L	L	M

CO5	H	H	M	M	H	H	H	M	H	L	L	L

Syllabus

Module 1: Network Theory (16 hours)

Conventions for describing the Networks: Network equations, Number of network Equations, Source transformations, Loop variable analysis and Node variable analysis, Duality. First-order differential equations: General and Particular solutions, Time Constants, Initial conditions in networks, Second- order Differential Equations.

Module 2: Frequency domain analysis and network functions (14 hours)

The Laplace Transformation: Basic Theorems for the Laplace Transformation, Examples of the Solutions of Problem with Laplace Transformations, Partial Fraction Expansion, transforms of other Signal Waveforms, Shifted Unit Step, Ramp, Impulse Functions, Waveform Synthesis, Impedance Functions; Network functions: Poles and Zeros, Restrictions on Pole and Zero Locations for driving point Impedance. Stability of Active networks.

Module 3: Two-port network (12 hours)

Two-Port Parameters: Short-Circuit Admittance and Open-Circuit Impedance Parameters, Transmission and Hybrid Parameters, Relationship between Parameter sets. Sinusoidal Steady State Analysis: The Sinusoidal Steady State, Phasor Diagrams.

Module 4: Network synthesis (12 hours)

Network Synthesis: Elements of Realizability theory, Causality and Stability, Hurwitz polynomial, Positive Real Functions. Synthesis of One-port Network with two kinds of Elements- Properties of L- C Immittance functions, Synthesis of L-C Driving point Immittance functions, Properties of R-C Driving point Impedance function, Synthesis of R-C Driving point Impedance function, Properties of R-L Impedance and R-C Admittance function, Synthesis of R-L Impedance and R-C Admittance function. Properties of RC network functions - Foster and Cauer forms of RC and RL networks.

Text/Reference Books:

1. Van Valkenberg, “Network Analysis”, Prentice Hall of India.
2. Franklin F. Kuo, “Network Analysis and Synthesis”, Wiley International Edition.
3. Roy Choudhary, “Network and Systems”, Wiley Eastern, 2nd Edition, 1988.
4. William H. Hayt Jr, Jack E Kemmerly and Steven M Durbin, “Engineering Circuit Analysis”, Mc Graw Hill, 8th Edition, 2012.

Course Code	Course Name	L	T	P	Credits
EC202	Digital System Design	3	0	0	3

Course Objectives

1. To understand and apply the principles of Boolean algebra for the simplification of logic functions.

2. To design and implement various combinational logic circuits.
3. To analyze and design sequential logic circuits including counters and registers.
4. To comprehend the basics of memory operations and different logic families.

Course Outcomes

CO1. Demonstrate the ability to minimize Boolean functions.

CO2. Design and implement combinational logic circuits such as adders, subtractors, multiplexers, and encoders.

CO3. Analyze and construct sequential circuits including latches, flip-flops, and different types of counters.

CO4. Develop state machines using state diagrams and tables, and implement state minimization techniques.

CO5. Explain the operation of various memory types and logic families.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	L	L	M	L	M	L	L	L	M
CO2	H	H	H	M	M	M	M	M	M	M	M	M
CO3	H	H	H	M	M	M	M	M	M	M	M	M
CO4	H	H	H	H	M	M	M	M	M	M	M	M
CO5	H	M	M	M	H	M	M	M	M	H	M	H

Syllabus

Module 1: Minimization of Boolean function (06 hours)

Number systems and binary codes, error detecting & correcting codes, Boolean algebra and Logic Gates, simplification of logic functions using Karnaugh map, Quine McCaskey method.

Module 2: Combinational Logic Design (08 hours)

Implementation of combinational logic functions, binary adder- subtractor, parallel adder, BCD adder, binary multiplier, magnitude comparator, decoders, BCD to 7-segment decoder driver, encoders, priority encoders, code converters, parity generator/checker, multiplexers & de-multiplexers, implementation of logical functions using multiplexers. Programmable.

Logic Devices: introduction to PLD’s, ROM, PAL, PLA, FPGA, Implementation of digital functions.

Module 3: Sequential Logic Design (12 hours)

Sequential circuits, latches and flip-flops: SR-latch, D-latch, D flip-flop, JK flip-flop, T flip-flop, timing hazards and races, edge-triggered flip-flops, register, shift register, universal shift register; application of shift register: ring counter, Johnson counter, sequence generator and detector, up- and down counter, asynchronous ripple counter, synchronous counters, counter design using flip flops, counter design with asynchronous reset or preset, applications of counters.

Module 4: State Machine (08 hours)
Canonical model of a state machine, types of state machines, state diagram, state table, state assignment, Moore and Mealy model, state minimization.
Hardware modeling using Verilog/VHDL; Laboratory exercises and assignments to supplement the course.

Module 5: Memory and Logic families (08 hours)
Read-only memory, read/write memory - SRAM and DRAM. TTL, ECL, MOS Inverters, CMOS, CMOS inverters.

Text/Reference Books:

1. M. Morris Mano, Michael D. Ciletti, "Digital Design: With an Introduction to Verilog HDL", 5th Edition, Pearson Education India, 2013.
2. Stephen Brown, Zvonko Vranesic, "Fundamentals of Digital Logic with VHDL Design", 3rd Edition, McGraw Hill Education, 2017.
3. Ronald J. Tocci, "Digital Systems", 10th Edition, Pearson, 2009.
4. Vahid, "Digital Design, with RTL Design, VHDL, and Verilog", 2nd Edition, John Wiley and Sons Publishers, 2010.
5. S. Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", 2nd Edition, Pearson Education, 2004.

Course Code	Course Name	L	T	P	Credits
EC203	Signals & Systems	3	0	0	3

Course Objectives

1. The main objective of studying this course is to know the basics and theoretical concepts of generation of signals and its characteristics.
2. To know the importance of signals and systems by analysing it by time domain.
3. To understand the behaviour of the signals and systems by converting from time domain to frequency domain.
4. To observe the impact of LTI system by convolving the signal with it and how it works as filtering.
5. To understand the use of Fourier series and Fourier transform for signals analysis.
6. To know the impact of Laplace and Z transform for the analysis of CT and DT signal respectively.

Course Outcomes

After completing this course, the student can able to

CO1. Know how to generate the signal and perform the mathematical operation on it.

CO2. Understand the characteristics of test signals like impulse, step, ramp, complex exponential and arbitrary.

CO3. Observe the effect of signal operations like shifting, folding, scaling etc.,

CO4. Get the significance of time domain and frequency domain analysis of signals and systems.

CO5. Know the importance of LTI system and its properties and how to use it for filtering operation in signal processing.

CO6. Understand the use of Laplace transform for continuous time signals and systems analysis.

CO7. Know the importance of Z transform the discrete time signals and systems analysis.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	M	H	L	L	L	L	M	L	L	M
CO2	H	M	M	H	L	L	L	L	M	L	L	M
CO3	H	M	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M
CO5	H	H	H	H	L	L	L	L	M	L	M	M
CO6	H	H	H	H	L	L	L	L	M	L	M	M
CO7	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Introduction to Signals and Systems (8 hours)

Definition of Signals and Systems, Classification of Signals, Operations on signals, Singularity functions and related functions. Analogy between vectors and signals - orthogonal signal space, complete set of orthogonal functions, Parseval's relations.

Module 2: Analysis of Signals (12 hours)

Fourier series representation of continuous time periodic signals -Trigonometric and Exponential Fourier series- Properties of Fourier series. Fourier transform of aperiodic signals, standard signals and periodic signals - Properties of Fourier transforms. Hilbert transform and its properties. Laplace transforms-RoC-properties. Inverse Laplace transform.

Module 3: Analysis of Systems (8 hours)

Continuous-time Systems and its properties. Linear time invariant (LTI) system-Impulse response. Convolution. Analysis of LTI System using Laplace and Fourier transforms.

Module 4: Sampling and Quantization (4 hours)
Sampling and reconstruction of band limited signals. Low pass and band pass sampling theorems. Aliasing. Anti-aliasing filter. Practical Sampling-aperture effect. Quantization.

Module 5: Analysis of DT Signals and Systems (10 hours)
Discrete-time signals and systems. Discrete Fourier series, DTFT, Z-transform and its properties. Analysis of LSI systems using Z – transform.

Text Books/Reference Books

1. Alan V. Oppenheim, Alan S. Willsky, and S. Hamid Nawab, “Signals and Systems”, 2nd Edition, PHI, 2003.
2. Simon Haykin, and Barry Van Veen, “Signals and Systems”, 2nd Edition, John Wiley, 2012.
3. Alan V. Oppenheim and Ronald W. Schafer, "Discrete-Time Signal Processing", 3rd Edition, Pearson, 2010.
4. Sanjit K Mitra, “Digital Signal Processing: A Computer based Approach”, 3rd Edition, Tata McGraw Hill, India, 2009.
5. S. Esakkirajan, T. Veerakumar, and B N Subudhi, “Digital Signal Processing”, Tata McGraw Hill, India, 2021.

Course Code	Course Name	L	T	P	Credits
EC204	Digital System Design Laboratory	0	0	3	2

Course Objectives

1. To teach the fundamentals of designing digital logic systems using Boolean algebra and logic gates.
2. To enable students to implement and verify various digital circuits such as adders, subtractors, and comparators.
3. To familiarize students with different coding schemes and their conversions in digital circuits.
4. To provide practical experience in designing and simulating digital systems, emphasizing societal, health, safety, and environmental considerations.

Course Outcomes

CO1. Simplify and realize Boolean expressions using logic gates and universal gates.

CO2. Design and implement arithmetic circuits such as adders and subtractors using discrete logic components and ICs.

CO3. Convert between different number systems including BCD, Excess-3, binary, and Gray codes.

CO4. Utilize multiplexers, demultiplexers, decoders, and encoders for various applications in digital circuits.

CO5. Implement and verify sequential circuits including flip-flops, counters, and sequence generators.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	L	L	L	L	L	L	L	L	L	M
CO2	H	H	H	M	M	L	L	L	M	M	M	M
CO3	H	H	H	M	M	L	L	L	M	M	M	M
CO4	H	H	M	M	M	M	M	M	M	M	M	M
CO5	H	M	M	M	H	L	L	L	M	M	M	M

List of Experiments

Experiment No. 1: Simplification, realization of Boolean expressions using logic gates/universal gates

Experiment No. 2: Realization of half/full adder & half/full subtractors using logic gates, Realization of parallel adder/subtractors using 7483 chip.

Experiment No. 3: BCD to Excess-3code conversion & vice versa, binary to gray code conversion & vice versa.

Experiment No. 4: MUX/DEMUX – use of 74153,74139 for arithmetic circuits & code converter.

Experiment No. 5: Realization of one/two bit comparator and study of 7485 magnitude comparator.

Experiment No. 6: Use of a) Decoder chip to drive LED display & b) Priority encoder.

Experiment No. 7: Truth table verification of flip-flops: i) JK Master Slave ii) T type iii) D type.

Experiment No. 8: Realization of 3 bit counters as a sequential circuit & MOD-N counter design (7476, 7490, 74192, 74193).

Experiment No. 9: Writing & testing of sequence generator.

Experiment No. 10: Hardware modeling using Verilog/VHDL; Laboratory exercises and assignments to supplement the lab.

Text Books/Reference Books

1. M. Morris Mano, Michael D. Ciletti, "Digital Design: With an Introduction to Verilog HDL", 5th E dition, Pearson Education India, 2013.
2. Stephen Brown, Zvonko Vranesic, "Fundamentals of Digital Logic with VHDL Design", 3rd Edition, McGraw Hill Education, 2017.
3. Ronald J. Tocci, "Digital Systems", 10th Edition, Pearson, 2009.

Course Code	Course Name	L	T	P	Credits
EC205	Signals & Systems Laboratory	0	0	3	2

Course Objective

1. To generate the signals and process the signals using simulation tool like MATLAB/Python.
2. To verify the system operations on signal.
3. To visualize characteristics of signals and systems and understand the concepts of signals and systems in time domain and frequency domain.
4. To analyse the effect of reconstructions from sampled signal.

Course Outcomes

CO1. Use simulation software like MATLAB/Python to study the behavior of signals and systems as they arise in a variety of contexts.

CO2. Use the simulation tool to visualize the effect of convolution in signals and systems

CO3. Use the simulation tool to understand the effect of sampling process on continuous time signal while converting it into discrete time signal.

CO4. Analyze the discrete time signals and systems in both time and frequency domains

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	L	M	H	L	L	L	M	L	L	M
CO2	H	H	L	M	H	L	L	L	M	L	L	M
CO3	H	H	L	M	H	L	L	L	M	L	L	M
CO4	H	H	H	M	M	M	L	L	M	M	L	M

List of Experiments

Experiment No. 1: Generation of signals and systems

Experiment No. 2: Operations on signal and system

Experiment No. 3: Analysis of signals and systems in time domain

Experiment No. 4: LTI systems analysis

Experiment No. 5: Perform the Convolution operation between signals and systems

Experiment No. 6: Fourier series or transform representation of signals and systems

Experiment No. 7: Sampling and Quantization

Experiment No. 8: Reconstruction of analog signal from discrete time signal

Experiment No. 9: Effects of sampling and quantization

Experiment No. 10: Analysis of DT signal and system using Z-Transform

Text Books/Reference Books

1. A.V. Oppenheim, A. Willsky, S. Hamid Nawab, “Signals and Systems”, Pearson 2018.
2. S. Haykin and B.Van Veen “Signals and Systems, Wiley, 1998.
3. S. Esakkirajan, T. Veerakumar and B. N. Subudhi, “Digital Signal Processing”, Tata McGraw Hill, 2021.
4. S. Esakkirajan, T. Veerakumar and B. N. Subudhi, “Digital Signal Processing Illustration Using Python”, Springer, 2024.

Course Code	Course Name	L	T	P	Credits
IE250	**Innovation & Entrepreneurship**	**1**	**0**	**0**	**1**

Course Objectives

1. To introduce to a project-based learning approach from Ideation to Innovation and Entrepreneurship will be the key process considered here.
2. To learn the essential concepts of innovation and entrepreneurship through hands-on activities and the best and most relevant practical examples.
3. The course is designed to provide the tools necessary for starting independent innovation and businesses.
4. To give students practical experience in market survey, commercialization, IPR and proactively work in projects in risky market environments.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability

CO1. To comprehend the basic theories and concepts that underlie a survey study of Innovation, Entrepreneurship and Social Business/ Entrepreneurship

CO2. To understand how to generate good large company or startup business ideas / societal ideas, and refine these ideas, to substantially increase chances for success in the marketplace

CO3. The students will be exposed to the thoughts and strategies of some very effective real-life innovators and entrepreneurs through videos and small cases.

CO4. To understand about IPR, prototyping and financial management.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	L	H	L	H	M	H	H	L	H	H	H	H
CO2	L	H	L	H	H	H	H	L	H	H	H	H
CO3	L	H	L	H	H	H	H	L	M	H	H	H
CO4	L	H	L	H	H	H	H	H	L	L	H	H

Syllabus

Module 1: Introduction

Creative thinking, blocks to creativity, factors that influence creative design, engineering design and creative design, influence of society, market pull & technology push, attribute of a creative person Three levels of Design – Viceral, Behavioral and Reflective design.

Qualities and skills required for entrepreneurship, Functions of an entrepreneur, Importance of entrepreneur in economic development.

Module 2: Ideas for Entrepreneurship

Need or identification of a problem, market survey, data collection, review & analysis, problem definition, challenge statement, problem statement initial specifications, Brain storming, analogy technique or Synectic, check list, trigger words, morphological method, interaction matrix method, analysis of interconnected decision making.

Module 3: Theory of Inventive Problem Solving (TRIZ)

20 key TRIZ principles – multifunction, compensation, nested doll, blessing in disguise, segmentation, separation, symmetry change, opaque & porous, inflate and deflate, recycle & recover, phase transformation, energy, imaging, environment, composition, economical, surface response, static & dynamic, continuous & intermittent, dimensions.

Module 4: Product Design, IPR & Finance

Detail design, prototyping, product deployment, useful life assessment and recycling and sustainability; patent act, patent laws, Types of entrepreneurs- Based on type of business, based on use of technology, based on motivation, based on stages of development, based on motive, Based on capital ownership, Business Plan, Finance and Funding.

Text/Reference Books:

1. C. B. Gupta and N. P. Srinivasan, "Entrepreneurial Development", Sultan Chand & Sons, 2020, ISBN: 978-93-5161-132-5
2. Floyd Hurt, and Rousing, "Creativity: Think New Now", Crisp Publ Inc. 1999, ISBN 1560525479,
3. Kalevi Rantanen & Ellen Domb, "Simplified TRIZ", 2nd Edition, Auerbach Publications, Taylor & Francis Group, 2010, ISBN: 978-142-0062-748.

Course Code	Course Name	L	T	P	Credits
EC250	**Numerical Methods for ECE**	**3**	**0**	**2**	**4**

Course Objectives

This course is designed to offer engineers and scientists a thorough understanding of numerical methods. It emphasizes essential concepts, including numerical solutions for algebraic, transcendental, and differential equations, and explores their practical applications.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability

CO1. Gain expertise in numerical solving techniques for single-variable equations and systems of equations, and then apply these principles to address intricate engineering challenges.

CO2. Understanding of the significance of curve fitting, interpolation, numerical differentiation and integration.

CO3. Foster a deep comprehension of the importance of numerically solving ordinary and partial differential equations (ODEs) and explore their wide-ranging applications across diverse fields.

CO4. Develop a profound understanding of the significance of employing numerical methods through the utilization of diverse programming languages.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	M	M			L	L	M		H
CO2	H	H	H	H	H			L	L	M		H
CO3	H	H	H	H	H			L	L	M		H
CO4	H	H	H	H	H			L	L	M		H

Syllabus

Module 1: Numerical solution of equations and systems

Equations in one variable: The Bisection method, fixed point iteration method, Secant method, Regular-Falsi method, Newton's method and its extensions, Convergence of Newtons's method. System of equations: Jacobi and Gauss-Seidel iterative methods, sufficient conditions for convergence, Power method to find the dominant Eigen value and eigenvector.

Module 2: Interpolation, Numerical Differentiation and Integration

Interpolation and Curve fitting: The Lagrange polynomial, divided differences, Method of least square approximations. Numerical differentiation: Difference formula, three and five point formula. Numerical integration: Open and closed Newton-Cotes formulae, Gaussian quadrature formula.

Module 3: Numerical solutions of ordinary differential equations

Euler's method, Euler's modified method, Taylor's method and Runge-Kutta method, Multi-step methods, Variables step-size multi step methods, Numerical methods for higher order and system of equations, Error analysis of all the methods, Stability.

Module 4: Numerical solutions of partial differential equations

Elliptic partial differential equations: Fine difference method for two dimensional equations. Parabolic partial differential equations: Forward difference method, backward difference method and the Crank-Nicolson method for one dimensional equations.

Hyperbolic partial differential equations: Central difference method for one dimensional equations.

Lab Experiments

Experiment No. 1: Basic operations on MATLAB/Python.

Experiment No. 2: Program to solve one variable equation using Bisection and Fixed point method.

Experiment No. 3: Program to solve one variable equation using Newton Raphson, Regula-Falsi and Secant method.

Experiment No. 4: Program to solve system of equations using Gauss-Jacobi Method.

Experiment No. 5: Program to solve system of equations using Gauss-Seidal Method.

Experiment No. 6: Program to find dominant eigenvalue using the Power Method.

Experiment No. 7: Program to fit a curve using method of least square.

Experiment No. 8: Program to interpolate using the Lagrange polynomial method.

Experiment No. 9: Program to evaluate differentiation and integration.

Experiment No. 10: Programs to solve ordinary differential equations using Euler's and Taylor's method.

Experiment No. 11: Programs to solve ordinary differential equations using R-K method of order four.

Experiment No. 12: Programs to solve ordinary differential equations using multistep methods.

Experiment No. 13: Programs to solve elliptic equations using the finite difference method.

Experiment No. 14: Programs to solve parabolic equations using the finite difference method.

Experiment No. 15: Programs to solve hyperbolic equations using the finite difference method.

Text/References Books

1. M. K. Jain, S. R. K Iyengar and R.K. Jain, "Numerical Methods for Scientific and Engineering Computation," New Age Publishers, 6 th Edition, 2012.
2. E. Kreyszig, "Advanced Engineering Mathematics", 8th Edition, Wiley India Pvt. Ltd., 2010.
3. R. L. Burden and J. D. Faires, "Numerical Analysis", 9th Edition, Brooks/Cole, 2012.
4. G.D Smith, "Numerical solution of Partial Differential Equations," Oxford University Press.

Course Code	Course Name	L	T	P	Credits
EC251	Analog Electronics	3	0	0	3

Course Objectives

1. To develop the concepts for different transistors-analog and digital.
2. Importance of different amplifiers.
3. Exploration of the advanced transistors

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability

CO 1: Understand BJTs, their behaviour, and analyze basic amplifier circuits.

CO 2: Analyze MOSFETs, their behaviour, and design differential amplifiers.

CO 3: Analyze high-frequency response of amplifiers using advanced techniques and design feedback amplifiers.

CO 4: Compare advanced transistor types for specific applications.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	M	-	L	-	-	-	M	L	-	-
CO2	H	M	H	-	L	-	-	-	M	L	-	-
CO3	H	H	H	L	M	-	-	-	M	L	-	-
CO4	M	M	L	L	L	-	-	-	M	L	-	-

Syllabus

Module 1: Diode circuits, Bipolar Transistors & Amplifiers (12 hours)

Series diode configurations with DC inputs, parallel and series-Parallel configuration, AND/OR gates using diodes, half wave rectification, full wave rectification, series and parallel clippers, clampers, Small and Large Signal Model, DC & Small Signal Analysis, Operating Point Analysis and Design: Simple Biasing and Resistive Divider Biasing, Ebers-Moll and Gummel-Poon Model, Common Emitter and Common Base Bipolar Amplifiers with Active Load, BJT Differential Pair, Heterojunction and Schottky Bipolar Transistor.

Module 2: MOSFETs & Differential Amplifiers (10 hours)

MOSFET Structure, I-V Characteristics, Channel Length Modulation, Velocity Saturation, Small & Large Signal Model, Current Source, Current Mirror Circuits, MOS Differential Amplifiers, Differential and Common Mode Gain, CMRR, MOS Differential Amplifiers with Active Load-Qualitative & Quantitative Analysis.

Module 3: Frequency Response & Feedback Amplifiers (12 hours)

Miller's Theorem, High Frequency Models of Transistors, Use of Miller's Theorem, Frequency Response of Followers, Cascode Stage and Differential Pairs. Voltage Amplifiers, Current Amplifiers, Series-Shunt Feedback Amplifiers, Series-Series Feedback Amplifiers, Shunt- Shunt Feedback Amplifiers, Shunt Series Feedback Amplifiers, Loop Gain Stability.

Module 4: Advanced Transistors (10 hours)

Polysilicon Emitter Bipolar Transistor, Schottky Collector Bipolar Transistor, Heterojunction Bipolar Transistor, PN Junction FET, Metal-Semiconductor FET, Tunnel FET.

Text & References Books

1. Behzad Razavi, "Fundamentals of Microelectronics", John Wiley & Sons, 2008.
2. A.S. Sedra and K.C. Smith, "Microelectronic Circuits", Saunder's College Publishing, 1991.
3. B.G. Streetman and S. K. Banerjee, "Solid State Electronic Devices", Prentice Hall of India, New Delhi, 1995.
4. Donald Neamen, "Semiconductor Physics and Devices", 3rd Edition, McGraw-Hill, Inc., USA, 2002.

Course Code	Course Name	L	T	P	Credits
EC252	Principles of Communication Systems	3	1	0	4

Course Objectives

1. Realizing the time and frequency domain nature of all linear modulation schemes, their corresponding circuits, signals, and spectra.
2. Analysis of time and frequency domain description of angle modulation systems and their corresponding circuits, signals, and spectra.
3. Detail analysis, working, and comparative performance of AM/FM transmitters and receivers' circuits.
4. Understanding noise in communication systems and various types of noise. Noise performance in AM and FM systems, Figure of Merit calculation.

Course Outcomes

CO1. Understand and apply various analog modulation techniques like AM, FM, and PM, with the ability to analyze their time and frequency characteristics.

CO2. Analyze, design, and optimize transmitter and receiver circuits, including Superheterodyne Receivers, evaluating sensitivity, selectivity, and designing components like mixers and AGC circuits.

CO3. Analyze noise in communication systems, classify types, calculate SNR and Noise Figure, and assess noise performance in both AM and FM systems.

CO4. Demonstrate proficiency in pulse modulation techniques (PAM, PWM, PPM, PCM), applying them in communication systems, and understanding principles like line coding and delta modulation.

CO5. Apply learned principles to solve practical communication problems, including system design, analysis, troubleshooting, and informed decision-making.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	H	M	M	L	M	H	M	H	M	M
CO2	M	H	H	M	H	L	M	M	M	H	M	M
CO3	H	L	H	L	M	M	H	H	L	M	M	H
CO4	M	H	H	M	M	M	L	L	M	H	M	M
CO5	L	M	M	M	H	H	M	M	H	L	M	H

Syllabus

Module 1: Analog Modulations (18 hours)

Amplitude Modulation (AM), Envelope Detection, Double Sideband Suppressed Carrier (DSB-SC) Modulation, Demodulation, Single Sideband Modulation (SSB), Demodulation of SSB.

Angle modulation: Frequency Modulation (FM), Phase Modulation (PM), Modulation Index, Spectrum of FM Signals, Carson's Rule for FM Bandwidth, Narrowband FM Generation, Wideband FM Generation via Indirect Method, FM Demodulation, PLL.

Module 2: Transmitters and Receivers in Analog Modulations (12 hours)

Sensitivity and Selectivity of a receiver, Superheterodyne Receiver, Image Frequency and its Rejection, Mixer, Automatic Gain Control (AGC), FM Receivers: FM Discriminator, Stereo FM Receiver.

Module 3: Noise Performance in Continuous-wave Modulation (12 hours)

Noise Sources and Classification, Thermal Noise, Power Spectral Density (PSD) of Thermal Noise, White Noise, Signal-to-Noise Ratio (SNR), Noise Figure, Figure of Merit, Figure of Merit for different AM systems, Noise performance FM systems, Figure of Merit of FM, Pre-Emphasis and De-Emphasis.

Module 4: Pulse modulation Techniques (14 hours)

Pulse Modulation: sampling process; pulse amplitude modulation (PAM); pulse width modulation (PWM); pulse position modulation (PPM); pulse code modulation (PCM); line coding; differential pulse code modulation; delta modulation; adaptive delta modulation.

Text/Reference Books:

1. Herbut Taub, Donald L. Schilling, and Goutam Saha, "Principles of Communication Systems", 4th Edition, McGraw Hill Education, 2017.
2. B. P. Lathi, Z. Ding Modern, "Digital and Analog Communication Systems", Oxford University Press, 2010.
3. S. Haykin, "Communication Systems", Wiley India Edition, 2009.
4. Wayne Tomasi, "Electronic Communications System: Fundamentals Through Advanced", Pearson Education, 5th Edition, 2008.

Course Code	Course Name	L	T	P	Credits
EC253	**Sensor Technologies**	**3**	**0**	**0**	**3**

Course Objectives

This is a basic introductory course on Sensor Technology with an objective to understand and assimilate the importance of sensors, their properties, characteristics and applications from traditional sensors to Micro sensor Technologies and their applications.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability

CO1. To obtain a basic understanding of the Sensor fundamentals and their importance, classification and characteristics and a overview of a spectrum of sensor types.

CO2. To gain insights into MEMS technology, its applications and micro fabrication principles and technologies involved in fabrication of sensors at miocroscale.

CO3. To analyze and understand future trends in Sensor Technologies namely Wearable Sensing to IoT and Sensors at Nano Scale.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	M	M			L	L	M		H
CO2	H	H	H	H	H			L	L	M		H
CO3	H	H	H	H	H			L	L	M		H

Syllabus

Module 1: Introduction to Sensors (8 hours)

Definition of sensors, Importance and role of sensors in technology, Types and Classification of sensors based on resistive, capacitive, inductive, optical, sensing principles. Introduction to basic Transduction mechanisms, Sensor characteristics and performance parameters, accuracy, precision, resolution, sensitivity, linearity, and hysteresis. Principles of Calibration and compensation techniques.

Module 2: Physical Sensors and Transducers (12 hours)

Types of sensors: active and passive sensors, Thermal sensors, Microwaves sensors, Atmospheric sensors, Sonar sensors, Cameras for remote sensing. Optical Sensors: Photodiodes, phototransistors, Fiber optic sensors and FBG sensors. Imaging sensors -CCD and CMOS. Transducer and classification: Primary & Secondary, active & passive transducers; analog & digital modes of operation; null & deflection methods. Capacitive transducer- various arrangements, Inductive transducer, LVDT, RTD temperature characteristics, thermistor characteristics, Thermocouple characteristics.

Module 3: Microsensors (12 hours)

MEMS- Introduction to MEMS, Definitions and classifications, history, applications, Miniaturization issues, Microsystems versus MEMS, Microfabrication and Integrated Microsystems (micromechanical structures, microsensors and micro actuators). Micromachining Technologies–Photolithography, Etching, Thin-film deposition (evaporation, sputtering and chemical vapor deposition), Classification of micro sensors and micro actuators, An overview of Silicon capacitive accelerometer, Piezoresistive pressure sensor, Electrostatic comb-drive.

Module 4: Emerging trends in Sensor Technology (10 hours)

Wearable Sensor Technology: Introduction to world of wearable, Textiles and Clothing Wearable applications Personal Health, and Sports. Wearable Bio and Chemical Sensors and Challenges in Chemical Biochemical Sensing.

Sensors at Nano Scale: Properties and applications of Carbon Nano tube (CNT), Graphene, Quantum dots in sensing applications. Soft-lithography based sensors and applications.

Internet of Things (IoT): Definition, vision, conceptual framework, Major components of IoT system, IoT Sensing and Actuation, IoT Case Studies and Introduction to future trends: Vehicular IoT, Healthcare IoT, IoT Analytics.

Texts/References Books:

1. A.K. Sawhney, 'Electrical and Electronic Measurements and Instrumentation., Dhanpat Rai, 2015.
2. Alan S Morris Measurement and Instrumentation Principles, 3rd/e, Butterworth Hienemann, 2001.
3. David A. Bell Electronic Instrumentation and Measurements 2nd/e, Oxford Press, 2007.
4. Chang Liu, "Foundations of MEMS", Pearson Education Inc., 2012.
5. M.Madou, "Fundamental of Microfabrication", CRC Press, 2nd Edition.
6. Raj Kamal, "Internet of Things: Architecture and Design Principles", 1st Edition, Mc Graw Hill Education Pvt. Ltd., 2017.
7. Sudip Misra, Anandarup Mukherjee, Arijit Roy, "Introduction to IoT", Cambridge University Press, 2021.
8. T. Pradeep, "NANO: The Essentials: Understanding Nanoscience and Nanotechnology", 1st Edition,

Tata McGraw Hill, 2007.

9. Maity, Asit Baran, “Optoelectronics and Optical Fiber Sensors”, PHI Learning.

E-Resources:

1. https://nptel.ac.in/courses/108/108/108108147/
2. https://www.coursera.org/lecture/wearabletechnologies/introduction-to-wearable-technology- e0kP5
3. http://digimat.in/nptel/courses/video/108108147/L01.html

Course Code	Course Name	L	T	P	Credits
EC254	**Semiconductor Devices**	**3**	**1**	**0**	**4**

Course Objectives

1. To understand the fundamental principles of various modern semiconductor devices.
2. To understand and describe the impact of solid-state device capabilities and limitations on electronic circuit performance.

Course Outcomes

CO1: Grasp semiconductor basics & carrier movement.

CO2: Analyze p-n junctions & their applications.

CO3: Understand BJT operation & amplification. CO4: Explain MOSFETs & compare them to BJTs.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	-	M	-	-	-	-	M	-	M	H
CO2	M	H	M	M	-	-	-	-	M	-	M	H
CO3	H	H	M	M	-	-	-	-	M	-	M	H
CO4	H	H	M	M	-	-	-	-	M	-	M	H

Syllabus

Module 1: (10 hours)

Semiconductor materials, Crystalline and organic semiconductors, Crystal Lattices; Cubic Lattices - Planes and Directions, Energy Bands and Charge Carries in Semiconductors: Equilibrium Carrier concentration, intrinsic semiconductor - Bond and Band models; Extrinsic semiconductor -Bond and Band models; Carrier transport.

Excess Carriers in Semiconductors: Injection level, Lifetime, Direct and Indirect Semiconductors, Diffusion and Drift of Carrier; Built-in Fields - Diffusion and Recombination, The Continuity Equation, Steady State Carrier Injection.

Module 2: (10 hours)

P-N Junction: Device Structure, Equilibrium Picture, Band Diagram, DC Forward and Reverse Characteristics, Small-signal Equivalent Circuit, Switching Characteristics; Zener Breakdown; Graded Junctions, Metal-Semiconductor Junctions, Schottky Barriers, Other PN Junctions: Photodiodes, Solar cells, Light-Emitting Diode, Lasers, Semiconductor Lasers.

Module 3: (08 hours)

Bipolar Junction Transistor: Device Structures, Doping levels, Band Diagram, Understanding - Injection efficiency & Base transport factor, Operation of BJT. Transistor action and Amplification; Common Emitter DC characteristics, Small-signal Equivalent circuit; Ebers- Moll model, SPICE model.

Module 4: (14 hours)

MOS Junction: Band diagram, C-V characteristics, Threshold voltage, Body effect. Metal Oxide Field Effect Transistor: Device Structures, Band Diagram, Operation, Common Source DC Characteristics, Small-signal Equivalent of MOSFET, SPICE level-1 model. Secondary effects of MOSFET: Hot Electron Effects, Drain-Induced Barrier Lowering, Short Channel Effect and Narrow Width Effect, Gate Induced Drain Leakage; Differences between a MOSFET and a BJT. FET Biasing: Fixed-Bias Configuration, Self-Bias Configuration, Voltage-Divider Biasing, Depletion- Type MOSFETs, Enhancement-Type MOSFETs, p- Channel FETs. FinFET Technology, Large and small geometry FinFET Device Operation, Leakage Currents in FinFETs, Challenges to FinFET Process and Device Technology.

Text/Reference Books:

1. Ben. G. Streetman, and Sanjan Banerjee, “Solid State Electronic Devices”, 5th Edition, PHI Private Ltd, 2003
2. Nandita Das Gupta, and Aamitava Das Gupta, “Semiconductor Devices; Modeling and Technology”, PHI, 2004.
3. M. K. Achuthan, and K. N. Bhat, “Fundamentals of Semiconductor Devices”, Tata McGraw- Hill, New Delhi, First Print, 2007.
4. Neaman, Donald A. Semiconductor physics and devices. Irwin, 1992.

Course Code	Course Name	L	T	P	Credits
EC255	Analog Electronics Laboratory	0	0	3	2

Course Objective

1. To provide experience on design, testing, and analysis of basic.

Course Outcomes

CO1: Design and analyze basic digital logic circuits using p-n junction diodes.

CO2: Analyze the characteristics and biasing techniques of Bipolar Junction Transistors (BJTs) in common-emitter configuration.

CO3: Design and analyze basic circuits using operational amplifiers (op-amps) for signal processing functions.

CO4: Apply simulation tools to analyze the behaviour of electronic circuits.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	H	M	L	-	-	-	-	M	L	-	-
CO2	H	H	M	-	L	-	-	-	M	L	-	-
CO3	M	M	H	L	M	-	-	-	M	L	-	-
CO4	L	M	L	-	H	-	-	-	M	L	-	-

List of Experiments

Experiment No. 1: To realize positive AND & positive OR gate using p-n junction diode

Experiment No. 2: To realize different clipping and clamping circuits and observe the waveforms Experiment

Experiment No. 3: To study input and output characteristics of a NPN Bipolar Junction Transistor (BJT) in Common-emitter configuration.

Experiment No. 4: Measure the current gain of the common emitter BJT amplifier

Experiment No. 5: To study transfer and output characteristics of an n-channel MOSFET in common-source configuration.

Experiment No. 6: Find out the threshold voltage of the N-type MOSFET & cut-in voltage of the NPN BJT

Experiment No. 7: Determine the Q-point stability of base bias

Experiment No. 8: Construct the dc load line and plot the Q-point of voltage divider bias

Experiment No. 9: To design and set up an integrator circuit using op-amp

Experiment No. 10: To design and set up differentiator circuit using op-amp

Experiment No. 11: Simulating current mirror to extract DC response and plot of current mirror output Impedance.

Experiment No. 12: Study and simulate the frequency response of the common emitter amplifier.

Text/Reference Books:

1. Behzad Razavi, "Fundamentals of Microelectronics", John Wiley & Sons .2008.
2. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Saunder's College Publishing, 1991.
3. B.G. Streetman and S. K. Banerjee, Solid State Electronic Devices, Prentice Hall of India, New Delhi, 1995.

Course Code	Course Name	L	T	P	Credits
EC256	Communication Systems Laboratory	0	0	3	2

Course Objectives

1. Realization of AM transmitters and receivers using discrete components.
2. Realization of DSB-SC transmitters and receivers using discrete components.
3. Realization of FM transmitters and receivers using discrete components.
4. Detailed analysis of AM, FM, and PM signals through software modeling.

Course Outcomes

CO1. Develop proficiency in designing and implementing communication systems using discrete electronic components.

CO2. Design and generate signals by incorporating amplitude modulation (AM) through the use of discrete electronic elements.

CO3. Generate and analyze Double-Sideband Suppressed Carrier (DSB-SC) signals using discrete electronic components.

CO4. Design and evaluate Frequency Modulated (FM) transmitters and receivers employing discrete electronic components.

CO5. Utilize MATLAB software for the study and modeling of diverse signal types, including AM, FM, and PM.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs → COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	H	M	M	L	M	H	M	H	M	M
CO2	M	H	H	M	H	L	M	M	M	H	M	M
CO3	H	L	H	L	M	M	H	H	L	M	M	H

CO4	M	H	H	M	M	M	L	L	M	H	M	M
CO5	L	M	M	M	H	H	M	M	H	L	M	H

List of Experiments

Experiment No. 1: Generation of Amplitude Modulated (AM) signal using discrete components.

Experiment No. 2: Demodulation of AM Signal using discrete components.

Experiment No. 3: Generation of DSB-SC Modulated waveform using discrete components.

Experiment No. 4: DSB-SC Demodulation using discrete components.

Experiment No. 5: Generation of Frequency Modulated waveform using discrete components.

Experiment No. 6: Generation of PAM, PWM, PPM waveform.

Experiment No. 7: Demodulation of FM Signal using discrete components.

Experiment No. 8: Generation and Detection of AM using MATLAB.

Experiment No. 9: Generation and Detection of FM using MATLAB.

Experiment No. 10: Generation and Detection of PM using MATLAB.

Text/Reference Books:

1. Herbut Taub, Donald L. Schilling, and Goutam Saha, Principles of Communication Systems, 4th Edition, McGraw Hill Education, 2017.
2. B. P. Lathi, Z. Ding Modern, Digital and Analog Communication Systems, Oxford University Press, 2010.

Course Code	Course Name	L	T	P	Credits
EC300	**Control Systems**	**3**	**1**	**0**	**4**

Prerequisites: **EC201, EC203**

Course Objectives

1. Understand the fundamental concepts of control systems and their applications.
2. Analyze system stability using various criteria.
3. Design controllers using classical and modern control techniques.
4. Apply control theory to real-world engineering problems.
5. Implement a control system using simulation studies.

Course Outcomes

After completing this course, the student can able to

CO1. Explain the basic concepts of control systems and classify different types of control systems.

CO2. Analyze the time-domain and frequency-domain response of control systems.

CO3. Evaluate system stability using root locus, Bode plot, and Nyquist criteria.

CO4. Design and implement controllers to meet performance requirements.

CO5. Utilize computational tools for system analysis and simulation.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	H	L	L	L	M	L	L	M
CO2	H	H	H	H	H	L	L	L	M	L	L	M
CO3	H	H	H	H	H	L	L	L	M	L	L	M
CO4	H	H	H	H	H	L	L	L	M	L	M	M
CO5	H	H	H	H	H	L	L	L	M	L	M	M

Syllabus

Module 1: Introduction to Control Systems (12 Hours)
Overview of control systems, Open-loop vs. closed-loop control, Transfer functions, Block diagrams, Block diagram reduction rules, Signal flow graphs, Mason's Gain formula, Feedback characteristics of closed loop system.

Module 2: Time-Domain and Stability Analysis (12 Hours)
Time response Analysis: Standard test signals, Time response of First and Second order systems, Steady-state Errors and Error constants and Dynamic Error coefficients, Effect of addition of poles and zeroes on response of system, Stability analysis using the Routh-Hurwitz criterion, Root locus method for system stability. Software simulations for control system analysis.

Module 3: Frequency-Domain Analysis (12 Hours)
Bode plots and Nyquist criterion, Gain and phase margins, Nichols and polar plots, Stability analysis using frequency response techniques. Simulation tools for control system analysis.

Module 4: Control System Design (12 Hours)
PID controllers (Proportional, Integral, Derivative), Lead, lag, and lead-lag compensators, State-space representation and controllability/observability, Pole placement and state feedback. Software tools for control system analysis

Module 5: Applications of Feedback Control systems (8 Hours)
Case study applications of control systems. Simulation tools for control system analysis.

Text/References Books:

1. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", 14th Edition, Pearson, 2021.

2. Norman S. Nise, “Control Systems Engineering”, 8th Edition, Wiley, 2020.
3. Benjamin C. Kuo and Farid Golnaraghi, “Automatic Control Systems”, 9th Edition, McGraw-Hill, 2014.
4. Katsuhiko Ogata, “Modern Control Engineering”, 5th Edition, Pearson, 2010.
5. J. Nagrath and M. Gopal, “Control Systems Engineering”, 6th Edition, New Age International, 2017.

Course Code	Course Name	L	T	P	Credits
EC301	**Digital Signal Processing**	**3**	**0**	**0**	**3**

Course Objectives

1. This course is structured to provide students with a comprehensive knowledge of digital signal processing for engineering applications.
2. It highlights crucial concepts such as discrete Fourier Analysis of signals and systems for delving into their practical applications.
3. The course introduces the structures of systems, filter design techniques, special filters and transforms, and multi-rate systems.
4. It is anticipated that students will develop a deep understanding of representation of digital signals and systems, processing methods, and their real-world applications.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability

CO1. Acquire knowledge of the basics of Fourier representation of signals and systems.

CO2. Understanding of the significance of various signal filtering techniques and delve into its diverse applications.

CO3. Develop a profound understanding of the significance of signal modeling, signal transformation and filtering techniques.

CO4. Comprehend the importance of conventional and optimal filtering for adaptive signal processing.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	M	H	L	L	L	L	M	L	H
CO2	H	H	H	M	H	L	L	L	L	M	L	H
CO3	H	H	H	M	H	L	L	L	L	M	L	H
CO4	H	H	H	H	H	H	L	L	L	M	L	H

Syllabus

Module 1: The Discrete Transforms (8 hours)
Reviews of signals, systems, Fourier series, Fourier transform, and Z transform, DFT, properties, Digital filtering using DFT, linear and circular convolution, overlap add and overlap save, FFT, DIT FFT, DIF FFT, other discrete transforms: DCT, DST, Hartley, Hadamard, Hilbert transform.

Module 2: Design of FIR and IIR Filters (10 hours)
FIR Filter Design: Ideal characteristics of standard filters, types of FIR filter, FIR filter design using frequency sampling method, windowing method, maximally flat FIR filter approximation, FIR filter approximation by optimization.
IIR Filter Design: Analog filter approximations, continuous time to discrete time transformations: impulse invariant technique, bilinear transformation, Butterworth filter, Chebyshev filter, elliptic filter, frequency transformation.

Module 3: Realizations of Digital Filters (8 hours)
Representation of system by linear constant coefficient difference equations, block diagram and signal flow representation, Structures for FIR filters: Direct form, lattice form, cascade form, structures for IIR filters: Direct form, canonic form, cascade form and parallel form, comparison of different structures.

Module 4: Finite Word Length Effect (8 hours)
DSP algorithm implementation and finite word length effect: Number representation and overflow, Quantization Process and Errors, fixed and floating point numbers, coefficient quantization, A/D conversion noise analysis, Low sensitivity digital filters, Limit Cycle oscillations in IIR digital filters.

Module 5: Advanced Topics in DSP (8 hours)
Multirate Systems: Applications, sampling, the up-sampler, the down-sampler, signal rate-changing and interpolation, half-band filters.
Adaptive Systems: Motivation of Adaptive filter, Wiener filter, gradient search algorithm, steepest descent algorithm, LMS and Its variants algorithms.

Text/References Books:

1. Alan V. Oppenheim and R. W. Schafer, “Discrete-Time Signal Processing”, 3rd Edition. Pearson, 2014.
2. John G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms and Applications”, 4th Edition. Pearson, 2007.
3. Sanjit K. Mitra, “Digital Signal Processing: A Computer-Based Approach”, 4th Edition. Tata McGraw-Hill, 2013.
4. P. P. Vaidyanathan, “Multirate Systems and Filter Banks”, Prentice Hall, 1993.
5. B. Widrow and S. D. Stearns, “Adaptive Signal Processing”, Pearson Education, 2002.
6. S. Haykin, “Adaptive Filter Theory”, Pearson Education, 2013.
7. S. Esakkirajan, T. Veerakumar, and B. N. Subudhi, “Digital Signal Processing”, 1st Edition, Tata McGraw Hill Education, 2021.

Course Code	Course Name	L	T	P	Credits
EC302	**Microprocessors and Microcontrollers**	**3**	**0**	**0**	**3**

Course Prerequisites: None

Course Objectives

1. To introduce Computer Organization and Architecture and introduction to architecture and programming of microprocessors.
2. To familiarize the architecture and programming of Microcontrollers using 8051 and advanced processors.

Course Outcomes

The student will be able to

CO1. Understand the principles of Computer organization and the architecture and design of microprocessors and programming.

CO2. Understand architecture 8051 Microcontroller, its interfacing with peripherals and programming

CO3. Understand the Fundamentals of advanced processors, its interfacing with peripherals and programming in assembly and C language

CO4. Design and Develop interfacing models according to applications.

Relationship of Course Outcomes to Program Outcomes
H=High correlation; M=Medium correlation; L=Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	M	L	M	L		M		H
CO2	H	H	H	H	H	L	L	L		M	L	H
CO3	H	H	H	H	H	M	L	L	L	M	L	H
CO4	H	H	M	H	M	L	M	M	L	L	L	M

Syllabus

Module 1: Computer Organization and Architecture (6 hours)

Introduction to Computers and computing, Von Neumann and Harvard architecture Machine instructions and addressing modes, ALU, data-path and control unit, instruction pipelining.

Module 2: 8085 Microprocessor (10 hours)

Architecture of 8085 Processor., Hardware model and Programming model, Instruction set, Memory and I/O interface, Partial Decoding and Absolute Decoding. Interrupts, Stacks and Subroutines. Architecture of 8086 Microprocessor.

Module 3: 8051 Microcontroller (14 hours)

Introduction to Architecture of 8051. Internal hardware, ports and port circuits, external memory interface, counters and timers, serial communication, and interrupts.

Addressing modes & Instructions: Addressing modes, external data moves, stack and subroutines, C programming Timer/counter, serial communication and interrupt programming, 8051 interrupts. Interfacing Applications.

Module 4: Advanced Processors (12 hours)

Introduction ARM family, ARM 7 register architecture, ARM programmer's model. Raspberry pi 4 board- Introduction and brief description. Applications Portable Bluetooth speaker, Remote-controlled car, Photo Booth, lol weather station, Home Automation Centre, Portable Digital eBook Library.

Text/Reference Books:

1. Carl Hamacher, et. al, “Computer Organization, McGraw Hill; 5th Edition.
2. Krishna Kant, “Microprocessors and Microcontrollers, Architecture, Programming, and System Design-8085, 8086, 8051, 8096”, PHI Publication.
3. Kenneth J Ayala, “8051 Microcontroller Architecture, Programming and Application”, 2nd Edition, Penram International 1996.
4. Muhammad Ali Mazidi and Janice Gillespie, “8051 Microcontroller and embedded”, Pearson Education, 2003.
5. Definitive Guide to ARM CORTEX-M3 and to ARM CORTEX Edition-Elsevier 2014.
6. Andrew N Sloss, Dominic Symes and Chris Wright, “ARM System developers guide-Designing and

developing system software", Elsevier 2004.

Course Code	Course Name	L	T	P	Credits
EC303	Linear Integrated Circuits	3	0	0	3

Course Objectives

1. To understand the fundamentals of operational amplifiers and their applications in analog signal processing.
2. To study the design and analysis of active filters and oscillators using linear integrated circuits.
3. To explore the working principles of comparators, waveform generators, and timer circuits.
4. To understand the concepts of analog-to-digital and digital-to-analog conversion techniques and their performance parameters.
5. To analyze the operation of Phase Locked Loops (PLLs) and their applications in communication and control systems.
6. To familiarize students with recent advancements in linear integrated circuits and their role in industrial applications.

Course Outcomes

After completing this course, the student will be able to:

CO1. Analyze the operation and characteristics of operational amplifiers and their configurations.

CO2. Design and implement active filters, oscillators, and waveform generators for various applications.

CO3. Understand and apply the working principles of comparators, Schmitt triggers, and timer circuits in signal processing.

CO4. Evaluate different ADC and DAC architectures and their performance parameters for real-world applications.

CO5. Understand the principles of Phase Locked Loops (PLLs) and their significance in frequency synthesis and demodulation.

CO6. Gain insights into modern integrated circuit technologies and their applications in industry and research.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	M	M	M	M	M	M	M	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M
CO5	H	H	H	H	L	L	L	L	M	L	M	M
CO6	H	H	H	H	H	H	H	H	H	H	H	H

Syllabus

Module 1: Operational Amplifier and applications (10 hours)

Operational Amplifier (op-amp) circuit analysis, ideal op-amp, types of feedback, inverting and non-inverting configurations. DC and AC characteristics of op-amp and compensation techniques, Applications of op-amp.

Module 2: Comparators, waveform Generators and oscillators (12 hours)

Comparators: Comparator, Schmitt trigger

Waveform generators: Monostable and Astable multivibrators, triangular wave generators, NE555 timer, internal architecture and working principle, applications of 555 timer.

Oscillators: Principle of oscillators, RC-phase shift oscillators, Wien Bridge Oscillators.

Module 3: Active Filters and Phase Locked Loop (10 hours)

Active filters: First and second order filter transfer functions, low-pass active filter, high-pass active filter, narrow band pass filter, band reject filter, all-pass filter.

Phase Locked Loop: Block schematic and analysis of PLL, lock range and capture range, typical applications of PLL.

Module 4: Converters and State of art integrated circuits (10 hours)

Converters: Digital to Analog (D/A) converters, types of D/A converters and operations, analog to digital (A/D) converters, A/D conversion techniques.

State of art integrated circuits: Recent advancements and industrial applications of linear integrated circuits

Text books/Reference Books:

1. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Edition, McGraw Hill Science Engineering, 2014.
2. D. Roy Choudhury and Shail B. Jain, "Linear integrated Circuits", 6th Edition, New Age International Publishers, India, 2021.

3. Sedra A.S. and Smith K.C., “Microelectronic Circuits”, 7th Edition, Oxford University Press, 2014.
4. Ramakanth Gaykward, “Op Amps and Linear Integrated Circuits”, 4th Edition, Pearson Education, 2015.

Course Code	Course Name	L	T	P	Credits
EC304	**Digital Signal Processing Laboratory**	**0**	**0**	**3**	**2**

Course Objectives

1. This laboratory course is designed to complement the lecture-based course "Digital Signal Processing."
2. Throughout the course, students will engage in practical, hands-on training focused on the design and development of digital signal processing systems.
3. This will occur within simulation environments.
4. Additionally, students will gain exposure to the implementation of these systems on Digital Signal Processors (DSPs), providing them with both theoretical and applied knowledge in the field.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability

CO1. Acquire practical knowledge of the basics of Fourier representation of signals and systems.

CO2. Experimentally understand the significance of various signal filtering techniques.

CO3. Develop a practical understanding of the significance of signal modeling, signal transformation, conventional and optimal filtering.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	M	H				L	M		H
CO2	H	H	H	M	H				L	M		H
CO3	H	H	H	M	H				L	M		H

List of Experiments

Experiment No. 1: Transfer function and frequency response.

Experiment No. 2: Stability analysis: Relationship between pole-zero diagram and magnitude response.

Experiment No. 3: Discrete Fourier Transform (DFT).

Experiment No. 4: Equivalence between linear and circular convolution: implying use of DFT for linear convolution.

Experiment No. 5: FIR filter design using windowing.

Experiment No. 6: FIR filter design using frequency sampling.

Experiment No.7: Optimal FIR filter design: Minimax optimal filter using the Remez exchange algorithm.

Experiment No. 8: IIR filter design.

Experiment No. 9: Comparison of second-order FIR and IIR notch filters for tonal noise suppression in a noisy speech signal.

Experiment No. 10: Zero-phase (non-causal) digital filtering: Illustration with Electrocardiogram waveform.

Experiment No. 11: Periodogram estimation: Illustration with signals.

Experiment No. 12: Implementation of DSP algorithms on DSP Processor.

Text/Reference Books

1. Alan V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing", 3rd Edition. Pearson, 2014.
2. John G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", 4th Edition. Pearson, 2007.
3. Sanjit K. Mitra, "Digital Signal Processing: A Computer-Based Approach", 4th Edition. Tata McGraw-Hill, 2013.
4. P. P. Vaidyanathan, "Multirate Systems and Filter Banks", Prentice Hall, 1993.
5. B. Widrow and S. D. Stearns, "Adaptive Signal Processing", Pearson Education, 2002.
6. S. Haykin, "Adaptive Filter Theory", Pearson Education, 2013.
7. S. Esakkirajan, T. Veerakumar and B.N. Subudhi, "Digital Signal Processing", Tata McGraw Hill, 2021.
8. S. Esakkirajan, T. Veerakumar and B. N. Subudhi, "Digital Signal Processing: Illustration Using Python", Springer, 2024.
9. B. Venkataramani and M. Bhaskar, "Digital Signal Processor, Architecture, Programming and Applications", 2nd Edition, McGraw- Hill, 2010.

Course Code	Course Name	L	T	P	Credits
EC305	**Microprocessor and Microcontroller Laboratory**	**0**	**0**	**3**	**2**

Course Objective

1. To provide hands on experience on programming and interfacing microcontrollers.

Course Outcomes

CO1: To write, debug and execute assembly level programs for 8085, 8051 and/or advanced processors.

CO2: To obtain practical experience on interfacing I/O devices with 8051 and /or advanced processors.

CO3: To write, debug and execute problems using Embedded C programming.

Relationship of Course Outcomes to Program Outcomes
H=High correlation; M=Medium correlation; L=Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	L	-	L	-	-	-	-	-	-	L
CO2	H	H	M	-	L	-	-	-	-	-	-	L
CO3	H	H	H	-	L	-	-	-	-	-	-	L

List of Experiments

Experiment No. 1: Programs on data transfer and exchange using 8085 and 8051.

Experiment No. 2: Programs on arithmetic and logical operations using 8085 and 8051.

Experiment No. 3: Programs related to programming timers in all modes with and without interrupts using 8051.

Experiment No. 4: Programs related to programming serial communication with and without interrupts using 8051.

Experiment No. 5: Programs related to handling external interrupts using 8051.

Experiment No. 6: Programming on Timer 0 and Timer 1 to generate different square waveforms using 8051.

Experiment No. 7: Interfacing LCD Interfacing matrix keypad using 8051 and/or advanced Processors.

Experiment No. 8: Interfacing ADC using 8051 and/or advanced processors.

Experiment No. 9: Interfacing multi digit 7 segment displays 8051 and/or advanced processors.

Experiment No. 10: Interfacing DAC using 8051 and/or advanced processors.

Experiment No. 11: Interfacing stepper motor using and/or advanced processor.

Text/Reference Books:

1. Krishna Kant, "Microprocessors and Microcontrollers, Architecture, Programming, and System Design-8085, 8086, 8051, 8096", PHI Publication.
2. Kenneth J Ayala, "8051 Microcontroller Architecture, Programming and Application", 2nd Edition, Penram International, 1996.
3. Muhammad Ali Mazidi and Janice Gillespie, "8051 Microcontroller and embedded", Pearson Education, 2003.

Course Code	Course Name	L	T	P	Credits
EC306	Linear Integrated Circuits Laboratory	0	0	3	2

Course Objectives

1. To understand the practical implementation of operational amplifiers and analyze their gain and frequency characteristics.
2. To design and implement fundamental analog circuits, including amplifiers, comparators, and waveform generators.
3. To study and analyze active filters, ADCs, DACs, and PLL circuits for signal processing applications.
4. To develop hands-on skills in designing and troubleshooting integrated circuit-based systems.
5. To apply theoretical knowledge to real-world applications through a mini-project.

Course Outcomes

After completing this course, the student will be able to:

CO1. Analyze the gain, frequency response, and characteristics of operational amplifiers.

CO2. Design and implement analog circuits such as amplifiers, comparators, and Schmitt triggers.

CO3. Construct and evaluate active filters, ADCs, DACs, and PLL circuits.

CO4. Apply knowledge of integrated circuits to develop a practical mini-project.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	L	M	H	L	L	L	M	L	L	M
CO2	H	H	L	M	H	L	L	L	M	L	L	M
CO3	H	H	L	M	H	L	L	L	M	L	L	M
CO4	H	H	H	M	M	M	H	H	M	M	H	M

List of Experiments

Experiment No. 1: Realization of Op-Amp gain and frequency characteristics

Experiment No. 2: Analysis of inverting and non-inverting amplifiers.

Experiment No. 3: Integrators and differentiators - AC analysis, transient analysis.

Experiment No. 4: Instrumentation amplifier-gain, CMRR & input impedance.

Experiment No. 5: Design and implementation of comparators, zero crossing detector.

Experiment No. 6: Design of inverting and non-inverting Schmitt trigger.

Experiment No. 7: Single op-amp second order LFF and HPF - Sallen-Key configuration.

Experiment No. 8: Astable and monostable multivibrators using IC 555.

Experiment No. 9: Design an 8-bit ADC (IC ADC084) circuit that utilizes LEDs to indicate its binary output value.

Experiment No. 10: Design and Implementation of a 3-Bit Digital-to-Analog Converter (DAC) Using Op-Amp.

Experiment No. 11: PLL circuit analysis.

Experiment No. 12: Mini Project

Text Books/Reference Books:

1. Sergio Franco, "Design with Operational Amplifiers and Analog Integrated Circuits", 4th Edition, McGraw Hill Science Engineering, 2014.
2. D. Roy Choudhury and Shail B. Jain, "Linear integrated Circuits", 6th Edition, New Age International Publishers, India, 2021.
3. Sedra A. S., and Smith K. C., "Microelectronic Circuits", 7th Edition, Oxford University Press, 2014.
4. Ramakanth Gaykward, "Op Amps and Linear Integrated Circuits", 4th Edition, Pearson Education, 2015.

Course Code	Course Name	L	T	P	Credits
ES300	Environmental Studies	1	0	0	1

Course Objectives

Understanding environment, its constituents, importance for living, ecosystem, human developmental activities vs environment, climate change, national and international environment related developments, need for public awareness, its protection and conservation activities.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability to,

CO1: Understand in-depth knowledge on natural processes and resources that sustain life.

CO2: Understand the effect of human interference on the web of life, economy, and quality of human life.

CO3: Develop critical thinking for shaping strategies for environmental protection, conservation of biodiversity, environmental equity, and sustainable development.

CO4: Acquire values and attitudes towards understanding complex environmental economic- social challenges, and active participation in solving current environmental problems and preventing the future ones.

CO5: Adopt sustainability as a practice in life, society, and industry.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		L	L	H		H	H	H	H	L	L	H
CO2		H	H	M	L	H	H	H	H	L	L	H
CO3		H	H	L		H	H	H	M	L	L	H
CO4		L	L	L		L	H	H	L	L	L	H
CO5		H	H	M	M	M	H	H	H	L	M	H

Syllabus

Module 1: Introduction

Environment, interaction organism, scale of interaction, types of environment, Human interference, environmental ethics, environmental problems, sustainable society, ecological foot prints.

Module 2: Ecosystem

Current status, Role of organism, species, Life supporting system, Factors sustaining life, Components of ecosystem, Ecological efficiency, Matters in ecosystem, Major chemical cycles, Role of Species, Classification of species.

Module 3: Biodiversity and Species Interaction

Biodiversity and Ecosystem, Species interaction, Natural selection, population growth, factor limiting population growth, Population dynamics, Species and reproductive pattern, Biodiversity, Population and Economy, Food and nutrition

Reference Book/Materials

1. Textbook for environmental studies for undergraduate courses of all branches of higher education (Online book-UGC website), Erach Bharucha, University Grants Commission, India.
2. Environmental science: Earth as a living planet, 8th edition, Daniel B. Botkin, Edward A. Keller, John Wiley & Sons, Inc., ISBN 978-0-470-52033-8
3. Environmental science: Problems, concepts, and solutions, 16th edition, G. Tyler Miller, Jr., Scott Spoolman, Brooks/Cole, ISBN-13: 978-0-495-55671-8
4. Principles of environmental science: Inquiry & application, 7th edition, William P. Cunningham, Mary Ann Cunningham, Mcgraw-Hill, ISBN 978–0–07–353251–6
5. Environmental science: A global concern, 12th edition, William P. Cunningham, Mary Ann Cunningham, Mcgraw-Hill, ISBN 978–0–07–338325–5.

Course Code	Course Name	L	T	P	Credits
HS353	**Industrial Economics**	**3**	**0**	**0**	**3**

Course Objectives

1. Identify and analyse the behaviour of a firm under different market situations systematically.
2. Understand and assimilate the issues related to strategic behaviour in firms, R&D and innovation.
3. Have a comprehensive coverage of firms & profitability and efficiency measurements, with applications to India's industrial structure.
4. To understand the rich complexities and paradox of fourth industrial revolution.

Course Outcomes

Upon completion, students should have an in-depth knowledge of

CO1. Market structure, conduct and performance

CO2. Strategic behaviour in firms

CO3. Innovation, R&D and the market

CO4. Industrial efficiency and its applications for the Indian economy.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	M	M	M	M	M	M	M	L	M

CO2	M	H	H	M	M	H	M	M	H	M	M	M
CO3	M	M	H	H	H	M	M	M	H	M	M	M
CO4	H	M	M	M	L	L	H	H	M	M	M	H

Syllabus

Module 1: (5 hours)

Introduction to Economics- Introduction to Industrial economics - nature and scope - concept of firm and industry- types of firms - structure, conduct and performance.

Module 2: (10 hours)

Standard forms of market structure - pricing strategies and output determination of firms - profit maximization, sales maximization (William J. Baumol), utility maximization (Oliver E. Williamson), growth maximization (George K. Yarrow) - equilibrium of firms under perfect competition, monopoly, monopolistic competition and oligopoly – optimum, price and output - economies of scale.

Module 3: (10 hours)

Price and non-price competition - strategic behaviour of firms - collusion and mergers - game theory - market failures and information asymmetry - advertising and product differentiation - market entry and exit - concentration and diversification.

Module 4: (5 hours)

Patents and technological change- the economics of patent-innovation and diffusion measures of concentration.

Module 5: (6 hours)

Research and Development (R&D) and market structure -- product and process innovation- R&D and patent race-licensing and incentive to innovate.

Module 6: (6 hours)

Economics of the fourth Industrial Revolution – Industrial revolution past, present and Future, Internet Artificial Intelligence- Blockchain technologies

Essential Reading

1. Donald A. Hay, Derek J. Morris, Industrial Economics: Theory and Evidence, Oxford University Press, 1979
2. Carton, D. and J. Perloff. Modern Industrial Organization (Reading, Massachusetts: Addison-Wesley), 1999.
3. Lall, Sanjaya. Competitiveness, Technology and Skills (Cheltenham: Edward Elgar), 2001.
4. Shy, O. (1996). Industrial organization: Theory and applications. MIT Press.

Supplementary Reading

1. A. Singh and A.N. Sandhu, Industrial Economics, Himalaya Publishing House, Bombay, 1988.
2. Ferguson, Paul R. and Glenys J. Ferguson, (1994), Industrial Economics - Issues and Perspectives, Macmillan, London.
3. Stephen Martin, Advanced Industrial Economics, Oxford, UK Blackwell Publisher, 2002.
4. R. R. Barthwal, Industrial Economics: An Introductory Textbook, New Age International Publishers, 2007.
5. Hay, Donald A. and Derek J. Morris. Industrial Economics and Organization: Theory and Evidence, 2nd Edition (Oxford: Oxford University Press), 1991.
6. Schmalensee, R., Inter-industry studies of Structure and Performance, in Schmalensee, R. and R. D. Willig (eds.): Handbook of Industrial Organization [Amsterdam: North-Holland] Vols. 2 Chapter 16, pp. 951-1009, 1989.
7. Siddharthan, N. S. and Y.S. Rajan. Global Business, Technology and Knowledge Sharing: Lessons for Developing Country Enterprises (New Delhi: Macmillan), 2002.
8. Tirole, Jean. The Theory of Industrial Organization (Cambridge, MA: The MIT Press), 1988.

Course Code	Course Name	L	T	P	Credits
EC350	Digital Communication	3	0	0	3

Course Objectives

1. To understand the generation of digital sources for efficient communication which includes sampling and waveform coding techniques?
2. To understand the analytical model for baseband and passband digital communication.
3. Performance analysis and comparison of digital systems in terms of spectral efficiency and BER.
4. To know the basics of source and channel coding

Course Outcomes

After completing this course, the student can able to

CO1. Know sampling and reconstruction techniques

CO2. Understand the generation of digital sources and various line coding techniques.

CO3. Understand the issues in baseband transmissions and theory behind how to minimize their effects.

CO4. Get the knowledge to design the best baseband receiver.

CO5. Know various digital modulation techniques and their performance analysis.

CO6. Get the basic knowledge of coding theory.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	M	M	H	L	L	L	L	M	L	L	M
CO3	H	M	M	H	L	L	L	L	M	L	L	L
CO4	H	H	H	H	L	L	L	L	M	L	M	L
CO5	H	H	H	H	L	L	L	L	L	L	M	L
CO6	H	H	M	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Digital source (08 hours)

Digital Source - Sampling Theorem, Quadrature Sampling of Band-pass signals, Nyquist Criterion, Signal Distortion in Sampling.

Waveform Coding Techniques: PCM, Channel Noise and Error Probability, Quantization Noise and Signal to Noise Ratio, DPCM, Delta Modulation, Different types of signaling.

Module 2: Baseband Communication (08 hours)

Detection of Known Signals in Noise, Probability of Error, Correlation Receiver, Matched Filter Receiver, Estimation: Concepts and Criteria, MAP and ML detection techniques. Inter symbol Interference and pulse shaping.

Module 3: Passband Communication: Digital Modulation (16 hours)

Gram-Schmidt Orthogonalization Procedure, Geometric Interpretation of Signals, Response of Bank of Correlators to Noisy Input, Coherent detection for M-ary signaling, decision region, approximate error probability using union bound, bit and symbol error rates.

Coherent Modulation Techniques – ASK, PSK, FSK, PAM, and Quadrature Amplitude Modulation, M-QAM and M-PSK. Noncoherent Modulation Techniques, Continuous Phase Modulation and Minimum Shift Keying. Bandwidth efficiency and symbol; error rate for each modulation techniques, Digital Modulation Tradeoffs.

Module 4: Digital Communication Through Band-limited Channel (10 hours)

Optimum demodulation of digital signals over bandlimited channels- Maximum likelihood sequence detection (Viterbi receiver). Equalization techniques. Synchronization and Carrier Recovery for Digital modulation and the Viterbi algorithm. Source and Channel coding preview.

Text/Reference Books:

1. John G. Proakis, *Digital Communication*, 4th Edition, McGraw Hill, 2000.
2. Simon Haykin, *Communication Systems*, 4th Edition, John-Wiley & Sons Inc.
3. John G Proakis, and M Salehi, *Communication Systems Engineering*, 2nd Edition, Pearson Education, 2001.

4. B. Sklar and P. K. Ray, *Digital Communications: Fundamentals and Applications*, 2nd edition, Pearson , 2009.
5. B. P. Lathi and Z. Ding, *Modern Digital and Analog Communication Systems*, 4th edition, Oxford, 2011.

Course Code	Course Name	L	T	P	Credits
EC351	**Antenna and RF Engineering**	**3**	**1**	**0**	**4**

Course Objectives

1. To introduce the basics of how antennas work, including concept of radiation, radiation patterns, gain, and efficiency and measurement techniques.
2. To study different types of antennas like dipole, monopole, and loop antennas.
3. To understand aperture and microstrip antennas, along with how they receive and transmit signals.
4. To learn about antenna arrays, including how they work in broadside and end-fire configurations.
5. To explore the concepts of receiving antennas and also how radio waves travel in free space, over the ground, and through the atmosphere.

Course Outcomes

CO1. Understand how antennas radiate signals and key factors like gain, efficiency, and impedance.

CO2. Analyze and design basic antennas like dipole, monopole, and loop antennas.

CO3. Learn about aperture and microstrip antennas and how they are used.

CO4. Study antenna arrays and how they affect signal direction and strength.

CO5. Understand the concept of Receiving Antennas, RADAR equations and also how radio waves travel in different environments and affect communication.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	L	L	L	L	L	L	L	L	L	M
CO2	H	H	H	M	M	L	L	L	M	L	L	L
CO3	H	H	H	M	H	M	L	L	M	M	L	M
CO4	H	H	M	M	H	M	M	L	M	M	L	M
CO5	H	H	H	H	H	M	M	M	H	H	M	H

Syllabus

Module 1: Fundamental Concepts and Measurements (16 hours)

Physical concept of radiation, Hertzian dipole, radiation pattern, near- and far-field regions, reciprocity, directivity and gain, polarization, input impedance, efficiency.

Microwave parameters, S-parameters (S11, S21) and their significance, ABCD parameters, VNA calibration (SOLT), measurement of return loss and insertion loss, impedance matching techniques.

Module 2: Wire and Planar Antennas (14 hours)

Dipole antennas: Half-wave dipole, quarter-wave monopole.

Microstrip antennas: Basic characteristics, feeding methods, design considerations. Dielectric resonator antennas: Principles, design, and applications.

Module 3: Aperture Antennas, Arrays (14 hours)

Horn antennas: Design principles and radiation characteristics.

Antenna arrays: Uniform linear arrays, broadside vs. end-fire arrays, beam steering, antenna array analysis

Module 4: Receiving Antennas and Radio wave propagation (12 hours)

Reciprocity and Receiving Antennas, Yagi–Uda array**,** Log-periodic antennas, Effective Area and the Friis equation, Introduction to RADAR, basics of wave propagation.

Text/Reference Books:

1. Constantine A. Balanis, "Antenna Theory: Analysis and Design", 3rd Edition, Wiley, 2009.
2. John D Kraus, Ronald J Marhefka, and Ahmad S Khan, "Antennas and Wave Propagation", 4th Edition, McGraw Hill Education, 2017.
3. Robert S. Elliot, "Antenna Theory and Design", Revised Edition, Wiley, 2006.
4. A.R. Harish, M. Sachidananda, "Antennas and Wave Propagation", Oxford University Press, 2007.

Course Code	Course Name	L	T	P	Credits
EC352	**VLSI Circuit Design**	**3**	**0**	**0**	**3**

Course Objectives

1. To introduce the basic concepts of digital CMOS VLSI design, estimation of power, delay and area of basic standard digital cell.
2. Design of transistor level gates and combinational circuit design
3. To understand the system level design of arithmetic blocks
4. To understand the concepts of memory cell design.

5. To introduce the various steps in IC fabrication.

Course Outcomes

After completing this course, the student can able to understand

CO1. VLSI/ IC design flow and design styles

CO2. Design of CMOS Inverter standard cell and other gates Delay estimation of the gates and logical effort.

CO3. Design of CMOS inverter chain and Multiple chain of gates.

CO4. Estimates of Delay power and other technical parameters of CMOS gates

CO5. Design of combinational circuits and their implementation, placements and delay estimation.

CO6. CMOS based Sequential circuit design and analysis, delay estimation

CO7. The basic fabrication process and their application for the CMOS design.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	L	L	L	L	M	L	L	L
CO2	H	M	M	H	L	L	L	L	M	L	L	M
CO3	H	M	M	H	L	L	L	L	M	L	L	L
CO4	H	H	H	H	L	L	L	L	M	L	M	L
CO5	H	H	H	H	L	L	L	L	M	L	M	M
CO6	H	H	H	H	L	L	L	L	M	L	M	M
CO7	M	M	M	M	M	L	L	L	L	L	L	L

Syllabus

Module 1: VLSI Design Flow, Inverter Design (12 hours)

Overview of VLSI Design flow, Issues in Digital Integrated Circuit Design, Quality Metrics of a Digital Design, Review of NMOS and PMOS, Performance of CMOS Inverter Static and Dynamic Behavior, Power, Energy and Energy-Delay.

Module 2: VLSI Logic Circuit (12 hours)

Designing Combinational logic gates in CMOS: Static CMOS Design, logical efforts, Layout issues, Stick diagrams. Rationed Logic, Pass-Transistor Logic, Dynamic CMOS Design, Logic circuits for Reduced Supply Voltages, Designing Sequential Logic Circuits: Static Latches and Registers, Dynamic Latches and Registers, Alternative Register Styles.

Module 3: Arithmetic, Memory and drivers (12 hours)

Cell Based Design: Standard cells and Data path cells, Logic and Arithmetic Circuits – Adders, Ripple carry, Carry look ahead Adder and other high Speed Adders; Array multipliers, Logarithmic and Barrel Shifters, 6-Transistor SRAM and DRAM cell design.

Driving large capacitive loads: Wire Delay models, Lumped, RC and Distributed RC models, Delay Calculation with Distributed Circuit Elements, Latch up and its prevention.

Module 4: VLSI Fabrication Process (06 hours)

Wafer Processing: Wafer Preparation, Oxidation, Diffusion, Ion Implantation, Etching-Wet, Plasma and Ion etching; Epitaxial Growth - Molecular Beam Epitaxy; Optical lithography- Optical Exposures; Photoresists –Types of Photoresists, Positive and Negative PR.

Text/Reference Books:

1. Jan M. Rabaey, "*Digital Integrated Circuits- A Design Perspective*", Prentice Hall, 2nd Edition, 2016.
2. Behzad Razavi, Fundamentals of Microelectronics, John Wiley & Sons, 2021.
3. Sung Mo Kang, Yusuf Leblebici, Chulwoo Kim "CMOS Digital Integrated Circuits- Analysis & Designing", MGH, 4th Edition, 2016.
4. J Baker, CMOS: Circuit Design, Layout and Simulation, 2nd Edition, John Wiley & Sons, 2009.
5. S K Gandhi, "VLSI Fabrication Principles: Silicon and Gallium Arsenide", John Wiley, 2nd Edition, 2008.
6. John P Uyemura, "Introduction to VLSI Circuits and Systems", Wiley India, 2006.

Course Code	Course Name	L	T	P	Credits
EC353	**Digital Communication Laboratory**	**0**	**0**	**3**	**2**

Course Objectives

1. To introduce student to the experiments which demonstrate the theory learnt in the Digital Communication course
2. Know how to design and implement important concepts used in digital communication systems
3. Understand to realize the theory in discrete components
4. Get the knowledge of doing the simulation of a communication system using simulation studies.

Course Outcomes

CO1. Implementation of sampling and reconstruction circuit and analysing the Nyquist theorem

CO2. Understanding the simulation of digital source generator like PCM and DM using simulation studies.

CO3. Implementation of digital modulation techniques such as ASK, PSK, FSK using discrete components.

CO4. Analyze the BER performance of digital modulation techniques.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	L	M	H	L	L	L	M	L	L	M
CO2	H	H	L	M	H	L	L	L	M	L	L	L
CO3	H	H	L	M	H	L	M	L	M	L	L	L
CO4	H	H	H	M	M	M	L	L	M	M	L	M

List of Experiments

Experiment No.1: Sampling and reconstruction of analog signals

Experiment No.2: Pulse code modulation (PCM) signal transmission and reception.

Experiment No.3: Delta modulation (DM) and demodulation

Experiment No.4: Time division multiplexing (TDM) and demultiplexing of a digital signal

Experiment No.5: ASK Modulation and demodulation

Experiment No.6: PSK Modulation and demodulation

Experiment No.7: DPSK Modulation and demodulation

Experiment No.8: FSK Modulation and demodulation

Experiment No.9: BER analysis of coherent modulation techniques: BPSK and QPSK

Experiment No.10: To study channel coding and decoding techniques for digital communication systems.

Text Books/Reference Books:

1. Simon Haykin, *Communication Systems*, 4th Edition, John-Wiley & Sons Inc.
2. John G Proakis, and M Salehi, *Communication Systems Engineering*, 2nd Edition, Pearson Education, 2001.
3. B. P. Lathi and Z. Ding, *Modern Digital and Analog Communication Systems*, 4th Edition, Oxford, 2011.

Course Code	Course Name	L	T	P	Credits
EC354	Antenna and RF Engineering Laboratory	0	0	3	2

Course Objectives

1. Measurement of antenna parameters and analyzing radiation characteristics of antenna.
2. Measurement of parameters such as insertion loss of two port passive devices
3. Design and implement antennas using EM simulation tools.
4. Prototyping of antennas and other passive devices

Course Outcomes

CO1. Use electromagnetic simulation tools like CST Microwave Studio/HFSS to simulate and study the behavior of different planar, non-planar antennas and other passive devices such as filters

CO2. Experimental validation of designed and fabricated antenna prototypes

CO3. Use of high frequency equipment such as VNA, microwave bench.

CO4. Evaluate performance parameters like HPBW, FNBW, directivity, VSWR, and gain of different antennas

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs → / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	L	M	H	L	L	L	M	L	L	M
CO2	H	H	L	M	H	L	L	L	M	L	L	M
CO3	H	H	L	M	H	L	L	L	M	L	L	M
CO4	H	H	H	M	M	M	L	L	M	M	L	M

List of Experiments

Experiment No.1: Characteristic of GUNN diode and slotted line measurements

Experiment No.2: Calibration of the Vector Network Analyzer (VNA) using SOLT

Experiment No.3: Measurement of return loss, insertion loss of transmission lines under different load terminations

Experiment No.4: Design and analysis of dipole antennas

Experiment No.5: Design and analysis of microstrip patch antennas

Experiment No.6: Design and analysis of dielectric resonator antennas

Experiment No.7: Design and analysis of conventional horn antennas

Experiment No.8: Design and analysis of antenna arrays

Experiment No.9: Measurement of insertion loss of two port devices such as filter

Experiment No.10: Antenna radiation pattern, HPBW, FNBW. directivity, VSWR and gain measurement

Experiment No.11: Fabrication of prototype

Text Books/Reference Books:

1. Constantine A. Balanis, "Antenna Theory: Analysis and Design", Hoboken: Wiley, 1982.
2. J. D. Kraus and Ronald Marhefka, "Antennas for All Applications", McGraw-Hill, 2002.
3. D. M. Pozar, "Microwave Engineering", 4th Edition, Wiley, 2011.
4. Girish Kumar; K.P. Ray, "Broadband Microstrip Antennas", Artech, 2002.
5. Petosa Aldo, "Dielectric Resonator Antenna Handbook", Artech House, 2007.

Course Code	Course Name	L	T	P	Credits
EC355	**VLSI Circuit Design Laboratory**	**0**	**0**	**3**	**2**

Course Objectives

1. To provide the practical understanding of design and simulation of VLSI circuit and layout using CADENCE tool.
2. To learn the concepts of standard cell gate design using Cadence tool.
3. To verify and test the basic and Universal gates using cad tools.
4. To understand the concepts of layouts and draw the layouts for various gates, combinational and sequential circuits.
5. To analyse the effect of parasitics from the extracted layouts and minimise their effects.

Course Outcomes

CO1. How to use the cadence tools for the simulation of VLSI circuits

CO2. Design the standard cell using cadence tools

CO3. To understand the concepts of integrated circuits design

CO4. Learn the concepts of system level integration and verification of the design.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	M	H	H	H	H	M	H	M	M
CO2	H	H	L	M	H	L	L	M	M	L	L	L
CO3	H	H	L	M	H	L	M	L	M	L	M	L
CO4	M	M	M	M	M	M	L	L	M	M	L	L

List of Experiments

Experiment No. 1: NMOS and PMOS– ID/VDS Characteristics – extraction of VT and body effect factor.

Experiment No. 2: CMOS inverter design and power delay estimation along Layout & parasitic extraction.

Experiment No. 3: Design, Simulation and layout of CMOS NAND, NOR, XOR, XNOR.

Experiment No. 4: Design, Simulation and layout of AND, OR, NOT cells.

Experiment No. 5: Design, Simulation and layout of basic digital blocks such as Adder, Subtractor.

Experiment No. 6: Design, Simulation and layout of basic digital blocks such as Decoder, Mux, etc.

Experiment No. 7: Design, Simulation and layout of basic Arithmetic block like Multiplier, etc.

Experiment No. 8: Mini Project based evaluation.

Text/Reference Books:

1. Jan M. Rabaey, "Digital Integrated Circuits- A Design Perspective", Prentice Hall, Second Edition, 2016.
2. Behzad Razavi, "Fundamentals of Microelectronics", John Wiley & Sons, 2021.
3. J. Baker, "CMOS: Circuit Design, Layout and Simulation", Second Edition, John Wiley & Sons, 2009.

List of Elective Courses

S. No.	Course Code	Course Name	L	T	P	Credits
1.	EC500	Advanced Digital Signal Processing	3	0	0	3
2.	EC501	Biomedical Signal Processing	3	0	0	3
3.	EC502	Adaptive Signal Processing	3	0	0	3
4.	EC503	Statistical Signal Processing	3	0	0	3
5.	EC504	Digital Image Processing	3	0	0	3
6.	EC505	Computer Vision	3	0	0	3
7.	EC506	Information Theory and Coding	3	0	0	3
8.	EC507	Satellite Communication	3	0	0	3
9.	EC508	Fiber Optical Communication	3	0	0	3
10.	EC509	Spread Spectrum Techniques	3	0	0	3
11.	EC510	Wireless Communication	3	0	0	3
12.	EC511	Wireless and Mobile Communication	3	0	0	3
13.	EC512	Remote Sensing Systems	3	0	0	3
14.	EC513	Radar and Navigation System	3	0	0	3
15.	EC514	Modern Radar System	3	0	0	3
16.	EC515	Microwave Devices and Circuits	3	0	0	3
17.	EC516	Power Electronics	3	0	0	3
18.	EC517	VLSI Testing and Testability	3	0	0	3
19.	EC518	Low-Power VLSI	3	0	0	3
20.	EC519	Active Filter Design	3	0	0	3
21.	EC520	Digital System Design using FPGA	3	0	0	3
22.	EC521	Advanced Analog IC Design	3	0	0	3
23.	EC522	Electromagnetic Interference and Compatibility	3	0	0	3
24.	EC523	Computer Architecture and Organization	3	0	0	3
25.	EC524	Array Signal Processing	3	0	0	3
26.	EC525	Communication Networks and Switching	3	0	0	3
27.	EC526	Computational Electromagnetics	3	0	0	3
28.	EC591	Selected Topics in Communication	3	0	0	3
29.	EC592	Selected Topics in Signal Processing	3	0	0	3
30.	EC593	Selected Topics in VLSI	3	0	0	3
31.	EC594	Selected Topics in Electronics	3	0	0	3
32.	EC595	Selected Topics in Microelectronics	3	0	0	3

Detailed Syllabi of Elective Courses

Course Code	Course Name	L	T	P	Credits
EC500	Advanced Digital Signal Processing	3	0	0	3

Course Objectives

1. The main objective of studying this course is to know the importance of advanced topics in signal processing.
2. To know the importance of multirate signal processing concepts like decimation, interpolation, sampling rate conversion and filter banks.
3. To understand the behaviour of the noisy signal and predict the original signal from the noisy environment data using optimal filters.
4. To know the importance of power spectrum estimation in signal processing and how it is estimated using different spectrum estimation approaches like parametric, non-parametric, and eigen decomposition methods.
5. To understand the use of Time-Frequency analysis methods like STFT and wavelet transform for signal analysis.
6. To know the importance of multiresolution analysis in signal processing applications.

Course Outcomes

Upon completing this course, the student will be able to

CO1. Understand how to change the sampling rate of a discrete-time signal and its applications.

CO2. Grasp the concepts of linear prediction and optimal filtering to extract actual information from input data in noisy environments.

CO3. Estimate the power spectrum of input data within noisy environments using parametric, non-parametric, and eigen decomposition methods.

CO4. Learn how the Short-Time Fourier Transform (STFT) and wavelet transform are used to analyze the time-frequency characteristics of input signals.

CO5. Recognize the significance of multiresolution analysis in signal processing applications.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	H	M	M	L	M	H	M	H	M	M
CO2	M	H	H	M	H	L	M	M	M	H	M	M
CO3	H	L	H	L	M	M	H	H	L	M	M	H
CO4	M	H	H	M	M	M	L	L	M	H	M	M
CO5	L	M	M	M	H	H	M	M	H	L	M	H

Syllabus

Module 1: Multi-rate digital signal processing (8 Hours)

Decimation, interpolation, sampling rate conversion, digital filter banks, two-channel quadrature mirror filter bank, M-channel QMF bank

Module 2: Linear prediction and optimum linear filters (8 Hours)

forward and backward linear prediction, normal equations, AR lattice and ARMA lattice-ladder filters, Wiener filters.

Module 3: Power Spectrum Estimation (10 Hours)

Nonparametric and parametric methods, filter bank methods, Eigen analysis algorithms.

Module 4: Time-frequency analysis (8 Hours)

Uncertainty principle, Short-time Fourier transform, Wigner distribution, Kernel design, Gabor wavelets.

Module 5: Multi-Resolution Analysis (8 Hours)

Wavelet transform, Empirical mode decomposition, Variational mode decomposition, Applications of multi-resolution analysis.

Text/Reference Books:

1. Proakis and Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", 4th Edition, Pearson, 2012.
2. Cohen, "Time-frequency Analysis", Prentice-Hall, 1995.
3. Vaseghi, "Advanced digital signal processing", 4th Edition, Wiley, 2008.
4. Vaidyanathan, "Multi-rate systems and filter banks", Pearson, 1992.
5. Vikram Gadre and Aditya Abhyankar, "Multiresolution and Multirate Signal Processing: Introduction, Principles and Applications", 1st Edition, McGraw Hill, 2017.

6. S. Esakkirajan, T. Veerakumar, and B. N. Subudhi, “Digital Signal Processing”, 1st Edition, Tata McGraw Hill, 2021.

Course Code	Course Name	L	T	P	Credits
EC501	**Biomedical Signal Processing**	**3**	**0**	**0**	**3**

Course Objectives

1. To learn biological and engineering principles related to the human body.
2. To understand the origin and role of bio-electricity, nature of electrophysiological and other biomedical signals.
3. To apply various statistical and signal processing techniques for modelling, and processing biomedical signals in various healthcare applications.
4. To develop skills to integrate the knowledge of anatomy and physiology, biomedical signals, statistical and signal processing methods, and modeling for solving real-world medical applications.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability:

CO1. Acquire knowledge of the basics of cellular physiology, anatomy and physiology of muscular, cardiovascular, and nervous system and subsequently apply these knowledges to tackle complex biomedical problems.

CO2. Understanding of the significance of various statistical methods and signal processing techniques and delve into its diverse biomedical applications.

CO3. Develop a profound understanding of the significance of time-domain, frequency-domain and time-frequency domain based waveform analysis, signal preprocessing, filtering, event detection, and modeling of biomedical signals.

CO4. Comprehend the importance of conventional, optimal and adaptive filtering, parametric and non-parametric modeling for biomedical signal processing.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	H	L	M	M	-	-	-	L	M	-	H
CO2	H	H	H	M	H	-	-	H	H	M	-	H

CO3	H	H	H	H	H	H	-	H	H	M	-	H
CO4	H	H	H	H	H	H	-	H	H	M	-	H

Syllabus

Module 1: Introduction to Human Body and Biomedical Signals (10 hours)

Bioelectricity: Resting, action and graded potentials, Nernst and GHK equation. Basics of muscular, cardiovascular and nervous system. ECG, PCG, EMG and EEG signals, their origin, characteristics and applications in medical diagnosis.

Module 2: Review of Digital Signal Processing (8 hours)

FFT and STFT, periodogram, issues of leakage, resolution, bias and variance in periodograms and related solutions. Bias and normalization in Welch's method, multitaper method, Blackman-Tukey spectral estimator, Daniell's spectral estimator, measures derived from PSD, cross-spectral density function, transfer function estimate, coherence function.

PSD analysis of PCG signals, EEG signals, and speech signals.

Module 3: Signal Preprocessing and Filtering (10 hours)

Signal normalization, segmentation, delineation and epoching, time-domain filtering: synchronized averaging, moving average, integration, and derivative-based filters, frequency-domain filtering with notch filter, optimal filtering: the Wiener Filter, adaptive filtering: Newton’s method, steepest descent algorithm, LMS adaptation algorithm and its variants, recursive least-squares (RLS) algorithms. Applications in utility noise removal, fetus ECG separation from mother ECG signals etc.

Module 4: Event Detection (6 hours)

Representative cases of events (viz. P, QRS and T wave in ECG), Classification of QRS detection methods, derivative based approaches for QRS detection: Pan Tompkins algorithm.

Module 5: Modelling of Biomedical Systems (8 hours)

Parametric system modelling, Autoregressive model, Autocorrelation method, Application to biomedical signals like EEG signals, Computation of model parameters, Levinson-Durbin algorithm, Computation of gain factor, Covariance method, Spectral matching and parameterization, Model order selection, Relation between AR and cepstral coefficients.

Reference Books/Material

1. R. M. Rangayyan, “Biomedical Signal Analysis: A case Based Approach”, IEEE Press, John Wiley & Sons. Inc, 2002.
2. Willis J. Tompkins, “Biomedical Digital Signal Processing”, EEE, PHI, 2004.
3. D. C. Reddy, “Biomedical Signal Processing: Principles and Techniques”, Tata McGraw-Hill Publishing Co. Ltd, 2005.
4. J. G. Webster, “Medical Instrumentation: Application & Design”, John Wiley & Sons Inc., 2001.

5. C. Raja Rao and S. K. Guha, “Principles of Medical Electronics and Biomedical Instrumentation”, Universities Press, 2001.
6. A.V. Oppenheim and R. W, Shafer, “Discrete-time Signal Processing”, Prentice Hall, Englewood Cliffs, NJ, 1989.
7. Steven M. Kay, “Modern spectral estimation theory and application”, Prentice Hall, Englewood Cliffs, NJ, 1988.

Course Code	Course Name	L	T	P	Credits
EC502	**Adaptive Signal Processing**	**3**	**0**	**0**	**3**

Course Objectives

1. To introduce some practical aspects of signal processing, and in particular adaptive systems.
2. Current applications for adaptive systems are in the fields of communications, radar, sonar, seismology, navigation systems and biomedical engineering.
3. This course will present the basic principles of adaptation, will cover various adaptive signal processing algorithms (e.g., the LMS algorithm) and many applications, such as adaptive noise cancellation, interference canceling, system identification, etc.

Course Outcomes

After completing this course, the student will be able to:

CO1: The students would learn how to use iterative techniques to solve parameter estimation problems.

CO2: Theoretical guarantees of iterative and recursive methods will be learnt to enable them to choose the appropriate method for signal processing systems.

CO3: A good understanding of techniques like Kalman Filtering and Recursive Least-Squares techniques will be useful to extend them to machine learning paradigms.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	H	H	L	H	L	L	M	L	M	M

Syllabus

Module 1: Introduction (10 hrs)

Random variables, random processes, filtered random processes. Ensemble averages, correlation, covariance, power spectrum, cross power, spectrum. Ergodicity, time averages, biased & unbiased estimators, consistent estimators. Direct form linear prediction filtering. Normal equations for linear prediction filtering. Levinson algorithm. Linear prediction lattice filtering.

Module 2: Digital Wiener Filtering (08 hours)

Wiener smoothing and prediction filters, Application of Wiener smoothing to noise cancelling, Application of Wiener prediction filters, Constrained, linear MMSE filtering.

Module 3: Least mean squares adaptive filter (08 hours)

LMS adaptive algorithm, Properties of LMS adaptive filter, Normalized forms, Finite precision effects, Adaptive beamforming, Frequency domain adaptive filters, Adaptive lattice filters.

Module 4: Least squares adaptive filters (8 hours)

Godard algorithm, Lattice, Neural networks and multi-layer perceptrons, Adaptive IIR filtering. Blind adaptive filtering, Cost functions, Higher-order statistics.

Text/Reference Books:

1. S. Haykin, Adaptive Filter Theory, Prentice-Hall, 4-th edition, 2001.
2. Ali H. Sayed, Fundamentals of Adaptive Filtering, John Wiley, 2003.
3. D. Manolakis, V. Ingle, S. Kogan, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw Hill, 1999.
4. B. Widrow, S. Stearns, Adaptive Signal Processing, Prentice-Hall, 1985.

Course Code	Course Name	L	T	P	Credits
EC503	Statistical Signal Processing	3	0	0	3

Course Objectives

The students will be able to appreciate advanced techniques in signal processing in a non deterministic setting and apply this to a variety of applications and also appreciate the current literature.

Course Outcomes

After completing this course, the student will be able to:

CO1: The students would learn how to use iterative techniques to solve parameter estimation problems.

CO2: Theoretical guarantees of iterative and recursive methods will be learnt to enable them to choose the appropriate method for signal processing systems.

CO3: A good understanding of techniques like Kalman Filtering and Recursive Least-Squares techniques will be useful to extend them to machine learning paradigms

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	H	H	L	H	L	L	M	L	M	M

Syllabus

Module 1: Review of digital signal processing (06 hours)

Representation of Narrow band signals, correlation analysis and spectral density, minimum phase and system invertibility, spectral factorization, lattice filter realization.

Module 2: Statistical characterization and analysis of signals (12 hours)

Discrete time stochastic processes, Second Order statistics, Stationarity, Ergodicity, Frequency domain description of stationary processes: autocorrelation, power spectral density, white noise; Linear Systems with Stationarity random inputs and cross power spectral density; Innovation Representation – Eigen Decomposition, K-L transform.

Module 3: Linear Signal Models (04 hours)

Linear Non Parametric and parametric models, Mixed processes and the Wold Decomposition; All-Pole Models : Model Properties, All-pole modelling and Linear Prediction, AR Models, Lower Order Models; All-Zero Models: Model properties, MA Models, Low order Models; Pole-Zero Models: Model Properties, Autoregressive Moving-Average Models, The First -Order Pole-Zero Model.

Module 4: Optimal Linear Filtering (12 hours)

Optimum signal estimation, Linear Mean Square Estimation – Error performance measure, Linear MMSE Estimator, Principal Component Analysis of the optimum Linear Estimator, Geometric Interpretation and Principle of Orthogonality, Optimum FIR and IIR Filter design and properties and application to filtering to additive noise, Linear Prediction. The principle of least squares, Linear Least-Squares Error Estimation, Least Square filtering, Least squares Signal Estimation, Least Square computations using SVD. Methods of Steepest descent; Least-Mean-Square Adaptive Filters – stability and steady state in Stationary Signal Operating Environment (SOE), RLS Algorithm.

Module 5: Applications (12 hours)

Echo cancellation, Linear Predictive coding, Noise Cancellation, Stability and Steady-State Performance of Adaptive filters; Fundamentals of Array processing and Beam forming.

Text books/Reference Books:

1. S. Haykin, Adaptive Filter Theory, Prentice-Hall, 4-th edition, 2001.
2. D. Manolakis, V Ingale, S Kogon, “Statistical and Adaptive Signal Processing”, Artech House, 2005.
3. Ali H. Sayed, Fundamentals of Adaptive Filtering, John Wiley, 2003.
4. D. Manolakis, V. Ingle, S. Kogan, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, McGraw Hill, 1999.
5. B. Widrow, S. Stearns, Adaptive Signal Processing, Prentice-Hall, 1985.

Course Code	Course Name	L	T	P	Credits
EC504	Digital Image Processing	3	0	0	3

Course Objectives

1. The main objective of studying this course is to know the basics and theoretical concepts of image formation and representation.
2. To know the importance of image enhancement using time domain as well as frequency domain.
3. To understand the significance of image segmentation and how it works for real time object detection and image analysis.
4. To observe the impact of image restoration process and binary image processing algorithms to useful in the field of image processing.
5. To understand the use of image compression algorithms for efficient storage and effective transmission of image data.

Course Outcomes

After completing this course, the student can able to

CO1. Know how to enhance the image quality using spatial and frequency domain image enhancement algorithms.

CO2. Understand the types of edges in an image and how it can be extracted from the image by using image segmentation algorithms.

CO3. Observe the effect of inverse filtering, and wiener filtering to restore the original image from the degraded image.

CO4. Get the significance of morphological operations helps in binary image processing.

CO5. Know the importance of image compression standards and how it reduces storage space without compromising the image quality.

CO6. Understand the use of image processing algorithms in real time applications like object detection, medical image analysis, object recognition, etc.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	H	M	M	L	M	H	M	H	M	M
CO2	M	H	H	M	H	L	M	M	M	H	M	M
CO3	H	L	H	L	M	M	H	H	L	M	M	H
CO4	M	H	H	M	M	M	L	L	M	H	M	M
CO5	L	M	M	M	H	H	M	M	H	L	M	H
CO6	M	H	H	M	H	L	M	M	M	H	M	M

Syllabus

Module 1: Introduction to image processing (6 Hours)
Image formation, Sampling and Quantization, Image representation, Image resolution.

Module 2: Image Enhancement (10 Hours)
Image enhancement in Spatial domain, Gray level transformations: Image negative, μ-law, power law transformations, logarithmic functions. Contrast stretching, histogram, histogram equalization. Spatial filtering, LPF, HPF, Gaussian filtering, median filtering, high boost filtering, gradient, Laplace filtering, Image convolution, Halftoning, bilateral filtering.
Image enhancement in Frequency domain: 2D DFT, Properties of 2D DFT, image enhancement in Fourier domain.

Module 3: Image Segmentation (8 Hours)
Mask operation, edge, edge detection, canny edge detection, Hough transform, hard thresholding, optimal thresholding, OTSU method, region growing, region splitting and merging, watershed algorithm.

Module 4: Image Restoration and Binary image processing (10 Hours)
Inverse filtering, pseudo inverse filtering, Wiener filtering. Morphological operation, dilation, erosion, opening, closing, hit-or-miss transform.

Module 5: Image Compression (8 Hours)
Image compression techniques: Lossy and lossless compression, Fidelity criteria, Huffman coding, variable length coding, arithmetic coding, dictionary-based coding, predictive coding, Transform coding, JPEG, JPEG2000, Image warping, Image pyramids.

Text/References Books

1. Rafael C Gonzalez and Richard E Woods, Digital Image Processing, Pearson Education, 2nd Edition, 2002.

2. Kenneth R Castleman, Digital Image Processing, Pearson education, 1996.
3. Anil K Jain, Fundamentals of Digital Image Processing, Pearson Education, 1989.
4. S. Jayaraman, S. Esakkirajan, and T. Veerakumar, Digital Image Processing, 2nd Edition, Tata McGraw Hill, 2020.
5. Image processing journals and magazines.

Course Code	Course Name	L	T	P	Credits
EC505	**Computer Vision**	**3**	**0**	**0**	**3**

Course Objectives

1. This course emphasizes the development of algorithms and techniques for analyzing and interpreting the visible world around us.
2. Students will gain an understanding of fundamental concepts related to multi-dimensional signal processing, feature extraction, pattern analysis, visual geometric modeling, stochastic optimization, and more.
3. Knowledge of concepts such as depth estimation and multi-camera views will enable students to explore and contribute to research and advancements in the field of computer vision.

Course Outcomes

After completing this course, the student can able to

CO1. Know the image formation, low level image processing for the enhancement of the image quality using spatial and frequency domain image enhancement algorithms.

CO2. Understand the depth estimation concepts and multi camera view interpretation.

CO3. Observe the effect of inverse filtering, and wiener filtering to restore the original image from the degraded image.

CO4. Get the significance of feature extraction in image processing applications.

CO5. Know the importance of image segmentation algorithms and how it uses in the object detection and tracking applications.

CO6. Understand the use of motion analysis in video signal processing.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	H	M	M	L	M	H	M	H	M	M
CO2	M	H	H	M	H	L	M	M	M	H	M	M
CO3	H	L	H	L	M	M	H	H	L	M	M	H
CO4	M	H	H	M	M	M	L	L	M	H	M	M
CO5	L	M	M	M	H	H	M	M	H	L	M	H
CO6	M	H	H	M	H	L	M	M	M	H	M	M

Syllabus

Module 1: Digital Image Formation and low-level processing

Overview and State-of-the-art, Fundamentals of Image Formation, Transformation: Orthogonal, Euclidean, Affine, Projective, etc; Fourier Transform, Convolution and Filtering, Image Enhancement, Restoration, Histogram Processing.

Module 2: Depth estimation and Multi-camera views

Perspective, Binocular Stereopsis: Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.

Module 3: Feature Extraction

Edges - Canny, LOG, DOG; Line detectors (Hough Transform), Corners - Harris and Hessian Affine, Orientation Histogram, SIFT, SURF, HOG, GLOH, Scale-Space Analysis- Image Pyramids and Gaussian derivative filters, Gabor Filters and DWT.

Module 4: Image Segmentation and Pattern Analysis

Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.

Clustering: K-Means, K-Medoids, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA; Non-parametric methods.

Module 5: Motion analysis and Shape from X

Background Subtraction and Modeling, Optical Flow, KLT, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation.

Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation; Photometric Stereo; Use of Surface Smoothness Constraint; Shape from Texture, color, motion and edges.

Text/References Books/Journals

1. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer-Verlag London Limited 2011.
2. D. A. Forsyth and J. Ponce, "Computer Vision: A Modern Approach", Pearson Education, 2003.
3. Richard Hartley and Andrew Zisserman, "Multiple View Geometry in Computer Vision", 2nd Edition, Cambridge University Press, March 2004.
4. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006
5. R.C. Gonzalez and R.E. Woods, "Digital Image Processing", Addison- Wesley, 1992.
6. K. Fukunaga, "Introduction to Statistical Pattern Recognition", 2nd Edition, Academic Press, Morgan Kaufmann, 1990.
7. S. Jayaraman, S. Esakkirajan, and T. Veerakumar, "Digital Image Processing", 2nd Edition, Tata McGraw Hill, 2020.
8. IEEE-T-PAMI (IEEE Transactions on Pattern Analysis and Machine Intelligence).
9. IJCV (International Journal of Computer Vision) - Springer.

Course Code	Course Name	L	T	P	Credits
EC506	Information Theory and Coding	3	0	0	3

Course Prerequisite: Probability and random process, Digital communication

Course Objectives

1. To enable students to analyze fundamental of information theory
2. To explain source and channel coding and to find capacity for channels.

Course Outcomes

After completing this course, the student will be able to:

CO1: To estimate the information content of a source and the concept of entropy and its variants.

CO2: To have comprehensive knowledge of source coding methods

CO3: To have basic knowledge of channel capacity and channel coding techniques to achieve it.

CO4: Know different error correction coding algorithms

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Information Theory (10 hours)

Introduction: entropy and mutual information theory: joint entropy, conditional entropy, relationship between entropy and mutual information, chain rules for entropy, relative entropy, mutual information, Jensen's inequality Fano's inequality;

Module 2: Source Coding (12 hours)

An introduction to codes: coding: Kraft inequality, optimal codes, bounds on optimal code length, Kraft inequality for uniquely decodable codes, Shannon and Huffman codes, Shannon, Fano, Elias codes, block codes, linear block codes, cyclic codes, Efficient encoding, information sources; average code word length; Huffman encoding; noiseless coding: the noiseless coding theorem;

Module 3: Channel Coding (10 hours)

Channel capacity: discrete memoryless channels and capacity, examples of channel capacity, symmetric channels, properties of channel capacity, channel coding theorem;

Module 4: Error Correction code (10 hours)

Theory and practice of error-control coding: trellis diagram and the Viterbi algorithm, convolution coding in mobile communications and modern graph-based codes (turbo-codes and LPDC codes), the main coding theory problem

Text/Reference Books:

1. T. M. Cover and J. A. Thomas, Elements of Information Theory, Wiley Student Edition, 2009.
2. S. Lin and D. J. Costello, Error Control Coding, 2nd Edition, Pearson Prentice Hall, 2004.
3. R. G. Gallager, Information Theory and Reliable Communication, Wiley, 1968.
4. I. Csiszar and J. Korner, Information Theory: Coding Theorems for Discrete Memoryless Systems, Akademiai Kiado, 1981.
5. A. Neubauer, J. Freedenberg and V. Kuhn, Coding theory Algorithm, Architectures and Applications, Willey India Edition, 2007.

6. R. Bose, Information theory, Coding and Cryptography, TMH publication, 2008.

Course Code	Course Name	L	T	P	Credits
EC507	**Satellite Communication**	**3**	**0**	**0**	**3**

Course Prerequisite: Communication Engineering, Digital Communication

Course Objectives

1. Provide an in-depth treatment of satellite communication systems operation and planning, link design, modern satellite multiple access, modulation and coding schemes.
2. Review the state of the art in new research areas such as speech and video coding, satellite networking and satellite personal communications.

Course Outcomes

After completing this course, the student will be able to:

CO1: To know the orbital mechanics of a satellite

CO2: Able to design the communication link with proper planning.

CO3: To get the knowledge of modulations, multiplexing and multiple access techniques used in satellite communication

CO4: To get knowledge of positioning estimation using satellite constellations.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	M	L	M	L	L	L
CO4	H	H	H	H	L	H	L	L	M	L	M	M

Syllabus

Module 1: Overview of Satellite Systems and orbital mechanics (10 hours)

Orbital mechanics, Orbital parameters, Satellite trajectory, Period, Velocity and Position of a satellite, Geostationary satellites, Non-geostationary constellations, look angle determination, Launching of geostationary satellites, orbital perturbations. Satellite Subsystems.

Module 2: Satellite Link Design (12 hours)

Basic wireless transmission theory, system noise temperature and G/T ratio, Antenna parameters, Transmission Equations for down and uplinks, system design examples and design issues.

Module 3: Modulations, multiplexing and multiple access techniques (10 hours)

Modulation and multiplexing: Voice, data, video, analog- digital transmission system, digital video broadcast, Multiple Accesses: FDMA, TDMA, CDMA in satellite communication.

Module 4: Satellite Mobile and Specialized Services (10 hours)

Satellite Mobile Services, VSATs, RADARSAT, Global Positioning Satellite System (GPS), ORBCOMM, IRIDIUM.

Text/Reference books:

1. T. Pratt, C. Bostian and J. Allnutt, Satellite Communications, 2nd Ed., Wiley India, 2006.
2. W. L. Pritchart, H. G. Suyderhoud and R. A. Nelson, Satellite Communication Systems Engineering, 2nd Ed., Pearson Education, 2012.
3. D. Roddy, Satellite Communications, 4thEd., Tata McGraw-Hill Education, 2014.

Course Code	Course Name	L	T	P	Credits
EC508	Fiber Optical Communication	3	0	0	3

Course Prerequisite: **EC200, EC252**

Course Objective

The objective is to understand concepts related to optical components, links and systems.

Course Outcomes

After completing this course, the student will be able to:

CO1: Get the fundamentals of optical Communications

CO2: To have comprehensive knowledge about the optical sources

CO3: To get the knowledge about the optical amplifier

CO4: Digital transmission in optical link

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	M	L	M	L	L	L
CO4	H	H	H	H	L	H	L	L	M	L	M	M

Syllabus

Module 1: Introduction (14 hours)

Motivation for Light wave Communications, Key Elements of Optical Fiber Systems, Standards for Optical Fiber Communication. Optical Fibers (Structures, Wave guiding and Fabrication) : Fundamentals of Optical Laws and Definitions, Optical Fiber Modes and Configurations, Mode Theory for Circular Waveguides, Single Mode Fibers, Graded Index Fiber Structure. Signal Degradation in Optical Fibers, Attenuation, Losses, Dispersion and Group Delay, Pulse Broadening in GI Fibers.

Module 2: Optical Sources (12 hours)

Optical Sources: Direct and Indirect band gap materials, LED and Laser Diodes – Principle of Operation, Concepts of Line Width, Phase Noise, Switching and Modulation Characteristics Optical Detectors: PN detector, pin detector, Avalanche photodiode – Principles of operation, concepts of responsivity, sensitivity and quantum efficiency, noise in detection, typical receiver configurations (high impedance and trans Impedance receivers).

Module 3: Optical Amplifiers (8 hours)

Optical Amplifiers: Basic Applications and Types of Optical Amplifiers, Semiconductor Optical Amplifiers, Erbium-Doped Fiber Amplifiers, Amplifier Noise, Optical SNR, Raman Amplifiers.

Module 4: Digital Transmission (8 hours)

Digital transmission system-point-to-point links, fiber splicing and connectors, link power budget, rise-time budget, noise effects on system performance, operational principles of WDM and SONET.

Text/Reference Books:

1. Gerd Keiser, "Optical Fiber Communication", McGraw-Hill International, Singapore, 2000.
2. A Selvarajan, S. Kar, Optical Communications, Tata McGraw Hill, 2006.
3. Leonid Kazovsky, Sergio Benedetto and Alan Willner, "Optical Fiber Communication Systems", Artech House, 1996.
4. G. P. Agrawal, "Nonlinear Fiber Optics", 3rd Edition, Academic Press, 2004.
5. G.P. Agrawal, "Fiber optic communication systems", 3rd Edition, Wiley-Interscience, 2002.

Course Code	Course Name	L	T	P	Credits
EC509	**Spread Spectrum Communication**	**3**	**0**	**0**	**3**

Course Prerequisite: Digital Communication

Course Objectives

1. To enable students to understand different spread spectrum techniques and their applications.
2. Implementation of spread spectrum techniques in modern wireless communication.

Course Outcomes

After completing this course, the student will be able to:

CO1: Knowledge about spread spectrum pseudo sequences

CO2: Knowledge of different code generation and their properties

CO3: Knowing the spread spectrum modulation and demodulation techniques

CO4: Testing the performance in real time systems

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	M	M	M	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	M	L	L	L	L	L
CO4	H	M	H	H	L	H	L	L	M	L	L	L

Syllabus

Module 1: Introduction (10 hours)

Introduction to Spread Spectrum Systems: Introduction, Pulse Noise Jamming, Low Probability of Detection, Direct Sequence Spread Spectrum, Frequency Hop Spread Spectrum, Hybrid Direct Sequence/ Frequency Hop Spread Spectrum.

Module 2: Spread Spectrum Systems (14 hours)

Spread Spectrum Systems: Definitions, Mathematical Background and Sequence Generator Fundamentals, Maximum Length Sequences, Gold Codes, Nonlinear Code Generators.

Property of codes for spread spectrum, Autocorrelation and cross correlation of codes, composites codes, code selection and signal spectra, error detection and correlation codes.

Code Tracking Loops: Optimum Tracking of Wideband Signals, Baseband Delay Lock Tracking Loop, Code Tracking Loops for Frequency Hop Systems.

Module 3: Modulation and Demodulation (8 hours)

Modulation and demodulation- Balance modulator, quadriphase modulator, frequency synthesis for spread spectrum modulation, in line and heterodyne correlation, base band recovery, phase lock loop, costas loop, FM. Need for synchronization, types of synchronizers, RF link- Noise figure, co channel users, dynamic range and AGC, propagation medium, overall transmitter and receiver design.

Module 4: Digital Transmission (8 hours)

Test and evaluation of spread spectrum system- selectivity, sensitivity, jamming margin, synch acquisition, processing gain. Transmitter measurements

Text/Reference Books:

1. R. C. Dixen, "Spread Spectrum Systems with commercial application", John Wiley, 3rd Ed.
2. R. L. Peterson, R. E. Ziemer and D. E. Borth, "Introduction to Spread spectrum Communication", Pearson, 1995.
3. M. K. Simon, J. K. Omura, R. A. Scholtz and B. K. Levitt, "Spread spectrum communications", Handbook, McGraw-Hill, 2001.
4. J. S. Lee, "CDMA Systems Engineering handbook", Artech House, 1998.

Course Code	Course Name	L	T	P	Credits
EC510	Wireless Communication	3	0	0	3

Course Objectives

1. This course aims to cover the fundamental concepts and insights behind the development of modern wireless communication technologies such as 2G/3G/4G/5G.
2. Students will be exposed to modeling and analysis of wireless system along with several key technologies of the modern communication such as GSM, CDMA, SIMO/ MISO, OFDM, MIMO, MIMO-OFDM in detail.
3. It is anticipated that students will develop a deep understanding of nature and modeling of wireless mediums, performances of various modulation schemes, large and small-scale signal fading, diversity, channel estimation, signal reception techniques, multiple access technologies, teletraffic theory.

Course Outcomes

At the completion of this course, the student shall acquire knowledge and ability:

CO1. Acquire knowledge of the basics of modern wireless communication technologies such as 2G/3G/4G/5G.

CO2. Understanding of the significance of modeling and characterization of wireless mediums and signals, multiple access technologies, fundamentals of modern cellular network, performances of various modulation schemes, large and small-scale signal fading, diversity, mobility and Doppler effect, channel estimation, signal reception techniques and teletraffic theory.

CO3. Develop a profound understanding of the application of MIMO systems in modern wireless communication systems.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	L	L	L	H	H	M		L	M		H
CO2	H	H	H	M	H	H	M		L	M		H
CO3	H	H	H	M	H	H	M		L	M		H

Syllabus

Module 1: Principles of Wireless Communications (8 hours)

Introduction to 2G/3G/4G/5G wireless communications, modelling of wireless systems, Rayleigh fading wireless channel, BER performance, channel estimation for single antenna systems, introduction to diversity, multiple receive antenna system model and its BER performance, realization of independent paths, diversity system model, maximal ratio combining, channel estimation for multi-antenna system, diversity order.

Module 2: Wireless-System Planning (7 hours)

Large scale fading, free space propagation model, ground reflection model, Okumura and Hata models, log normal shadowing, receiver noise analysis, practical link budget analysis, teletraffic system model and steady-state analysis, determination of percentage of coverage area.

Module 3: Small Scale Fading and Multipath Propagation (7 hours)

Impulse response model of a multipath channel, parameters of mobile multipath channels: time dispersion parameters, coherence bandwidth, ISI and coherence bandwidth, Doppler spread and coherence time, types of small scale fading: flat fading, frequency selective fading, fast fading, slow fading, Jakes model for wireless channel correlation.

Module 4: GSM system (FDM-TDMA) (6 hours)

Description of GSM system block diagram, SIR analysis, channel reuse analysis: D/R ratio, N_reuse, cell sectorization, spectrum efficiency, channel allocation and multicell Erlang models, call blocking analysis, handovers – techniques, models and analysis.

Module 5: Fundamental Concepts of Spread Spectrum Systems (6 hours)

Code Division for Multiple Access (CDMA), Pseudo noise sequence, performance of direct sequence spread spectrum systems, analysis of direct sequence spread spectrum systems, the processing gain and anti-jamming margin, frequency hopped spread spectrum systems, time hopped spread spectrum systems, synchronization of spread spectrum systems, RAKE receiver.

Module 6: Multiple-Input Multiple-Output Wireless Communications (8 hours)

Multiple-Input Multiple-Output Wireless Communications: MIMO system model, zero-forcing receiver, MMSE receiver, SVD and MIMO capacity, Alamouti codes, OSTBC, V-BLAST, OFDM, MIMO-OFDM, SC-FDMA receiver.

Text/Reference Books:

1. Aditya K. Jagannatham, "Principles of Modern Wireless Communication Systems, Theory and Practice", 1st Edition, McGraw Hill Education, 2017.
2. Theodore Rappaport, "Wireless Communications: Principles and Practice", 2nd Edition, Pearson, 2010.
3. Anurag Kumar, D. Manjunath, and Joy Kuri, "Wireless Networking", Morgan Kaufmann Publishers, 2008.
4. Simon Haykin and Michael Moher, "Modern Wireless Communication", Prentice Hall, 2005.
5. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.

Course Code	Course Name	L	T	P	Credits
EC511	**Wireless and Mobile Communication**	**3**	**0**	**0**	**3**

Course Prerequisite: Probability and Random Process, Digital Communication

Course Objective

1. To enable students to understand concepts regarding wireless medium, cellular systems of mobile communication and spread spectrum technique.

Course Outcomes

After completing this course, the student will be able to:

CO1: To have the basic knowledge of wireless channel modeling and BER performance

CO2: To understand the basics of cellular communication and its performance measure.

CO3: To have comprehensive knowledge about modulation techniques used in wireless communication.

CO4: To have knowledge about MIMO/OFDM system

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	M	L	M	L	L	L
CO4	H	H	H	H	L	H	L	L	M	L	M	M

Syllabus

Module 1: Wireless Channel and Diversity (8 hours)

Wireless Channels: Fading Wireless Channel Modeling, Rayleigh/Rician Fading Channels, BER Performance in Fading Channels, Diversity modeling for Wireless Communications, BER Performance Improvement with diversity, RMS Delay Spread, Doppler Fading, Jakes Model, Jakes Spectrum, Impact of Doppler Fading, Types of Diversity – Frequency, Time, Space.

Module 2: Cellular Communication (12 hours)

Cellular Communications: Introduction to Cellular Communications, Frequency reuse, Multiple Access Technologies, Cellular Processes -Call Setup, Handover, grade of service

Module 3: Modulation Schemes (10 hours)

Review of Digital Communication: Block diagram of digital communication, Modulation Schemes (BPSK, M-PSK, M-QAM, M-FSK), Pulse Shaping, Bandwidth efficiency, MAP-Receivers, AWGN Channel and Performance analysis, Introduction to CDMA, Walsh codes, PN Sequences, Multipath diversity, RAKE Receiver

Module 4: MIMO OFDM (10 hours)

Introduction to MIMO, MIMO Channel Capacity, SVD and Eigenmodes of the MIMO Channel, MIMO Spatial Multiplexing–BLAST, MIMO Diversity–Alamouti, OSTBC, Introduction to OFDM, Multicarrier Modulation and Cyclic Prefix, OFDM Issues; Wireless Standards: GSM, GPRS, WCDMA, LTE, WiMAX.

Text/Reference Books:

1. Theodore Rappaport, "Wireless Communications: Principles and Practice", 2nd Edition, Pearson 2010.
2. Simon Haykin, Michael Moher, "Modern Wireless Communication", Prentice Hall, 2005
3. D. Tse and P. Viswanath, "Fundamentals of Wireless Communications", Cambridge University Press, 2005.
4. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.

Course Code	Course Name	L	T	P	Credits
EC512	Remote Sensing Systems	3	0	0	3

Course Prerequisite: Electromagnetics

Course Objective

1. To make understanding of remote sensing methodology in both optical and microwave domains.

Course Outcomes

After completing this course, the student will be able to:

CO1: To have the basic knowledge of electromagnetics used in remote sensing

CO2: Able to know the way electromagnetic waves interact with different medium

CO3: To have comprehensive knowledge about optical remote sensing

CO4: To have comprehensive knowledge about electromagnetic remote sensing

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	M	L	M	L	L	L
CO4	H	H	H	H	L	H	L	L	M	L	M	M

Syllabus

Module 1: Electromagnetics Basics (8 hours)

Electromagnetic waves, Polarization, Spectra and Fourier transform, Doppler effect, Angular, Distribution of radiation, Thermal radiation, diffraction.

Module 2: Interaction of Electromagnetic Radiation (12 hours)

Interactions of electromagnetic radiation: Propagation through homogeneous materials, Reflection and emission from real materials, Propagation through the atmosphere Molecular absorption and scattering, Radiative transfer equation.

Module 3: Optical Remote Sensing (10 hours)

Electro optical remote sensing system: Spectral Imagery, VIR imaging systems, Thermal infrared imagers.

Module 4: Microwave Remote Sensing (10 hours)

Passive Microwave Systems: Antenna Theory, Microwave Radiometry, Ranging Systems: Laser profiling, Radar altimetry, Scattering Systems: Lidar, Microwave Scatterometry, Synthetic Aperture Radar, Data Processing: Image Processing, Classification and Segmentation, Applications of Remote Sensing Systems.

Text/Reference Books:

1. W. G. Rees, Physical Principles of Remote Sensing, Cambridge University Press; 3rd edition, 2013.
2. R. C. Olsen, Remote Sensing from Air and Space, SPIE Press, 2007.
3. James B. Campbell, Randolph H. Wynne, Introduction to Remote Sensing, 5th Edition, Guilford Press, 2011.

Course Code	Course Name	L	T	P	Credits
EC513	Radar and Navigation System	3	0	0	3

Course Prerequisite: Electromagnetics and Communication Engineering

Course Objectives

1. To introduce the fundamental concepts of RADAR (RAdio Detection And Ranging) and Navigational aids.
2. To expose the students to different types of RADAR systems and Navigation.

Course Outcomes

After completing this course, the student will be able to:

CO1: Knowledge about the Fundamentals of Radar

CO2: Different types of Radar and their working

CO3: Radar signal Detection techniques

CO4: Radar Navigation techniques

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	M	L	M	L	L	L
CO4	H	H	H	H	L	H	L	L	M	L	M	M

Syllabus

Module 1: Introduction to Radar Systems (8 hours)

RADAR Block Diagram & operation, RADAR Frequencies, RADAR Equation, Detection of signals in Noise, RADAR cross section of targets, RADAR cross section fluctuations, transmitter power, pulse repetition frequency, system losses and propagation effects.

Module 2: MTI and Pulse Doppler Radar (12 hours)

Introduction to Doppler & MTI RADAR, Delay Line canceller, Moving Target Detector, Pulse Doppler RADAR, Non-Coherent MTI, CW RADAR, FMCW RADAR, Tracking RADAR, Monopulse Tracking, Conical Scan and Sequential Lobing.

Module 3: RADAR Signal detection and Propagation of Waves (10 hours)

Detection criteria, automatic detection, constant false alarm rate receiver, Ambiguity diagram, pulse compression – introduction to clutter surface clutter RADAR equation – anomalous propagation and diffraction.

Module 4: Radio Navigation system (10 hours)

Adcock directional finder- automatic directional finder- hyperbolic Systems of Navigation- Loren and Decca Navigation System- Tactical Air Navigation. Track stabilization, Doppler navigation system, GPS principle of operation, Position location determination.

Text/Reference Books:

1. M. I. Skolnik, "Introduction to Radar System", Publisher: McGraw Hill.
2. Sen and Bhattacharya, "Radar Systems and Radio Aids to Navigation", Publisher: Khanna publishers.
3. F. E. Terman, "Electronic and Radio Engineering", Publisher: McGraw Hill.
4. M.I. Skolnik, "Radar Engineering Hand Book", Publisher: McGraw Hill.
5. Roger J Sullivan, "Radar Foundations for Imaging and Advanced Topics".
6. N S Nagaraja, "Elements of Electronic Navigation", TMH.

Course Code	Course Name	L	T	P	Credits
EC514	Modern Radar System	3	0	0	3

Course Objectives

1. Basics of Radar techniques for target detection in presence of clutter as well as noise.
2. Target and clutter modelling for signal processing.
3. Advanced digital signal processing for radar systems.

4. Masters students will be able to know the operational principle of various radar systems and their present day signal processing advancements.

Course Outcomes

After completing this course, the student will be able to:

CO1: Able to carry out research and development of the RADAR systems design.

CO2: Become well aware of the variety of RADAR systems, their application in divergent fields and technology developments including the recent low cost RADARS.

CO3: Able to do in-depth analysis on technology variations in RADAR depending on the application and involvement of signal processing, ASIC and FPGA development issues.

CO4: Getting the knowledge on the physical layer of communication systems, signal generation technology, detection and estimation, signal processing of RADAR sub-systems.

CO5: Computer control of Modern RADARs including antenna beam steering, null placement, weather forecasting

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M
CO5	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Introduction (6 hours)

Introduction, Radar Basics, Radar Equation including its search and track forms, Displays, Receivers, Transmitters, Radar Antennas including Reflectors and Phased Array Antennas,

Module 2: Radar Cross Section (5 hours)

Radar Cross Section, Statistical Models for Noise and Target RCS, [5 Hours]

Module 3: Doler and MTI Radar (11 hours)

General Characteristics of Clutter and Clutter Modelling, Clutter Reduction Techniques of Doppler and MTI

Module 4: Radar measurement (12 hours)
Radar Measurements, Pulse compression, Radar Tracking, Radar Detection and Target Classification, Constant False Alarm Rate Detectors, DPCA and STAP

Module 5: Emerging trends (4 hours)
Types of modern Radar and their application, Emerging Trends.

Text/Reference Books:

1. M.A. Richards et al, "Principles of Modern Radar, Basic Principles", *Vol. 1,1st Edition,* SciTech, 2010
2. M. I. Skolnik, "Radar Systems", 3rd Edition, Tata McGraw Hill, 2008.
3. Hamish Meikle, "Modern Radar Systems", 2nd Edition, ARTECH House, Inc, 2014.
4. Francois Le Chevalier, "Principles of Radar and Sonar Signal Processing", Artech House, 2002.

Course Code	Course Name	L	T	P	Credits
EC515	Microwave Devices and Circuits	3	0	0	3

Course Objectives

1. To understand the theory and principles of transmission lines and microwave networks.
2. To analyze microwave networks using different parameters and techniques.
3. To design and understand the functioning of power dividers, directional couplers, and microwave filters.
4. To study the operation and applications of various microwave semiconductor devices.
5. To familiarize with the concepts and techniques from reference books in the field of microwave engineering.

Course Outcomes

CO1. Understand transmission line theory fundamentals for both lossless and lossy lines.
CO2. Apply analytical tools like the Smith chart for impedance analysis.
CO3. Ability to analyze microwave networks using impedance and scattering matrices.
CO4. Ability to design microwave components like power dividers and filters.
CO5. Understand microwave semiconductor devices for circuit use.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	M	H	H	H	M	H	H	H
CO2	H	H	H	H	H	H	H	H	H	H	H	H
CO3	H	H	H	H	H	H	H	H	H	H	H	H
CO4	H	H	H	H	H	H	H	H	H	H	H	H
CO5	M	M	M	H	H	M	M	H	M	M	M	M

Syllabus

Module 1: Transmission Line Theory (12 hours)

The lumped element circuit model for a transmission line, transmission line parameters, propagation constant, impedance, and power flow for the lossless coaxial line, special cases of lossless terminated lines, Smith chart, combined impedance–admittance Smith chart, slotted line, quarter-wave transformer, generator and load mismatches, lossy transmission lines, low-loss line, distortion less line, terminated lossy line.

Module 2: Microwave Network Analysis (9 hours)

Equivalent voltages and currents, concept of impedance, impedance and admittance matrices of microwave junctions, scattering matrix representation of microwave networks, ABCD parameters, excitation techniques, impedance matching and tuning.

Module 3: Power Dividers, Directional Couplers and Microwave Filters (11 hours)

Scattering matrix of 3- and 4-port junctions, T-junction power divider, Wilkinson power divider, qualitative description of two-hole and multi-hole waveguide couplers, hybrid junctions, filter design by the image parameter method, filter design by the insertion loss method, filter transformations.

Module 4: Microwave Semiconductor Devices (10 hours)

Operation and circuit applications of Gunn diode, IMPATT diode, PIN Diode, and Schottky barrier diode; microwave BJT, MESFET, HEMT and their applications.

Text/Reference Books:

1. Pozar, D.M., *Microwave Engineering*, 4th Ed., John Wiley & Sons, 2014.
2. Liao, S.Y., *Microwave Devices and Circuits*, 3rd Ed., Pearson Education India, 2003.
3. Collin, R.E., *Foundations for Microwave Engineering*, 2nd Edition, John Wiley & Sons, 2001.

Course Code	Course Name	L	T	P	Credits
EC516	Power Electronics	3	0	0	3

Course Objectives

1. Understanding the constructions, characteristics and operation of various power semiconductor switches.
2. To learn the detail working of various types of converters, their analysis and design under various types of loads.
3. To learn the controlling of various types of converters and their applications in emerging areas.

Course Outcomes

CO1. Understand power semiconductor devices and their operational principles.

CO2. Analyze and design various converters for different load conditions.

CO3. Control different types of converters and apply them in emerging areas.

CO4. Master thyristors, controlled rectifiers, voltage controllers, and DC-DC converters.

CO5. Apply power electronics concepts to real-world applications in generation, transmission, and utilization sectors.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	L	H	M	H	H	H	L	H	H	H
CO2	H	H	H	H	H	M	M	M	H	H	H	H
CO3	H	H	H	H	M	H	H	H	H	H	H	H
CO4	H	H	H	H	M	H	H	H	H	H	H	H
CO5	M	M	M	H	H	M	M	H	M	M	M	M

Syllabus

Module 1: Introduction (8 hours)

Power semiconductor devices, control characteristics, Power Transistors, Power MOSFETs, IGBTs.

Module 2: Thyristors and Controlled Rectifiers (12 hours)

Thyristors: Principle of operation and terminal characteristics, switching mechanism and Gate characteristics, Thyristor protection, firing circuits, resistance firing circuit, resistance capacitance firing circuit. Controlled Rectifiers: Single-phase controlled rectifiers, single-phase full converter with RL Load, single-phase dual converters, single-phase semi converter with RL load, three phase rectifiers.

Module 3: Voltage Controllers and DC-DC converters (10 hours)

Voltage Controllers: Single-Phase AC Voltage Controllers, Three-Phase AC Voltage Controllers and Cycloconverters. Non-isolated DC-DC converters: Buck, Boost, Buck-boost & Cuk

Module 4: Inverters and application of Power Electronics (12 hours)

DC-AC Inverters: Single-phase and three-phase, modulation techniques, Current Source inverter. Applications of power electronics in Generation, Transmission, Distribution & Utilization sectors.

Text/Reference Books:

1. M. H. Rashid, "Power Electronics: Circuits, Devices and Applications", Pearson Education, PHI, 3rd Edition, New Delhi, 2004.
2. P. S. Bimbra, "Power Electronics", Khanna Publishers, third Edition, 2003.
3. L. Umanand, "Power Electronics Essentials and Applications", Wiley, 2010.
4. Joseph Vithayathil, "Power Electronics, Principles and Applications", McGraw Hill Series, 6th Reprint, 2013.
5. Ned Mohan, Tore. M. Undel and William. P. Robbins, "Power Electronics: Converters, Applications and Design", John Wiley and Sons, 3rd Edition,2003
6. Philip T. Krein, "Elements of Power Electronics" Oxford University Press, 2004 Edition.

Course Code	Course Name	L	T	P	Credits
EC517	**VLSI Testing and Testability**	**3**	**0**	**0**	**3**

Course Objectives

1. To understand the concepts and techniques of VLSI design verification and testing.
2. Concepts of defects, fault modeling and simulation,
3. Details of test economy and concept of yield.
4. To understand Automatic Test Pattern Generation (ATPG), design for testability, and built-in self-test (BIST)

Course Outcomes

After completing this course, the student can able to understand

CO1. Concepts of defects and faults

CO2. The modeling of various types of faults and their need for the testing.

CO3. Need for the design verification and testing of VLSI circuits

CO4. **Test** and testability economy and yield requirements.

CO5. The developments of design algorithm and verification requirements

CO6. ATPG algorithm implementation.

CO7. Implement the DFT and built in self-test for the verification of IC's

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	L	L	L	L	M	L	L	L
CO2	H	M	M	H	L	L	L	L	M	L	L	M
CO3	H	M	M	H	L	L	L	L	M	L	L	L
CO4	H	H	H	H	L	L	L	L	M	L	M	L
CO5	H	H	H	H	L	L	L	L	M	L	M	M
CO6	H	H	H	H	L	L	L	L	M	L	M	M
CO7	M	M	M	M	M	L	L	L	L	L	L	L

Syllabus

Module 1: Fundamental of VLSI testing (12 hours)

Basic of VLSI testing, Scope of testing and verification in VLSI design process, Issues in test and verification of complex chips, embedded cores and SOCs

Module 2: Fault Modeling and testing (12 hours)

Fault models, fault detection and redundancy, fault equivalence and fault location, fault dominance, automatic test pattern generation, Design for testability, Scan design, Test interface and boundary scan. System testing and test for SOCs. Delay fault testing.

Module 3: Test automation and Design verification (10 hours)

BIST for testing of logic and memories, Test automation, Design verification techniques based on simulation, analytical and formal approaches.

Module 4: Functional and Timing verification (8 hours)

Functional verification, Timing verification, Formal verification, Basics of equivalence checking and model checking, Hardware emulation.

Text/Reference books:

1. M. Abramovici, M. A. Breuer and A. D. Friedman, "Digital Systems Testing and Testable Design", Jaico Publishing House, 2001.
2. M. Bushnell and V. D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", 2002 Edition, Springer Publishers, 2013.
3. Rolf Drechsler and Sebastian Huhn, "Design for Testability, Debug and Reliability: Next Generation Measures Using Formal Techniques", Springer, May 2022.
4. Zainalabedin Navabi, "Digital System Test and Testable Design: Using HDL Models and Architectures", Springer, 2010.
5. Laung-terng Wang, Charles E. Stroud, Nur A. Touba "System-On-Chip Test Architectures: Nanometer Design for Testability", Morgan Kaufmann Publication, November, 2007.
6. Thomas Kropf, "Introduction to Formal Hardware Verification", Springer-Verlag Berlin and Heidelberg GmbH & Co. K, 2010.
7. Neil H. E. Weste and David Harris, "Principles of CMOS VLSI Design", Addison Wesley, Third Edition, 2004.

Course Code	Course Name	L	T	P	Credits
EC518	**Low-Power VLSI**	**3**	**0**	**0**	**3**

Course Objectives

1. To analyse the needs of low power VLSI design and study of its requirements
2. To understand the critical requirements and implementation of Low-power VLSI circuits.
3. To understand the different sources of power dissipation and their analysis.
4. To learn critical issue related to continued scaling of microelectronic circuits
5. To understand the critical issue related to power and performance management in system design

Course Outcomes

After completing this course, the student can able to understand

CO1. Need for low power circuit design

CO2. The various sources of power dissipation.

CO3. The methods to address the requirement of minimize the static power dissipation

CO4. Various methods of low power circuit design.

CO5. Necessity of scaling and its effects on circuits

CO6. The developments of system level power and performance optimization.

CO7. Different power management techniques.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	L	L	L	L	M	L	L	L
CO2	H	M	M	H	L	L	L	L	M	L	L	M
CO3	H	M	M	H	L	L	L	L	M	L	L	L
CO4	H	H	H	H	L	L	L	L	M	L	M	L
CO5	H	H	H	H	L	L	L	L	M	L	M	M
CO6	H	H	H	H	L	L	L	L	M	L	M	M
CO7	M	M	M	M	M	L	L	L	L	L	L	L

Syllabus

Module 1: Introduction (08 hours)

Why Low Power? Sources of Power Dissipations, Static Power Dynamic Power. Low-Power Design Methodologies. Different inverter topologies for low voltages.

Module 2: Sources of Power Dissipation (12 hours)

Short-Circuit Power Dissipation, Switching Power Dissipation, Dynamic Power for a Complex Gate Reduced Voltage Swing, Internal Node Power, Switching Activity, Switching Activity of Static CMOS Gates, Inputs Not Equi-probable, Mutually Dependent Inputs, Transition Probability in Dynamic Gates, Power, Leakage Power Dissipation, p–n Junction Reverse-Biased Current, Band-to-Band Tunneling Current, Subthreshold Leakage Current

Module 3: Low-Voltage CMOS Circuits (12 hours)

Design style, Leakage current in Deep sub-micron transistors, device design issues, minimizing short channel effect, Low voltage design techniques using reverse Vgs, steep sub threshold swing and multiple threshold voltages, testing with elevated intrinsic leakage, multiple supply voltages

Module 4: Supply Voltage Scaling for Low Power (10 hours)

Device Feature Size Scaling, Architectural-Level Approaches, Voltage Scaling Using High-Level Transformations, Multilevel Voltage Scaling, Challenges in MVS, Dynamic Voltage and Frequency Scaling, Adaptive Voltage Scaling, Subthreshold Logic Circuits.

Text/Reference Books:

1. Kaushik Roy, and Sharat Prasad, "Low-Power CMOS VLSI Circuit Design", Wiley, 2000.

2. Ajit Pal, “Low-Power VLSI Circuits and Systems”, Springer, New Delhi, 2015
3. Anantha P. Chandrakasan, and Robert W. Brodersen, “Low Power Digital CMOS Design”, Kluwer Academic Publications, 1995.
4. Gary K. Yeap, “Practical Low Power Digital VLSI Design”, KAP, 2002
5. Rabaey, and Pedram, “Low Power Design Methodologies”, Kluwer Academic,1997
6. Philip Allen, and Douglas Holberg, “CMOS Analog Circuit Design”, Oxford University Press, 2002.

Course Code	Course Name	L	T	P	Credits
EC519	**Active Filter Design**	**3**	**0**	**0**	**3**

Course Objectives

1. To analyse the needs of filter design and study of its requirements
2. To understand the critical requirements and implementation of Active filter circuits.
3. To understand the fundamental concepts involved in the design of Continuous-time filters.
4. To design and verify the various filter circuits using op-amps and OTA’s.
5. To design and verify the various filter circuits using switched capacitor type.

Course Outcomes

After completing this course, the student can able to understand

CO1. Need for filter circuit design

CO1. The various active filter circuit’s requirements.

CO2. The methods to address the requirement of filter architectures

CO3. Various methods of on chip integrated continuous time filters.

CO4. Necessity of various active filter circuit design and their limitations

CO5. Op-amps and OTA based active filter circuit design and their simulations.

CO6. Switched capacitor circuit based filter

CO7. Simulate the and understand filter circuit using the cadence tool

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	L	L	L	L	M	L	L	L
CO2	H	M	M	H	L	L	L	L	M	L	L	M
CO3	H	M	M	H	L	L	L	L	M	L	L	L
CO4	H	H	H	H	L	L	L	L	M	L	M	L
CO5	H	H	H	H	L	L	L	L	M	L	M	M
CO6	H	H	H	H	L	L	L	L	M	L	M	M
CO7	M	M	M	M	M	L	L	L	L	L	L	L

Syllabus

Module 1: Filter Fundamentals (10 hours)

Filter Characterization, Continuous-Time Filter Functions, Steps in Filter design, Butterworth, Chebyshev & Inverse-Chebyshev filter response and pole locations. The Approximation Problem.

Module 2: Ladder filter structures (12 hours)

LC ladder filter - prototype & synthesis; Frequency transformation of low-pass filter. Active elements Impedance converters, Characteristics of IC op-amps, The Ideal Operational Transconductance Amplifier (OTA).

Module 3: Realizations of active filters (12 hours)

Active-RC filters, Gm-C filters- Elementary Transconductance Building blocks, off-set problems, Limitations of op-amp based filters. Characterization of on-chip integrated continuous time filters.

Module 4: Switched capacitor circuits (8 hours)

Switched capacitor filters- First-order building blocks- Second order sections.

Text/Reference Books:

1. R. Schaumann and M.E. Van Valkenburg, “Design of Analog Filters”, Oxford University Press, 2003.
2. P. V. Ananda Mohan, “Current-Mode VLSI Analog Filters - Design and Applications”, Birkhauser, 2003.
3. Arthur Williams, “Analog Filter and Circuit Design Handbook (ELECTRONICS)”, McGraw-Hill Professional, November 2013.
4. Gobind Daryanani, “Properties of Active networks synthesis and Design”, Wiley, 1st Edition, 1976.
5. M. E. Van Valkenburg, “Analog Filter Design”, Oxford University Press, 1995.
6. T. Deliyannis, Y. Sun and J. K. Fidler, “Continuous-Time Active Filter Design”, CRC Press, 1998.

7. Material from the Journal of Solid-state Circuits and the International Solid-state Circuits Conference proceedings.

Course Code	Course Name	L	T	P	Credits
EC520	Digital System Design using FPGA	3	0	0	3

Course Objectives

1. To understand the timing intricacies of combinational and sequential design, students must be able to Simulate and Implement typical Combinational and Sequential Digital Systems using HDL
2. To explores the development and deployment of FPGA-based digital systems using the hardware description languages.
3. To explore the basic idea of Memory & System organization and Architecture of Computers.
4. To develop the solid grounding in FPGA principles, practices, and applications.
5. To understand the concepts and techniques of VLSI design verification and testing.
6. To understand Automatic Test Pattern Generation (ATPG), design for testability, and built-in self-test (BIST)

Course Outcomes

After completing this course, the student can able to understand

CO1. Concepts of combinational and sequential design

CO2. To simulate the basic blocks of digital system design in HDL.

CO3. Understand the PLD, PLA and FPGA based Architecture

CO4. Implementation of sequential algorithm using on behavioral, structural and hybrid module

CO5. Deployment in FPGA and develop their testing requirements.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	H	H	L	H	L	L	H
CO2	H	M	M	H	L			L		L	L	
CO3	H	M	M	H	L			L		L	L	

CO4	H	H	H	H	L			L		L	M	
CO5	H	H	H	H	L			L		L	M	

Syllabus

Module 1: Sequential Design

Asynchronous Sequential Circuits: Asynchronous behaviour, Analysis of Asynchronous Circuits, Synthesis of Asynchronous Circuits, Race Condition, State reduction, State Assignment, Transition Diagrams, State Assignment using Additional State Variables.

Module 2: System designing using HDL

Verilog/VHDL Fundamentals, Module Representation, Timing and Delays in Modeling Hierarchical Module Representation, Test bench Formation in Verilog, Structure of a Verilog Testbench File, Displaying Test Results, Combinational and Sequential Circuits, State Machine Design, Examples.

Module 3: Field-Programmable Gate Arrays,

FPGA Building Blocks, FPGA- Fundamentals, FPGA Based Digital System Design Philosophy, Usage of FPGA Areas, Basys3 and Arty FPGA Boards or any other boards. Design with Programmable Devices: Programmable Logic Arrays, Programmable Array Logic.

Module 4: Test automation and Design verification

Digital System Testing: Fault models, Fault Equivalence, Design for Testability, Testing Combinational Logic and Sequential Logic, Scan Testing, Boundary Scan, Built –In- Self-Test (BIST).

Text/Reference books:

1. R. C. Cofer, Benjamin F. Harding, “Rapid System Prototyping with FPGAs Accelerating the Design Process”, Newnes, 2011.
2. Cem Ünsalan, Bora Tar, “Digital System Design with FPGA: Implementation Using Verilog and VHDL”, 1st Edition, McGraw-Hill Education, 2017.
3. Peter Wilson, “Design Recipes for FPGAs: Using Verilog and VHDL” 1st Edition, Newnes, 2007.
4. Frank Bruno , Guy Eschemann, “The FPGA Programming Handbook - Second Edition: An essential guide to FPGA design for transforming ideas into hardware using System, Verilog and VHDL” Paperback, 2024.
5. M. Morris Mano, Michael D. Ciletti, “Digital Design: With an Introduction to Verilog HDL”, 5th Edition, Pearson Education India, 2013.
6. S. Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis”, 2nd Edition, Pearson Education, 2004.
7. M. Bushnell and V. D. Agrawal, “Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits”, 2002 Edition, Springer Publishers, 2013.

Course Code	Course Name	L	T	P	Credits
EC521	Advanced Analog IC Design	3	0	0	3

Prerequisites: **EC201, EC203, EC300**

Course Objectives

1. Learn how to design analog and mixed signal integrated circuits
2. Learn how to analyze the behavior of analog and mixed-signal circuits
3. Learn how to evaluate the performance metrics of transistors, interconnects, and circuits.

Course Outcomes

After completing this course, the student can able to

CO1. Design and analyze complex circuits, including amplifiers, oscillators, and filters

CO2. Understand the trade-offs between design parameters, such as speed, accuracy, and power

CO3. Understand the process of designing circuits, including layout and power considerations

CO4. Develop an intuition for analog and mixed-signal circuit behavior.

CO5. Demonstrate the ability to think critically and evaluate sources of information

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	H	L	L	L	M	L	L	M
CO2	H	H	H	H	H	L	L	L	M	L	L	M
CO3	H	H	H	H	H	L	L	L	M	L	L	M
CO4	H	H	H	H	H	L	L	L	M	L	M	M
CO5	H	H	H	H	H	L	L	L	M	L	M	M

Syllabus

Module 1: Introduction and Basic building blocks. (12 hours)

Review of Single stage amplifiers, Current Mirrors, differential amplifiers, frequency response of the amplifier.

Bandgap Reference: Temperature Independent Biasing, Negative TC voltage, Positive TC voltage, Constant Gm Biasing, Low-Voltage Biasing. Noise analysis: Single stage amplifiers, differential amplifiers, Feedback analysis with loading effect.

Module 2: Operational Amplifier (12 hours)

Folded Cascode Amplifier, Telescopic Amplifier, Two Stage Op-Amp, Gain Boosting Technique, Common mode feedback technique, Biasing of the Amplifier, Slew Rate performance of Amplifier, Stability Analysis with Compensation Technique.

Nanometer Design: Transistor Design Consideration, Deep Submicron Effects, Scaling. Gm-Id method for implementation, Implementation of Amplifier using Gm-Id method. Closed loop performances.

Module 3: Introduction to Switched Capacitor Circuits (10 hours)

Mosfet as Switches, Sampling Switches, Sources of error, Switched Capacitor Amplifiers, Filter Design using Switched Capacitor, Integrator, Common mode Feedback.

Non linearity and Mismatch: Analysis and Linearization Technique

Module 4: PLL (08 hours)

Oscillators: Ring, LC etc. VCO: Tuning and Mathematical Model. PLL: Phase Detector, Charge pump topology, Jitter analysis

Text/Reference Books:

1. A S Sedra and K C Smith, "Microelectronic Circuits: Theory and Applications", Oxford University Press, 7th Edition 2017.
2. Behzad Razavi, "Microelectronics", John Wiley & Sons, 2nd Edition. 2018.
3. Behzad Razavi, "Principles of Data Conversion System Design", Wiley, 1995.
4. Behzad Razavi, "Design of Analog CMOS Integrated Circuits" 2nd Edition Wiley, 2016.
5. Franco Maloberti, "Understanding Microelectronics: A Top–Down Approach", Wiley, 2011.

Course Code	Course Name	L	T	P	Credits
EC522	Electromagnetic Interference and Compatibility	3	0	0	3

Course Objectives

1. Understand EMC requirements, radiation, and conduction emissions in electronic systems.
2. Analyze noise sources, coupling mechanisms, and mitigation techniques.
3. Study spectral analysis, emission models, and signal integrity in PCB designs.
4. Explore crosstalk, transmission line effects, and shielding techniques.
5. Learn EMC measurement methods for conducted and radiated emissions.

Course Outcomes

After completing this course, the student will be able to:

CO1: Explain EMC standards, radiated/conducted emissions, and regulatory limits.

CO2: Identify noise sources, coupling mechanisms, and shielding methods.

CO3: Analyze spectral properties of signals and model emission behaviour.

CO4: Evaluate transmission line effects, crosstalk, and interference.

CO5: Design PCB layouts with EMC considerations and grounding techniques.

CO6: Implement EMC techniques for noise reduction in electronic circuits.

CO7: Perform EMC measurements for compliance with emission standards.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M
CO5	H	H	H	H	L	L	L	L	M	L	M	M
CO6	H	H	H	H	L	L	L	L	M	L	M	M
CO7	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: EMC Fundamentals and Radiated Emission (10 hours)

EMC requirements for radiated systems, radiation and conduction emissions, radiated emission limits for Class A, Class B, FCC, and CISPR. Noise sources, coupling, cabling, conductive coatings, and protection techniques.

Module 2: Signal Spectral Analysis and Emission Models (12 hours)

Spectral analysis of signals, non-ideal behavior of passive components, digital circuit radiation, differential and common mode radiation. Emission models for wires and PCB lands, differential and common mode current models, current probes, susceptibility models, shielded cables, and surface transfer impedance.

Module 3: Transmission Lines, Crosstalk, and Interference (10 hours)

Three-conductor transmission lines, crosstalk, lossless transmission line equations, per-unit length parameters, homogeneous and inhomogeneous media. Inductive-capacitive coupling models, lumped circuit models, shielded and twisted wires, signal reflections, crosstalk, decoupling capacitors, electrostatic discharge.

Module 4: EMC Design, Shielding, and Measurements (10 hours)
LISN, power supply filters, differential and common mode coupling, shielding techniques, grounding, PCB design, mixed-signal PCB layout, EMC techniques, noise voltage measurements, conducted and radiated emission measurements.

Text/Reference Books:

1. Clayton R. and Paul, "Introduction to Electromagnetic Compatibility", Wiley Interscience, 2006.
2. Henry W. Ott, "Electromagnetic Compatibility Engineering", Wiley, 2009.

Course Code	Course Name	L	T	P	Credits
EC523	Computer Architecture and Organization	3	0	0	3

Course Objectives

1. To introduce the fundamental concepts of computer architecture, including functional units, memory organization, and system design.
2. To develop an understanding of computer arithmetic operations and their implementation.
3. To explore instruction set architecture, addressing modes, and data transfer mechanisms.
4. To analyze input/output organization, including bus structures and interfacing techniques.
5. To study pipelining, parallel processing, and their impact on system performance.

Course Outcomes

CO1. Understand the fundamental structure and operation of computer systems, including Von Neumann and Harvard architectures.

CO2. Analyze and implement various arithmetic operations such as addition, multiplication, and division using different algorithms.

CO3. Apply knowledge of instruction set architecture, addressing modes, and data representation in computer systems.

CO4. Evaluate input/output mechanisms, data transfer techniques, and their role in system performance.

CO5. Assess the concepts of pipelining, parallel processing, and associated challenges in modern computing.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	M	L	M	M	L	L	L	L	L	M	M
CO2	H	H	M	H	H	L	L	L	L	L	M	M
CO3	H	H	H	H	H	M	L	M	M	M	M	H
CO4	H	H	H	H	H	M	M	M	M	M	H	H
CO5	H	H	H	H	H	M	M	M	M	M	H	H

Syllabus

Module 1: Introduction and (6 hours)

Basic Structure of Computers: Basic functional units, Von Neuman Architecture, Harvard Architecture, Generation of Computers, BUS architecture, ALU designs, Software, BIOS.

Module 2: Computer Arithmetic (8 hours)

Addition and subtraction with signed-magnitude, CLA Adder, Multiplication Algorithms, Booths Algorithm, Array Multiplier, Division Algorithms: Restoring and Non-restoring division, Floating point Arithmetic operations.

Module 3: Instruction Set and Addressing modes (10 hours)

Instruction Format, Types of Instructions, Types of Addressing Modes, Memory Model, Byte Alignment, Machine Instruction, Instruction Representation, Types of Operations, Data Transfer, System Control.

Module 4: Input/Output Organization (10 hours)

Functions of Input-Output Interface, Types of Input-Output Interface in Computer Architecture, Isolated I/O versus Memory-Mapped I/O, Input-Output Bus and Interface Modules, Asynchronous Data Transfer, Modes of Transfer.

Module 5: Pipelining and Parallel processing (8 hours)

Pipelining in Computer Architecture, Instruction Pipeline, Arithmetic Pipeline, Pipelining Hazards, Parallel Processing and Data Transfer Modes in a Computer System, Challenges in Parallel Processing.

Text/Reference Books:

1. C. Hamacher, Z. Vranesic, and S. Zaky, “Computer Organization”, 5th Edition, New Delhi, India: McGraw-Hill Education, 2002.
2. M. M. Mano, “Computer System Architecture”, 3rd Edition, New Delhi, India: Pearson Education, 2017.
3. W. Stallings, “Computer Organization & Architecture: Designing for Performance”, 8th Edition, New Delhi, India: Pearson Education, 2010.
4. K. Hwang and N. Jotwani, “Advanced Computer Architecture: Parallelism, Scalability,

Programmability", 2^{nd} Edition, New Delhi, India: Tata McGraw-Hill Education, 2003.

Course Code	Course Name	L	T	P	Credits
EC524	Array Signal Processing	3	0	0	3

Course Prerequisite: Digital Signal Processing, Probability and Statistics Processes

Course Objective

1. To make understanding the use of antenna array in modern communication systems

Course Outcomes

After completing this course, the student will be able to:

CO1: To synthesize different types of arrays like linear, circular and planar.

CO2: Understanding different types of beamforming algorithms required for next generation wireless communication

CO3: To know how to estimate the direction of arrival of a signal

CO4: To understand variety of application of array signal processing

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Introduction (10 hours)

Introduction: Array Processing and Applications, Arrays and Spatial Filters: Uniform Linear Array, Array Steering, Array Performance, Linear Aperture

Module 2: Array Synthesis (12 hours)

Synthesis of Linear Arrays and Apertures: Spectral Weighting, Array Polynomials, Minimum Beamwidth, Null Steering, Spatially Non-uniform Linear Arrays, Broadband Arrays, Planar Arrays and Apertures: Rectangular Arrays, Circular Arrays, Circular Apertures, Non-planar Arrays, Characterization of Space-time Processes: Snapshot Models, Space-time Random Process

Module 3: Beam Forming (10 hours)

Optimum Waveform Estimation: Optimum Beamformers, MVDR and MPDR Beamformers, LCMV and LCMP Beamformers, Eigenspace Beamformer, Beamspace Beamformer, Broadband Beamformer, Adaptive Beamformers: RLS, LMS, Gradient Algorithms

Module 4: DOA Estimation (10 hours)

Parameter Estimation and Direction of Arrival Estimation: Cramer-Rao Bounds, Maximum Likelihood Estimation, Capon methods, Subspace methods - MUSIC, Minimum-Norm and ESPRIT techniques.

Text/Reference Books:

1. Harry L. Van Trees, *Optimum Array Processing (Part IV of Detection, Estimation, and Modulation Theory)*, Wiley-Interscience, 2002.
2. D. E. Dugeon and D. H. Johnson, *Array Signal Processing: Concepts and Techniques*, Prentice Hall, 1993.
3. P. Stoica and R. L. Moses, *Spectral Analysis of Signals*, Prentice Hall, 2005.

Course Code	Course Name	L	T	P	Credits
EC525	Communication Networks and Switching	3	0	0	3

Course Prerequisite: Analog and Digital Communications

Course Objectives

1. To make understanding of switching technology in communication network.
2. Understanding the Routing concept in communication network

Course Outcomes

After completing this course, the student will be able to:

CO1: To get the basic knowledge of network switching technology

CO2: Comprehensive knowledge about network layers.

CO3: To have basic understanding of local area network

CO4: Know the routing methods in network and its security aspects

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Switching Technology (10 hours)

Introduction to Communication Networks, Communication Switching: Circuit Switching, Message and Packet Switching, Connectionless and Connection oriented packet switching;

Module 2: Network Layers (12 hours)

Communication Process and Layered Architecture: Communication between computers and layering concept, OSI Layers, Protocols, Standards: Physical Layer, Data link layer- HDLC, Network layer – X. 25, Transport and Session layers, Application and Presentation layers;

Module 3: Local Area Networks (10 hours)

Local Area Networks: LAN topologies, access mechanisms and media, contention based LANS, Token passing LANS; Metropolitan Area Networks: Distributed Queue Dual Bus (DQDB), Fiber Distributed Data Interface (FDDI).

Internet and Internet Protocol Suite: Internet, IPV4, IP addressing, ICMP, IPV6, Transport control protocol, UDP protocol suite.

Module 4: Domain specific applications and challenges (10 hours)

Routing: Concept, Techniques – Next-hop specific, Network-specific and Host-specific, routing algorithms, Protocols- RIP, OSPF, Link state routing, BGP; Flow-based routing, Hierarchical routing; Digital Switching: Space switching, Multistage switching, Time multiplexed space and time switching, time and space switches; Frame relay; Narrowband and Broadband ISDN: Data rates, Access channel types, reference points, services and standards, B-ISDN; Synchronous Digital Hierarchy; Network Security.

Text/Reference Books:

1. B. A Forouzan, Data Communications and Networking, 4th Edition, McGraw Hill, 2012.
2. D. Bertsekas and R. Gallager, Data Networks, 2nd Edition, PHI learning, 2011.
3. A. S. Tanenbaum, Computer Networks, 4th Edition, Prentice Hall, 2009.

Course Code	Course Name	L	T	P	Credits
EC526	**Computational Electromagnetics**	**3**	**0**	**0**	**3**

Course Objectives

1. Introduce fundamental analytical and computational techniques in electromagnetics.
2. Develop problem-solving skills using analytical methods like separation of variables and eigenfunction expansion.
3. Explore electromagnetic scattering and integral equation formulations.
4. Understand numerical techniques such as MoM, FDM, FEM, and FDTD.
5. Apply computational methods to real-world electromagnetic problems.

Course Outcomes

CO1: Solve electromagnetic problems using analytical techniques.

CO2: Formulate and analyze scattering problems with integral equations.

CO3: Implement MoM and FDM for boundary value problems.

CO4: Apply FEM and FDTD for wave propagation and field analysis.

CO5: Develop computational tools for electromagnetic simulations.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M
CO5	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Analytical Computational Electromagnetics (12 hours)

Computational electromagnetics: research trends and applications, analytical methods: method of separation of variables, orthogonal expansion, Eigen function expansion, numerical integration, numerical quadrature and orthogonal polynomials, stationary phase method for evaluation of radiation integrals.

Module 2: Electromagnetic scattering (10 hours)

Maxwell' equations, source representation, Green's function, source-field relationship, electric field integral equations (EFIE), magnetic field integral equations (MFIE), Analytical solutions for TM and TE scattering of PEC and Dielectric cylinders, subdomain basis functions, entire domain basis functions, discretization errors.

Module 3: Method of Moments and FDM (10 hours)

The method of weighted residuals (Method of Moments), TM wave scattering by a conducting cylinder, finite difference method (FDM), interface and boundary conditions, absorbing boundary conditions, application of FDM in the analysis of parallel plate capacitor.

Module 4: FEM and FDTD (10 hours)

Finite element method (FEM), Calculation of capacitance of parallel plate, Introduction to Finite Difference Time Domain (FDTD) method, Applications of FDTD in reflection of a wave at an interface, determination of propagation constant in the medium.

Text/Reference Books:

1. A. F. Peterson, S. L. Ray, and R. Mittra, Computational Methods for Electromagnetics, Universities Press, 2001.
2. Ramesh Garg, Analytical and Computational methods in Electromagnetics, Artech House, 2008.
3. Jian-ming Jin, Theory and computation of electromagnetic fields, Wiley-IEEE press, 2015.

List of Open Electives (OEs) (Offered for Other than ECE)

S. No.	Course Code	Course Name	L	T	P	Credits
1.	EC900	Introduction to Internet of Things	3	0	0	3
2.	EC901	Mathematical Foundation for AI and ML	3	0	0	3
3.	EC902	Principles of Communication Systems	3	0	0	3
4.	EC903	Introduction to Signal Processing	3	0	0	3

Detailed Syllabi of Open Elective Courses

Course Code	Course Name	L	T	P	Credits
EC900	Introduction to Internet of Things	3	0	0	3

Course Prerequisite: Wireless communication and networking, basic knowledge of Python

Course Objectives

1. The goal of the course is to look top-down as well as bottom-up, to provide students with a comprehensive understanding of the IoT.
2. The technology used to build IoT, how they communicate, store data, and the kinds of distributed systems needed to support them.
3. Students will be given the opportunity to apply these technologies to tackle scenarios of their choice as running applications.

Course Outcomes

After completing this course, the student will be able to:

CO1: To know the characteristics and its design aspect of IOT.

CO2: Understanding network and communication aspect of IOT

CO3: Getting the knowledge of different IOT tools to develop

CO4: Exposure to IOT applications in real time and facing the real world challenges

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Introduction to IOT

Defining IoT, Characteristics, Physical and Logical design of IoT, Functional blocks of IoT, Communication models & APIs.
IoT & M2M: Machine to Machine, Difference between IoT and M2M, Software define Network

Module 2: Network and Communication Aspect (12 hours)

Network, Linking & Loading, Cloud Computing Services, Cloud and IoT Integration, IoT Data and the Cloud

Module 3: Developing IOT (10 hours)

System Programming and OS Dependencies, Introduction to Python, Introduction to different IoT tools, Developing applications through IoT tools, Developing sensor based application through embedded system platform, Implementing IoT concepts with python.

Module 4: Domain specific applications and challenges (10 hours)

Home automation, Industry applications, Surveillance applications, Other real time IoT applications in the field of agriculture.
Design and development challenges, Security challenges, Other challenges.

Text/Reference books:

1. Rajkamal, "Internet of Things", McGraw Hill Education, 1st Edition, 2017.
2. C. Raman, Pethuru Raj and Anupama, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 1st Edition, 2017.
3. Arshdeep Bahga and Vijay Madisetti, "Internet of Things: A Hands-on Approach", Orient Blackswan Private Limited - New Delhi; 1st Edition, 2015.

Course Code	Course Name	L	T	P	Credits
EC901	Mathematical Foundation for AI and ML	3	0	0	3

Course Prerequisite: Wireless communication and networking, basic knowledge of Python

Course Objective

1. To have the mathematical knowledge to understand the modeling and learning of AI and ML models.

Course Outcomes

After completing this course, the student will be able to:

CO1: Understand the concepts of Vector space and inner-product spaces

CO2: Apply the linear algebra concepts in approximations and matrix decompositions

CO3: Understand functions of several variables, gradients relevant for machine learning

CO4: Acquire sound mathematical aspects of machine learning and artificial intelligence.

Relationship of Course Outcomes to Program Outcomes

H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs ↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Linear Algebra (14 hours)

Vector spaces, linear independence, basis, linear transformations, coordinates, matrix representation of linear transformations, affine spaces, affine mappings, inner products and norms on a vector space, lengths, angles, orthogonal complements, projections, least square approximations, Gram-Schmidt process, rotations; matrix decompositions – Cholesky decomposition, eigen decomposition and diagonalization, singular value decomposition.

Module 2: Domain specific applications (12 hours)

Mathematical aspects in Machine Learning: overview of linear regression, multiple linear regression, and logistic regression; Linear Regression and parameter estimation;
Dimensionality reduction - Principal Component Analysis, linear discriminant analysis; Density estimation with Gaussian mixture models.

Module 3: Classification (10 hours)
Classification with support vector machines –separating hyperplanes, primal and dual support vector machines, kernels.

Module 4: Random Process (6 hours)
Brief overview of random variables, known special probability distributions, function of one random variable - mean, variance, moment, covariance and correlations.

Text/References books:

1. Mark Peter Deisenroth, A. Aldo Faisal and Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2020.
2. Stephen H. Friedberg, Arnold J. Insel and Lawrence E. Spence, "Linear Algebra", Pearson, 5th Edition, 2019.
3. Gilbert Strang, "Linear Algebra and Learning from Data", Wellesley-Cambridge Press, 2019.
4. Charu C. Aggarwal, "Linear Algebra and Optimization for Machine Learning", Springer, 2020.

Course Code	Course Name	L	T	P	Credits
EC902	**Principles of Communication Systems**	**3**	**0**	**0**	**3**

Course Objectives

1. To build concepts on analog and digital communication systems.
2. To build fundamental concepts so that students can design some basic communication systems on their own.

Course Outcomes

After completing this course, the student will be able to:

CO1: Understand the importance of Fourier analysis to communication systems.

CO2: Understand fundamental concepts of analog and digital communication systems.

CO3: Investigate and compare the performance of different communication systems.

CO4: Apply the knowledge to design some basic communication systems on their own.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Introduction (6 hours)

Introduction to signals and systems, Spectral Analysis: Fourier series, Response of a linear system, Normalized power, Power spectral density. The Fourier transform, Parseval's theorem, Auto and Cross correlations.

Module 2: Amplitude Modulation (10 hours)

Amplitude Modulation: Frequency translation, recovery of baseband signals, amplitude modulation, maximum allowable modulation, the square law demodulator, spectrum of AM signal, balanced modulator, SSB modulation and generation, VSB.

Module 3: Frequency Modulation (10 hours)

Frequency Modulation System: Phase and frequency modulation and their relationship, frequency deviation, spectrum of FM signal, BW of FM signal, the effect of modulation on BW, constant BW, FM phasor diagram, narrowband FM, Armstrong and parameter variation methods of FM generation.

Module 4: Digital Modulation (16 hours)

Analog to Digital Conversion: Pulse modulation systems, sampling theorem, pulse amplitude modulation, quantization of signals, quantization error, pulse code modulation (PCM) system, companding, time-division multiplexing (TDM), DPCM, DM, ADM.

Basic Digital Modulation Techniques: DM, ADM, DPCM, and ADPCM for speech, ASK, PSK, QAM, FSK, etc. Baseband Communication: Line coding, matched filter, correlation receiver, basics of inter-symbol interference, equalization.

Text/Reference Books:

1. B.P. Lathi, Zhi Ding, "Modern Analog and Digital communication Systems", Oxford, 4th Edition 2011.
2. Michael Moher, Simon Haykin, "Communications Systems", Wiley, 5th Edition 2009.
3. H. Taub, D. L Schilling, G. Saha, "Principles of Communication System", Tata McGraw Hill, 3rd Edition 2008.
4. A. B. Carlson, "Communication Systems", McGraw-Hill, 5th Edition 2017.

Course Code	Course Name	L	T	P	Credits
EC903	Introduction to Signal Processing	3	0	0	3

Course Objectives

1. To understand the basics of signal generation and processing the signal using systems.
2. To know the knowledge of signal and system characteristics in time and frequency domains.
3. To learn the use of digital filters like FIR and IIR.
4. To design digital filters and apply it in real time applications like signal communication, multimedia etc.

Course Outcomes

After completing this course, the student can able to

CO1: Observe the effect of signal operations like shifting, folding, scaling etc.,

CO2: Get the significance of time domain and frequency domain analysis of signals and systems.

CO3: Know the importance of LTI system and its properties and how to use it for filtering operation in signal processing.

CO4: Understand the use of Laplace and Z. STFT and Wavelet transform for continuous time signals and systems analysis.

CO5: Know the importance of FIR and IIR filters for signal processing applications.

Relationship of Course Outcomes to Program Outcomes
H = High correlation; M = Medium correlation; L = Low correlation

POs→ / COs↓	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	M	H	L	L	L	L	M	L	L	M
CO2	H	H	M	H	L	L	L	L	M	L	L	M
CO3	H	H	M	H	L	L	L	L	M	L	L	M
CO4	H	H	H	H	L	L	L	L	M	L	M	M
CO5	H	H	H	H	L	L	L	L	M	L	M	M

Syllabus

Module 1: Introduction to Signals and Systems (08 Hours)

Introduction to signals and systems, classification of signals, basic system properties, LTI Systems, sampling and reconstruction.

Module 2: Time and Frequency domain analysis of signals and systems (10 Hours)
Fourier Series representation of periodic signals, Fourier Transform representation of aperiodic signals, Time and frequency characterization of signals and systems.

Module 3: Analysis of LTI system using Laplace and Z-transform (10 Hours)
Laplace transform and its properties, Analysis and characterization of LTI system using Laplace transform. Z-transform and its properties, Analysis and characterization of LTI system using Z transform.

Module 4: Time Frequency Representation of Signals (06 Hours)
DFT and its properties, FFT, time-frequency representation of signal: STFT, wavelets.

Module 5: Digital filter design (08 Hours)
IIR filter design, FIR filter design, structures for discrete time systems, Finite word length effect.

Text/Reference Books:

1. Alan V. Oppenheim, Alan S. Willsky, and S. Hamid Nawab, “Signals and Systems”, 2nd Edition, PHI, 2003.
2. Simon Haykin, and Barry Van Veen, “Signals and Systems”, 2nd Edition, John Wiley, 2012.
3. John G. Proakis, and Dimitris G. Manolakis, “Digital Signal Processing”, 4th Edition, Pearson India, 2007.
2. Sanjit K Mitra, “Digital Signal Processing: A Computer based Approach”, 3rd Edition, Tata McGraw Hill, India, 2009.
3. S. Esakkirajan, T. Veerakumar, and B N Subudhi, “Digital Signal Processing”, Tata McGraw Hill, India, 2021.