Detailed Syllabus

Course Title	Course Code	Structure (I-P-C)		
Basic Electrical and Electronics Engineering	**EC101**	**3**	**0**	**3**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Develop and employ circuit models for elementary electronic components and circuit analysis.
CO2	Analyze the voltage and current of an electric circuit using network theorems.
CO3	Understand the behaviour of the transient states in RL, RC, RLC circuits.
CO4	Understand PN junction diodes and its circuits.
CO5	Design the electric circuits with passive and active components.

Syllabus:

Electrical circuit elements: voltage and current sources, R,C,L,M,I,V, linear, non-linear, active and passive elements, inductor current and capacitor voltage continuity, Kirchhoff's laws, Elements in series and parallel, superposition in linear circuits, controlled sources, energy and power in elements, energy in mutual inductor and constraint on mutual inductance.

Network analysis: Nodal analysis with independent and dependent sources, super nodal analysis, mesh analysis, super mesh analysis.

Network theorems: superposition theorem, substitution theorem, Millman's theorem, Tellegen's theorem, reciprocity theorem, Thevenin's and Norton's theorems, pushing a voltage source through a node, splitting a current source, compensation theorem, maximum power transfer theorem.

RC and RL circuits: natural, step and sinusoidal steady state responses, series and parallel RC/RL/RLC circuits, steady state and transient response, resonance.

AC signal measures: complex, apparent, active and reactive power, power factor. Magnetic circuits: self-inductance, mutual inductance, dot convention, series/parallel connection of coils. Two port network functions: z, y, h, g, T, and t parameters; conversion of one parameter to another, condition for the reciprocity and symmetry.

Network topology: notion of network graphs, nodes, trees, twigs, links, co-tree, independent sets of branch currents and voltages, incidence matrix, tie set matrix, cut set matrix

Introduction to three phase supply: three phase circuits, star-delta transformations, balanced and unbalanced three phase load, power measurement, two wattmeter method.

Semiconductor diodes and application: PN diodes, rectifiers, and filters, clipping and clamping circuits.

Text Book(s):

1. Hayt. W. W, Kemmerly. J.E, and Durbin. S.M, Engineering Circuits Analysis, 8th edition, Tata McGraw Hill, 2013.
2. J. David Irwin and R. Mark Nelms, Basic Engineering Circuit Analysis, 10th edition, Wiley, 2011

References & Web Resources:

1. Hughes Edward, Electrical & Electronic Technology, 10th edition, Pearson Education, 2007.
2. Hambley. A, Electrical Engineering Principles and Applications: International Version, Pearson Education, 4 Edn, 2007.
3. Alexander.C. K. & Mathew. N. O. Sadiku, Fundamentals of Electrical circuits, 5th edition, Tata McGraw Hill, 2008.

Course Title	Course Code	Structure (I-P-C)		
Electronic Devices and Circuits	**EC151**	**3**	**0**	**3**

Pre-requisite, if any: Basic Electrical and Electronics Engineering

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the principles and characteristics of different types of semiconductor devices.
CO2	Understand the fabrication process of semiconductor devices.
CO3	Utilize the mathematical models of semiconductor junctions and MOS transistors for circuits and systems
CO4	Understand the constructional details and characteristics of Diode, BJT, and MOS Devices.
CO5	Understand the characteristics of special diodes.

Syllabus:

Semiconductor Basics: Bonding forces, Energy bands in Solids, Metals, Semiconductors and Insulators, Direct and Indirect semiconductors, Electrons and Holes, Intrinsic and Extrinsic materials, Conductivity and Mobility, Drift and Resistance, Effects of temperature and doping on mobility, Hall Effect.

P-N Junctions: Forward and Reverse biased junctions- Qualitative description of Current flow at a junction, reverse bias, Reverse bias breakdown- Zener breakdown, avalanche breakdown, Rectifiers, Optoelectronic Devices Photodiodes: Current and Voltage in an Illuminated Junction, Solar Cells, Photo detectors. Light Emitting Diode: Light Emitting materials**.**

Bipolar Junction Transistor: Fundamentals of BJT operation, Amplification with BJTS, BJT Fabrication, The coupled Diode model (Ebers-Moll Model), Switching operation of a transistor, Cutoff, saturation, switching cycle, specifications, Drift in the base region, Base narrowing, Avalanche breakdown.

Field Effect Transistors: Basic JFET Operation, Equivalent Circuit and Frequency Limitations, MOSFET Two terminal MOS structure- Energy band diagram, Ideal Capacitance – Voltage Characteristics and Frequency Effects, Basic MOSFET Operation- MOSFET structure, Current-Voltage Characteristics.

Fabrication of P-N Junctions: Thermal Oxidation, Diffusion, Rapid Thermal Processing, Ion implantation, chemical vapour deposition, photolithography, Etching, metallization.

Integrated Circuits: Background, Evolution of ICs, CMOS Process Integration, Integration of Other Circuit Elements.

Text Book(s):

1. Ben. G. Streetman, Sanjay Kumar Banergee, “Solid State Electronic Devices”, 7^{th} Edition, Pearson Education.

2. Donald A Neamen, Dhrubes Biswas, “Semiconductor Physics and Devices”, 4th Edition, MCGraw Hill Education, 2012.

References & Web Resources:

1. S. M. Sze, Kwok K. Ng, “Physics of Semiconductor Devices”, 3rd Edition, Wiley, 2018.

Course Title	Course Code	Structure (I-P-C)		
Signals and Systems	**EC152**	**3**	**0**	**3**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand various properties of continuous time signals.
CO2	Analyze the frequency spectrum of continuous time signals.
CO3	Describe a LTI system by impulse/frequency response.
CO4	Analyze magnitude/phase response of various LTI systems.
CO5	Analyze systems commonly used in Communications, Control, and Signal Processing.

Syllabus:

Introduction to Continuous/Discrete time Signals and Systems: The unit impulse and unit step functions, Continuous-time signals, Transformations of the independent variables, Exponential and Sinusoidal signals, Continuous-time systems and basic system properties.

Linear Time-invariant Discrete/Continuous Systems: Continuous-time Linear Time-invariant (LTI) system, Discrete-time LTI system, Properties of LTI systems, System representation through linear constant coefficient differential equations.

Discrete/Continuous Fourier Series Representation of Periodic Signals: Fourier series representation of continuous/discrete time periodic signals, Convergence of the Fourier series, Properties of continuous/discrete time Fourier series, Fourier series and LTI systems, Filtering, Examples of continuous-time filters described by differential equations.

Discrete/Continuous-time Fourier Transform: Representation of aperiodic signals, The Fourier transform for periodic signals, Properties of the continuous-time Fourier transform, Convolution and multiplication properties and their effect in the frequency domain, magnitude and phase response.

Laplace Transform: The Laplace transform for continuous-time signals and systems, the notion of Eigenvalue and Eigenfunctions of LTI systems, Region of convergence, System functions, Poles and zeros of system functions and signals, Properties of the Laplace transform, Analysis and characterization of LTI systems using the Laplace transform, The unilateral Laplace transform.

Z-transform: Introduction of z-transform, Properties of the region of convergence of the z-transform, The inverse z-transform, Properties of the z-transform, solving the difference equations using Z-transform.

Text Book(s):

1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab*,* "Signals and Systems," 2nd Edition, Prentice Hall, 2003.
2. S. Haykin and B. V. Veen*,* "Signals and Systems" 2nd Edition, Wiley, 2007.

References & Web Resources:

1. B.P. Lathi, "Principles of Linear Systems and Signals," Oxford University Press, 2nd Edition, 2009.

Course Title	Course Code	Structure (I-P-C)		
Digital Logic Circuits	**EC201**	**3**	**0**	**3**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand various number systems and their representation
CO2	Design combinational circuits
CO3	Design sequential circuits
CO4	Formulate logic and design circuits for practical problems.
CO5	Understand the issues at the digital circuits.

Syllabus:

Representation of Data: Introduction, Data representations, Number systems, conversions and codes.

Switching Theory: Laws and theorems of Boolean algebra, switching functions, truth table and algebraic form, realization using logic gates.

Digital Logic and Implementation: K-Maps, QM method, SOP, POS; NAND and NOR implementation, Digital Circuit Characterization.

Combinational Circuit Design: Design Procedure, Multiplexer, Decoder, Encoder, Comparator, Seven-segment display, Parity generator, Design of large circuits, Ripple Carry Adder, Carry look ahead adder, carry save adder, carry save array multiplier, Wallace tree multiplier, Restoring/Non Restoring division techniques.

Asynchronous and Synchronous Sequential Circuit Design; Design of sequential modules – SR, D, T and J-K Flip-flops, applications, Clock generation, Clock dividers, Registers, and Counters.

Design using State machines: Moore and Mealy machines, Design Examples.

Issues at the Digital Circuits: Glitches, Glitch free circuit design, Static and Dynamic Hazards, Hazard resolution techniques, Race, and Cycles.

Text Book(s):

1. C. H. Roth, Jr., "Fundamentals of Logic Design," 7th Edition, Cengage Learning, 2013.
2. S. Brown and Z. Vranesic, "Fundamentals of Digital Logic with VHDL Design," TMH, 3rd Edition

References & Web Resources:

1. J. F. Wakerly, "Digital Design- Principles and Practices," 3rd Edition, Pearson
2. M. M. Mano, "Digital Design," PHI.
3. T. L. Floyd and R. P. Jain, "Digital Fundamentals," 8th Edition, Pearson.

Course Title	Course Code	Structure (I-P-C)		
Electromagnetic Waves and Transmission Lines	**EC204**	**3**	**0**	**3**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the principles of vector algebra, vector calculus, and their physical interpretations in electromagnetic fields
CO2	Analyse Maxwell's equations for time-varying electromagnetic fields and understand the formation and characteristics of electromagnetic wave
CO3	Understand the plane wave reflections and wave dispersion in different mediums
CO4	Apply Maxwell's equations for solutions in transmission lines
CO5	Illustrate the wave propagation through different waveguides

Syllabus:

Vector Analysis: Scalars and Vectors, Vector Algebra, The Rectangular Coordinate System, Vector Components and Unit Vectors, The Vector Field, The Dot Product, The Cross Product, Other Coordinate Systems: Cylindrical Coordinates and The Spherical Coordinate System

Time-Varying Fields and Maxwell's Equations: Faraday's Law, Displacement Current, Maxwell's Equations in Point Form, Maxwell's Equations in Integral Form, The Retarded Potentials

The Uniform Plane Wave: Wave Propagation in Free Space, Wave Propagation in Dielectrics, Poynting's Theorem and Wave Power, Propagation in Good Conductors:Skin Effect, Wave Polarization

Plane Wave Reflection and Dispersion: Reflection of Uniform Plane Waves at Normal Incidence, Standing Wave Ratio, Wave Reflection from Multiple Interfaces, Plane Wave Propagation in General Directions, Plane Wave Reflection at Oblique Incidence
Angles, Total Reflection and Total Transmission of Obliquely Incident Waves,Wave Propagation in Dispersive Media, Pulse Broadening in Dispersive Media

Transmission Lines: Physical Description of Transmission Line Propagation, The Transmission Line Equations, Lossless Propagation, Lossless Propagation of Sinusoidal Voltages, Complex Analysis of Sinusoidal Waves, Transmission Line Equations and Their Solutions in Phasor Form, Low-Loss Propagation, Power Transmission and The Use of Decibels in Loss Characterization, Wave Reflection at Discontinuities, Voltage Standing Wave Ratio, Transmission Lines of Finite Length, Some Transmission Line Examples, Graphical Methods: The Smith Chart, Transient Analysis

Guided Waves: Transmission Line Fields and Primary Constants, Basic Waveguide Operation, Plane Wave Analysis of the Parallel-Plate Waveguide, Parallel-Plate Guide Analysis Using the Wave Equation, Rectangular Waveguides, Planar Dielectric Waveguides, Optical Fibre.

Text Book(s):

1. Matthew N.O. Sadiku, S.V. Kulkarni, Principles of Electromagnetics, 6th Edition, Oxford, 2015.
2. W. H. Hayt and J. A. Buck, Engineering Electromagnetics, Tata McGraw Hill Education Pvt. Ltd, 2006.

References & Web Resources:

1. Rao, Nannapaneni Narayana. Elements of engineering electromagnetics. Prentice Hall, 1991.
2. Griffiths, David J. "Introduction to Electrodynamics, 4th Edition, 2021.

Course Title	Course Code	Structure (I-P-C)		
Analog Electronics	**EC202**	**3**	**0**	**3**

Pre-requisite, if any: Electronic Devices and Circuits

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand analog circuits.
CO2	Analyse and design of amplifiers viz. VCVS, VCCS, CCVS, CCCS
CO3	Analyse and design of analog circuits with operational amplifiers.
CO4	Analyse and design the analog filters.
CO5	Design oscillators and multivibrators.

Syllabus:

Device Models: (Diode, BJT, MOSFET); Small signal analysis of nonlinear circuits, small signal equivalent of diode, BJT, MOSFET.

Biasing: Adding dc bias to ac signals, Concept of ac coupling, current mirrors, Cascode current mirrors.

Basic transistor Amplifiers: small signal and large signal (low frequency) characteristics, VCVS, VCCS, CCVS, CCCS, high frequency effects.

Differential pair: Need of active load, differential amplifier.

OpAmp internal circuitry: 2-stage plus buffer example, Miller compensation of a 2-stage OpAmp, Stability, frequency compensation.

OpAmp circuits: Amplifier Circuits, Filters, oscillators.

Text Book(s):

1. B. Razavi, “Fundamentals of Microelecronics,” Wiley Student Edition, 2010.
2. S. Franco, “Design with Operational Amplifiers and Analog Integrated Circuits,” McGraw-Hill Series in Electrical and Computer Engineering, 4th Edition, 2015.

References & Web Resources:

1. Sedra and Smith, “Microelectronic Circuits,” 7 th Edition, Oxford University Press.
2. D. A. Newman, “Electronic circuits,” 4 th Edition, TMH.

Course Title	Course Code	Structure (I-P-C)		
Digital Logic Circuits Practice	**EC205**	**0**	**3**	**2**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand digital circuits in practical prespective
CO2	Design Combinational circuits
CO3	Design sequential circuits
CO4	Formulate logic and design circuits for practical problems.
CO5	Design the digital circuits using HDL

Experiments:

1. Formulating Boolean expressions and truth tables from practical statements.
2. Designing logic circuits and simplifying using k-map,
3. Designing NAND-NAND & NOR-NOR diagrams & verifying the same by simulation and experiment.
4. Combinational circuits: code converters, arithmetic circuits, mux/demux, encoder/decoder, comparators etc.
5. Sequential circuits including flip flops, shift registers, counters, sequence generators etc.
6. Simple design examples with Moore and Mealy machines.
7. Digital circuits design using HDL
8. Implementation of combinational and sequential circuits in the digital trainer board.

Text Book(s):

1. C. H. Roth, "Fundamentals of Logic Design," 5th Edition, Thomson Books/Cole.
2. Samir Palnitkar: Verilog HDL - Guide to Digital design and synthesis, Pearson Guide to Digital design and synthesis, Pearson Education, 3rd Edn, 2003.

References & Web Resources:

1. S. Brown and Z. Vranesic, "Fundamentals of Digital Logic with VHDL Design," TMH, 3rd Edition.

Course Title	Course Code	Structure (I-P-C)		
Analog Electronics Practice	**EC206**	**0**	**3**	**2**

Pre-requisite, if any: Electronic Devices and Circuits

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand analog circuits.
CO2	Analyse and design of amplifiers viz. VCVS, VCCS, CCVS, CCCS
CO3	Analyse and design of analog circuits with operational amplifiers
CO4	Analyse and design the analog filters
CO5	Design oscillators and multivibrators.

Experiments:

1. Half wave and full wave rectifiers design,
2. Diode based clipper and clamper circuits design,
3. Voltage regulator design using Zener diode,
4. RC Circuit Analysis,
5. BJT voltage transfer characteristics analysis,
6. Operation amplifier analysis,
7. Circuits using Op-Amps, Filters, and Oscillators,
8. Common emitter amplifier design,
9. Analysis of common source characteristics of NMOS transistor,
10. Basic NMOS common source audio amplifier design,
11. Power Supply analysis
12. Frequency analysis of BJT and MOSFET

Text Book(s):

1. B. Razavi, "Fundamentals of Microelectronics," Wiley Student Edition, 2010.
2. S. Franco, "Design with Operational Amplifiers and Analog Integrated Circuits," McGraw-Hill Series in Electrical and Computer Engineering, 4th Edition, 2015.

References & Web Resources:

1. Sedra and Smith, "Microelectronic Circuits," 7th Edition, Oxford University Press.
2. D. A. Newman, "Electronic circuits," 4th Edition, TMH.

Course Title	Course Code	Structure (I-P-C)		
Probability Theory and Statistics	**DS151**	**3**	**0**	**3**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the concept of probability using an appropriate samplespace.
CO2	Solve problems on discrete and continuous random variables.
CO3	Identify the characteristics of different discrete and continuous distributions.
CO4	Analyze the statistical problems on large and small samples.
CO5	Apply the knowledge of probability and statistics in solving engineering problems.

Syllabus:

Introduction to Probability: Sets, Events, Axioms of Probability, Conditional Probability and Independence, Bayes Theorem.

Random Variables: Definitions, Cumulative Distribution Functions, Probability Mass Function, Probability Density Function, Joint and Conditional Distributions.

Expectations: Mean, Variance, Moments, Correlation, Chebychev and Schwarz Inequalities, Moment-Generating and Characteristic Functions, Chernoff Bounds, Conditional Expectations, Law of Large Numbers, Central Limit Theorem. Uniform, Binomial, Poisson and Normal Distributions.

Test for Large Samples: Testing of Hypothesis –Null and alternate hypothesis, level of significance and critical region-Z-test for single mean and difference of means, single proportion and difference of proportions.

Test for Small Samples: t-test for single mean and difference of means – F-test for comparison of variances, Chi-square test for goodness of fit, Chi-square test for independence.

Correlation and Regression: Correlation, lines of regression and examples.

Text Book(s):

1. S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, S. Chand & Co, 2006.
2. R. A. Johnson: Miller and Freund's Probability and Statistics for Engineers, Pearson Publishers, 9th Edition, 2017 Thomas. G.B, and Finney R.L, Calculus, Pearson Education, 2007.

References & Web Resources:

1. S. Milton and J. Arnold, Introduction to Probability and Statistics, Tata McGraw Hill Education Private Limited, 4th Edition, 2006.
2. R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House. 2005.

Course Title	Course Code	Structure (I-P-C)		
Microprocessors and Microcontrollers	EC251	**3**	**0**	**3**

Pre-requisite, if any: Digital Logic Design

Course Outcomes: At the end of the course, the students will be able to:

CO1	Learn the functional behaviour of a microprocessor using assembly instructions.
CO2	Learn to develop suitable computing architectures for certain applications
CO3	Use microprocessors and microcontrollers for building real time systems
CO4	Understand the data path architecture of microprocessors.
CO5	Understand the ISA of microprocessors and microcontrollers

Syllabus:

Evolution of processors. Harvard Versus Von-Neumann, RISC versus CISC, Register File, General Instruction Types, Addressing Modes, and concept of pipelining and parallelism.

Memory: Main memory Technologies (SRAM, DRAM), Cache memory organization, improving cache performance. Input/Output Unit: access of I/O devices, I/O ports, and I/O control mechanisms – Program Controlled I /O. Interrupt controlled I/O and DMA controlled I/O

8086 Architecture, Register Organization, Memory segmentation, Pin configuration, latching of address bus, Buffering of data bus. Minimum and Maximum mode operations.

8086 INTERFACING Memory interfacing: RAM, EPROM IC Chips I/O interfacing: 8255 PPI, 8257 DMA interface interfacing programmable interval timers – 8253/8254

Architecture of 8051, Pin configuration, built-in ROM & RAM organization, Stack organization. Assembly language Programming with 8051: Instruction set, Data transfer, Arithmetic, logical and branching instructions, Addressing modes.

Text Book(s):

1. D. A. Patterson and J. L. Hennessy, Computer Organization and Design - ARM, Morgan Kaufmann, 2010..
2. Douglas V Hall, “Microprocessors and Interfacing Programming and Hardware,” 2/e, THM, 2007
3. Mazidi M.A, Mazidi J.G &Rolin D. Mckinlay, “The 8051 Microcontroller & Embedded Systems using Assembly and C,” 2/e, Pearson Education, 2007.

References & Web Resources:

1. Morris Mano, M., "Computer System Architecture," 3/e, Pearson Education, 2005.
2. B. B. Brey, Intel Microprocessors, 8th edition, Prentice Hall, 2008.
3. Microprocessors and Microcontrollers by Dr.Santhanuchatopadhya, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc18_ec03/course
4. Microprocessors and Microcontrollers, IIT Kanpur. https://nptel.ac.in/courses/Webcourse-contents/IIT- KANPUR/microcontrollers

Course Title	Course Code	Structure (I-P-C)		
Analog and Digital Communications	**EC252**	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the basic concepts of signal modulation, demodulation, and transmission.
CO2	Analyze the performance of analog and digital communication systems.
CO3	Design and implement analog and digital communication systems for a given set of specifications.
CO4	Use laboratory equipment and software tools to test and verify the proper operation of communication systems.

Syllabus:

Introduction to Analog Communication Systems

- Introduction of Analog Communication Systems
- Modulation Types: Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (PM)
- Properties of Fourier Transform, Band-pass Signals, and their Spectra,Introduction to Mixers, Up-down Converters, and Channel Selection

Analog Communication Techniques

- Amplitude Modulation Techniques: DSB-SC, SSB-SC, VSB
- Frequency Modulation Techniques: Narrowband FM, Wideband FM, Phase Modulation (PM)
- Frequency Division Multiplexing Techniques (FDM), Time Division Multiplexing Techniques (TDM)
- Advanced Modulation techniques: single sideband suppressed carrier (SSBC), vestigial sideband (VSB),orthogonal frequency-division multiplexing (OFDM)

Introduction to Digital Communication:

- Sampling and Quantization, PCM, Delta modulation, Adaptive delta modulation,
- BER Analysis, Bandwidth/Power efficiency, Carrier recovery – squaring and Costas loop.

Digital Communication Principles

- Digital Modulation Techniques: ASK, PSK, FSK, QAM
- Performance Analysis of Digital Communication Systems
- Error Detection and Correction Techniques: Hamming codes, Parity codes, CRC codes, BCH codes
- Introduction to Spread Spectrum Techniques

Communication Systems, Design Challenges:

- Channel Distortions and Noises, Message Sources, Channel Effect,
- Signal-To-Noise Ratio, Information Capacity,
- Modulation and Detection, Matched filter, and correlation receiver, Super heterodyne receiver,

Text Book(s):

1. Simon Haykin, An Introduction to Analog and Digital Communications, wiley Vol 2, 2008.
2. B. P. Lathi and Z. Ding, "Modern Digital and Analog Communication Systems," 4th Edition, Oxford University Press, 2011.

References & Web Resources:

1. John G Proakis, Digital Communications, 4th edition, 2008.

Course Title	Course Code	Structure (I-P-C)		
Control Systems	EC254	**3**	**0**	**3**

Pre-requisite, if any: Signals and systems

Course Outcomes: At the end of the course, the students will be able to:

CO1	Model the linear systems using transfer functions and obtain transfer functions using block diagrams and signal flow graphs.
CO2	Understand the significance of time response and find it for system analysis in transient and steady state
CO3	Understand the concept of stability and know different techniques of stability analysis and to introduce the concept of frequency domain analysis, Bode plots, Polar plots
CO4	Understand the concept of state space modeling and analysis.
CO5	Understand the state space model of the systems

Syllabus:

Open loop and closed loop systems, Transfer Function models of linear SystemsModelling of Electrical & mechanical Systems, Block Diagram representation of Control Systems – Block Diagram Reduction, Signal Flow Graph Representation of Control Systems, Mason's gain formula, Feedback Characteristics of Control Systems

Time Response of First and Second Order Systems with Standard Input Signals, Time Domain Specifications of Second Order Systems, Steady State Error, Steady State Error Constants-Basic Control Actions- Effects of Integral and Derivative Control actions.

Concept of Stability, Routh-Hurwitz Criterion, Relative Stability Analysis, The Concept and Construction of Root Loci, Analysis of Control Systems with Root Locus

Frequency Response Bode Plots Log Magnitude versus Phase Plots, Polar Plots Frequency Domain specifications Correlation between Time and Frequency Responses, Stability in Frequency Domain Nyquist Stability Criterion - Assessment of Relative Stability, Gain Margin and Phase Margin.

Concept of state, State Variables and State Models, State space models for LTI electrical Systems, Phase variable form and diagonal canonical form, Conversion between Transfer Function models and State space models, Solution to the State Equation, State Transition Matrix, Concept of Controllability and Observability.

Text Book(s):

1. N. S. Nise, "Control Systems Engineering," Wiley, 2014.Meriam
2. B.C. Kuo, "Automatic Control Systems", 8th Edition, John Wiley.

References & Web Resources:

1. I. J. Nagrath and M. Gopal, "Control System Engineering," New Age International publishers, 2008.
2. J. J. Distefano, A. R. Stubberud, and I. J. Williams, "Control Systems," Shaum's outline Series, 3rd Edition, McGraw Hill.

Course Title	Course Code	Structure (I-P-C)		
Digital Signal Processing	EC253	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems

Course Outcomes: At the end of the course, the students will be able to:

CO1	Analyze DT signals using DFT along with FFT algorithms
CO2	Analyze discrete time LTI systems, and their impulse responses
CO3	Synthesize discrete signals from analog signals
CO4	Design of FIR type of Digital filters as per the specifications
CO5	Discuss briefly about DSP applications and understand basic concepts of multi rate signal processing.

Syllabus:

Review of Discrete-time Signals and Systems: Discrete-time signals: sequences, discrete-time systems, Linear time-invariant (LTI) systems, Properties of LTI systems, Linear constant coefficient difference equations, Frequency domain representation of discrete-time signals and systems, Representation of sequences by Fourier transforms, Symmetry properties of Fourier transform, Fourier transform theorems, Discrete-time random signals.

Transform Analysis of Linear Time Invariant Systems: The frequency response of LTI systems, System functions for systems characterized by linear constant-coefficient difference equations, Frequency response of rational system functions, Relationship between magnitude and phase, All-pass systems, Minimum phase systems.

Fast Fourier Transform: Introduction of the Discrete Fourier Transform (DFT), TheFourier transform of periodic signals, Properties of DFT, Linear convolution using the DFT. Efficient computation of the DFT, The Goertzel algorithms, Radix-2 decimation-in-time and decimation-in- frequency Fast Fourier Transform algorithms.

Structures for Discrete-Time Systems: Block Diagram Representation of Linear Constant-Coefficient Difference Equations, Signal Flow Graph Representation, Direct Forms, Cascade Form.

Filter Design Techniques: Analog filter design, Butterworth, Chebyshev filter technique. FIR filter design using Windowing and frequency sampling techniques. IIR filter design using impulse invariance and bilinear transformation, FIR and IIR filter structures.

Overview of DSP applications, DTMF signal detection, Spectral analysis of sinusoidal signals using FFT, Sub band coding of speech signals, Finite precision arithmetic effects.

Text Book(s):

1. A.V. Oppenheim, R.W. Schafer, and J. R. Buck, "Discrete-Time Signal Processing," Pearson Education, 3rd Edition, 2010.

References & Web Resources:

1. S. K. Mitra, "Digital Signal Processing: A Computer-Based Approach", 4th Edition, Tata Mcgraw Hill Publication, 2013.
2. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications", Fourth edition, Pearson, 2007.

Course Title	Course Code	Structure (I-P-C)		
Micro Processors and Microcontrollers Practice	EC255	**0**	**3**	**2**

Pre-requisite, if any: Digital logic design

Course Outcomes: At the end of the course, the students will be able to:

CO1	Program and use microprocessor 8086 for real time applications
CO2	Program and use ARM7 for real time application
CO3	use polar coordinates to describe rotational motion of an object.
CO4	understand the planetary motion and gravitation
CO5	apply the concepts of angular momentum and torque for rigid body dynamics

Experiments:

8086 programming : Assembly code for simple addition, simple subtraction, simple multiplication, division, multiply accumulation, matrix addition/subtraction/multiplication, finding the odd-even, addition of N numbers, convolution, find the largest of N numbers, and so on. Accessing the peripherals (Switches, LEDs, Keypad, seven segment display, buzzer, relay, ADC, and temperature sensor) of 8086 development boards. Real time applications (traffic light control, stepper motor control, logic control, and so on) using 8086 and 8051 development boards.

ARM7 programming : Accessing the peripherals (Switches, LEDs, Keypad, seven segment display, buzzer, relay, ADC, and temperature sensor) of ARM7-LPC2148 development board, Assembly code for simple addition, simple subtraction, simple multiplication, division, multiply accumulation, matrix addition/subtraction/multiplication, finding the odd-even, addition of N numbers, convolution, find the largest of N numbers, and so on.

Project Work (Individual or 2-per group with respect to the availability of boards): Any project work using the programming skills obtained from the aforementioned topics with 8086 or ARM7 development boards. The title and objective of the projects will be chosen or formed by the students.

Text Book(s):

1. S. Furber, ARM System-on-chip Architecture, 13th impression, Pearson, 2012.
2. Kenneth J. Ayala, The 8086 Microprocessor: Programming and Interfacing The PC, Delmar Publishers, 2007

References & Web Resources:

1. A. K. Ray, K. M. Bhurchandi, Advanced Microprocessors and Peripherals, TMH, 2007.

Course Title	Course Code	Structure (I-P-C)		
Analog and Digital Communications Practice	EC256	**0**	**3**	**2**

Pre-requisite, if any: Signals and systems

Course Outcomes: At the end of the course, the students will be able to:

CO1	Ability to analyze and design analog communication systems such as amplitude modulation, frequency modulation, and pulse modulation.
CO2	Ability to analyze and design digital communication systems such as pulse code modulation, delta modulation, and PCM encoding and decoding.
CO3	Ability to demonstrate the use of various communication test and measurement tools such as oscilloscopes, signal generators, and spectrum analyzers.
CO4	Ability to work effectively as part of a team to design and implement a communication system.
CO5	Ability to identify and solve communication system problems through experimentation and troubleshooting techniques.

Experiments:

1. (i) Amplitude modulation and demodulation (ii) Spectrum analysis of AM
2. (i) Frequency modulation and demodulation (ii) Spectrum analysis of FM
3. DSB-SC Modulator & Detector
4. SSB-SC Modulator & Detector (Phase Shift Method)
5. Frequency Division Multiplexing & De multiplexing
6. Pulse Amplitude Modulation & Demodulation
7. Pulse Width Modulation & Demodulation
8. Pulse Position Modulation & Demodulation
9. PCM Generation and Detection
10. Delta Modulation
11. Frequency Shift Keying: Generation and Detection
12. Binary Phase Shift Keying: Generation and Detection
13. Generation and Detection (i) DPSK (ii) QPSK

Text Book(s):

1. B. P. Lathi and Z. Ding, “Modern Digital and Analog Communication Systems,” 4th Edition, Oxford University Press, 2011.
2. S. Haykin, “Communication Systems,” 4th Edition, Wiley, 2006

References & Web Resources:

1. J. M. Wozencraft and I. M. Jacobs, “Principles of Communication Engineering,” Wiley, 1965.
2. J. R. Barry, E. A. Lee, and D. G. Messerschmitt, “Digital Communication,” 3rd Edition, Springer, 2004.

Course Title	Course Code	Structure (I-P-C)		
Digital Signal Processing Practice	EC257	**0**	**3**	**2**

Pre-requisite, if any: Signals and Systems

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand various properties of signals and systems
CO2	Apply various operations (filtering) on signals
CO3	Become aware of various applications of Signal Processing
CO4	Analyze DFT, DTFT, and FFT on discrete signals.
CO5	Design digital filters.

Syllabus:

1. Convolution of discrete signals
2. Auto and cross correlation of discrete signals
3. Verification of the properties of convolution and correlation
4. Implementation of DFS, DFT, and DTFT
5. Implementation of DIT-FFT and DIF-FFT algorithms
6. Verification of the properties of DFS, DFT, DTFT, and FFT
7. FIR filter design
8. Analysis of FIR filter with various windowing techniques
9. IIR filter design
10. Analysis of IIT filter design with various analog approximations
11. Read and write audio, image, and video signals
12. Analysis of differences between the mono audio, stereo audio, binary image, grey image, colour image, grey video, and colour video.

Text Book(s):

1. S. K. Mitra, “Digital Signal Processing: A Computer-Based Approach”, Fourth edition, Tata Mcgraw Hill Publication, 2013.

2. E. Ifeachor, B. W. Jervis, “Digital Signal Processing: A Practical Approach” Second edition, Pearson, 2002.

References & Web Resources:

1. S. W. Smith, “Digital Signal Processing: A Practical Guide for Engineers and Scientists”, 3rd Edition, Newnes (an imprint of Butterworth-Heinemann Ltd.), 2002.

2. Manuals of TI TMS320C67XX DSP Starter Kit.
3. A.V. Oppenheim, R.W. Schafer, and J. R. Buck, “Discrete-Time Signal Processing,” Pearson Education, 3rd Edition, 2010.

Course Title	Course Code	Structure (I-P-C)		
Wireless Communication	EC301	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital Communication Techniques

Course Outcomes: At the end of the course, the students will be able to:

CO1	Explain fundamental theories and concepts of modern wireless communication systems.
CO2	Design a wireless communication system using digital modulation techniques.
CO3	Select and implement protocols for wireless networks such as WLAN, WMAN, and WPAN.
CO4	Evaluate the potential of the next generation of wireless communication systems.
CO5	Analyze and solve problems in wireless communication networks

Syllabus:

Wireless Communication Overview, the Wireless Channel: Fading, Large scale fading, small scale fading, Physical modeling for wireless channels, different statistical channel models. Channel parameters: Time and Frequency coherence, delay spread, power profile, Capacity of wireless Channel- Capacity of Flat Fading Channel, Channel State Information, Capacity with Receiver diversity – Capacity comparisons – Capacity of Frequency Selective Fading channels, Jakes model for wireless channel correlation.

Overview of communication system design, Analog vs Digital and Single vs Multi-user communication, RF Circuits and Propagation: RF circuits and components, Propagation models and channels, Antennas and radiation patterns, Digital Modulation Techniques: Analog to digital conversion, Digital modulation techniques, Spread spectrum techniques.

Introduction to Cellular and Mobile communications, the cellular and mobile concept and system design fundamentals. Frequency reuse, Channel assignment strategies, Handoff strategies, Interference and system capacity, Trunk and grade services, Methods for improving coverage and capacity in cellular systems, Multiple access techniques TDMA, CDMA, FDMA and SDMA.

WLANs: IEEE 802.11 standards, WLAN architecture, Medium access control protocols, Wireless Personal Area Networks (WPANs): IEEE 802.15 standards, ZigBee and Bluetooth, standards, Protocols for WPANs

Wireless Metropolitan Networks (WMANs): IEEE 802.16 standards, WiMaxarchitecture, Medium access control protocols, Wireless Sensor Networks (WSNs): Introduction to WSNs, Types and architectures of WSNs, Protocols for WSNs

4G and 5G wireless systems: The evolution of wireless communication systems, Comparison between 4G and 5G wireless systems, Applications of 5G wireless systems

Wireless Network Security: Network and Information Security, Threats and Attacks on Wireless Networks, Security Solutions for Wireless Networks

Textbook(s):

1. Andrea Goldsmith, Wireless Communication, Cambridge University Press.
2. Aditya Jagannatham, Principles of Modern Wireless Communication Systems, McGraw Hill, (2016)

References & Web Resources:

1. Theodore Rappaport, Wireless Communications, principles and Practices, 2nd Edition, Pearson.

Course Title	Course Code	Structure (I-P-C)		
Electronic Manufacturing and Prototyping	EC302	**3**	**0**	**3**

Pre-requisite, if any: Analog and Digital Electronics

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the Overview of electronic systems manufacturing and packaging
CO2	Discover Design Considerations for Different Types of PCB
CO3	Understand to design PCB using CAD Tool
CO4	Analyze PCB design Rules
CO5	Select Appropriate technique to test PCB

Syllabus:

Overview of electronic systems manufacturing and packaging, Introduction to IC manufacturing and realization of passive components in ICs and VLSI, Surface Mount Technology, Thermal budget and Current trends
Design Considerations for Different Types of PCBs: Single Layer PCB, Multilayer PCB, Flexible PCB, etc. Design Considerations for PCBs for Different Applications: Digital Circuits, Analog Circuits, High-Speed Circuits, Power Circuits, etc

Introduction to PCB Design using PCB tool Introduction to PCBs and general guidelines, PCB design rules for various applications. Creation of new project in PCB tool, drawing the circuit in the schematic page using the components from the library. Simulation of Circuit using P-spice Simulation for verification of results, adding footprints to the components from the library. Creating the netlist, importing the components on PCB tool PCB Editor. Placing and moving the components in PCB Editor as per design sequence, Routing between the components. Generating pdf files and Gerber files

Layout Rules and Parameters. Design Rule Checks: Signal Layer Checks, Power / Ground Checks, Solder Mask Check, Drill Check, etc. Automated Processes, Through Hole Vs. SMT Technologies. Thermal Management for IC and PCBs, Cooling Requirements, Electronic Cooling Methods

Functions of an Electronic Package: Packaging Hierarchy, Driving Forces on Packaging Technology, Materials for Microelectronic Packaging, Material for High-Density Interconnect Substrates, Electrical Anatomy of Systems Packaging, Signal Distribution, Power Distribution, Electromagnetic Interference, Design Process.

Symptom Recognition, Bracketing Technique, Component failure Analysis, Fault types and causes in circuits, during manufacturing, Manual trouble shooting technique Tools and Instruments DMM CRO, PCO, Logic probes, Logic pulsar, Logic Analyzer.

Textbooks:

1. R. T. Rao, Fundamentals of Microsystems Packaging, McGraw Hill, 2001, ISBN- 10: 0071371699, ISBN-13: 978-0071371698. 2. J. Axelson, Making Printed Circuit Boards, TAB/McGraw Hill, 1993, ISBN- 10: 0070027994, ISBN-13: 978-0070027992.
2. J. Axelson, Making Printed Circuit Boards, TAB/McGraw Hill, 1993, ISBN- 10: 0070027994, ISBN-13: 978-0070027992.

References:

1. . R. K. Ulrich, W. D. Brown, Advanced Electronic Packaging, : IEEE Press Series on Microelectronic Systems, 2 nd edition, 2006, Wiley-IEEE Press; ISBN-10: 0471754501, ISBN-13: 978-0471754503
2. J. Varteresian, Fabricating Printed Circuit Boards (Demystifying Technology) 1 st edition, Newnes, 2002. ISBN-10: 1878707507, ISBN-13: 978-1878707505

3. R. A. Reis, Electronic project design and fabrication, 6 th edition, Prentice Hall, 2004, ISBN-10: 0131130544, ISBN-13: 978-0131130548
4. K. Mitzner Complete PCB Design Using OrCad Capture and Layout, Elsevier, 2009, ISBN :9780750689717.
5. J. H. Lau, C. P. Wong, J. L. Prince, Electronic Packaging: Design, Materials, Process, and Reliability Electronic Packaging and Interconnection Series, 1 st edition, McGraw- Hill Professional, 1998. ISBN-10: 0070371350, ISBN-13: 978-0070371354

Course Title	Course Code	Structure (I-P-C)		
Data Communication and Networking	EC304	**3**	**0**	**3**

Pre-requisite, if any: Computer Networks, C Programming

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand a transmission of a data in a network
CO2	Acquire knowledge of various OSI layers.
CO3	Understand topologies for specific networks.
CO4	Understand the basics of cryptography.
CO5	Understand various protocols of wireless transmission

Syllabus:

Overview of Data Communication and Networking: Introduction; Data communications: components, data representation (ASCII, ISO etc.), direction of data flow (simplex, half duplex, full duplex); network criteria, physical structure (type of connection, topology), categories of network (LAN, MAN, WAN); Internet: brief history, Protocols and standards; Reference models: OSI reference model, TCP/IP reference model, their comparative study.

Physical Layer: Overview of data (analog& digital), signal (analog& digital), transmission (analog& digital) & transmission media (guided & unguided); Circuit switching: time division & space division switch, TDM bus; Telephone Network; ATM, B-ISDN.

Data link Layer: Types of errors, framing (character and bit stuffing), error detection & correction methods; Flow control; Protocols: Stop & wait ARQ, Go-Back- N ARQ, Selective repeat ARQ, HDLC.

Medium Access sub layer: Point to Point Protocol, LCP, NCP, Token Ring; Reservation, Polling, Multiple access protocols: Pure ALOHA, Slotted ALOHA, CSMA, CSMA/CD, CSMA/CA Traditional Ethernet, fast Ethernet (in brief).

Network layer: Internetworking & devices: Repeaters, Hubs, Bridges, Switches, Router, Gateway; Addressing: IP addressing, subnetting; Routing: techniques, static vs. dynamic routing, Unicast Routing Protocols: RIP, OSPF, BGP; Other Protocols: ARP, IP, ICMP, IPV6.

Transport layer: Process to Process delivery; UDP; TCP; Congestion Control: Open Loop, Closed Loop choke packets; Quality of service: techniques to improve QoS: Leaky bucket algorithm, Token bucket algorithm.

Application Layer: Introduction to DNS, SMTP, SNMP, FTP, HTTP & WWW; Security: Cryptography (Public, Private Key based), Digital Signature, Firewalls.

Text Book(s):

1. B. A. Forouzan, Data Communications and Networking, 4th edition, Tata McGraw Hill 2012, ISBN: 0072967757
2. A. S. Tanenbaum, Computer Networks, 4th edition, Pearson, 2013, ISBN: 978-0132126953

References & Web Resources:

1. W. Stallings, Data and Computer Communications, 5th edition, Pearson, 5th edition, 2013, ISBN: 978-0133506488.

Course Title	Course Code	Structure (I-P-C)		
VLSI System Design	EC303	**3**	**0**	**3**

Pre-requisite, if any: Digital Logic Design

Course Outcomes: At the end of the course, the students will be able to:

CO1	Design the digital systems using Verilog or VHDL
CO2	Estimate the circuit/system performance, area, and power dissipation
CO3	Implement the low power and high throughput techniques on digital VLSI circuits.
CO4	Develop the Custom IPs to integrate into Digital Systems using EDA..
CO5	Understand the CMOS digital circuits.

Syllabus:

Introduction to VLSI Design, Need for VLSI Design, Various VLSI design flows, Basic classifications of VLSI design. Digital Arithmetic Circuits, Fixed Point/Floating Point/Galois Field Arithmetic, RTL Design using Verilog HDL. Introduction to Hardware-Software Co-design, Custom IPs, High level synthesis, and formal hardware verification.

MOS Transistors, Operation of MOSFET, CMOS Logic - Inverter, Logic Gates, Pass Transistors and Transmission Gates, Tri states, Multiplexers, Sequential Circuits, and Pass Transistor Logic .

CMOS Fabrication and Layout - Inverter Cross-section, Fabrication process, Layout Design Rules, Gate Layouts, Stick Diagrams. Timing optimization, Transient response, RC Delay Model, Linear Delay Model, Logical Effort of Paths. Statistical timing analysis.

Sources of Power Dissipation, Dynamic Power, Static Power, Energy-Delay Optimization, Low Power Architectures.Testers, text fixtures, and Test Programs, BIST, Scan Chains, Design for Testability, Fault tolerant designs. CMOS chip design options: Full custom ASICs, Std. Cell based ASICs, Gate Array based ASICs, Programmable logic structures-PLA, PAL, PROM, FPGA. Introduction to Physical Design: Floor plan, power plan, placement, routing, physical verification.

Text Book(s):

1. Weste and Eshraghian: Principles of CMOS VLSI design, Addison Wesley, 4th Edn, 2011.
2. Samir Palnitkar: Verilog HDL - Guide to Digital design and synthesis, Pearson Education, 3rd Edn, 2003

References & Web Resources:

1. CMOS Logic Circuit Design, John P Uyemura, 2009, Springer
2. Verilog for Digital Design, Frank Vahid, Roman Lysecky, Wiely, 2007

Course Title	Course Code	Structure (I-P-C)		
Wireless Communication Practice	EC305	**0**	**3**	**2**

Pre-requisite, if any: Signals and Systems, Analog and Digital Communication Techniques

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understanding of Wireless Communication system in detail with its concepts, techniques and application usage Practice.
CO2	This course Simulation basics of Wireless transmission, Channel Modelling, link budget calculations, Capacity and Fading.
CO3	Every topic in Wireless communication to be explained with its function either with demonstration and/or simulation using suitable software.
CO4	Upon completion of this course, students will be able to understand the principles of wireless communication and its applications.
CO5	Students will be able to design, conduct and evaluate experiments related to wireless communication.

Experiments:

Experiment-1: Basic experiments in Wireless Communication

- 1. Antenna, Antenna Polarization and Antenna measurements
- 2. Signal transmission and reception measurements
- 3. Signal propagation and interference measurements

Experiment-2: Introduction to Wireless Communication Systems

- Definition and scope of Wireless Communication
- Wireless Communication Systems and Techniques
- Differences between Wired and Wireless Communication Systems
- Advantages and Disadvantages of Wireless Communication

Experiment-3: Wireless Communication Standards and Protocols

- Overview of Wireless Communication Standards and Protocols
- GSM, CDMA and LTE standards
- WiFi and Bluetooth Protocols

Experiment-4: Signal Propagation and Channel Modeling

- Understanding Signal Propagation
- Link Budget Calculations
- Types of Channel Models

Experiment -5: Wireless Communication System Design

- System Design Methodology
- Frequency Allocation and Spectrum utilization
- Antenna System Design Principles
- Power Management

Experiment-6: Practical Aspects of Wireless Communication

- Wireless Communication Testing and Measurements
- Troubleshooting Wireless Communication Systems
- Security issues in Wireless Communication
- Wireless Communication Applications

Experiment-7: Final Project

- Students will work on a final project related to wireless communication.
- They will have to design, conduct and report the results of their project.
- Students will have to present their project to the class.

Text Book(s):

1. Andrea Goldsmith, Wireless Communication, Cambridge University Press.
2. Aditya Jagannatham, Principles of Modern Wireless Communication Systems, McGraw Hill, (2016)

References & Web Resources:

1. Theodore Rappaport, Wireless Communications, principles and Practices, 2nd Edition, Pearson.163

Course Title	Course Code	Structure (I-P-C)		
Electronic Manufacturing and Prototyping Practice	EC306	0	**3**	**2**

Pre-requisite, if any: Analog and Digital Electronics

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the Flow of PCB Designing Process
CO2	Discover Designing different types of PCB
CO3	Practice designing PCB using CAD Tool
CO4	Examine fabricated PCB
CO5	Design and fabrication of PCB for different applications

Tool: Open-Source Tools

Experiments:

1. Designing PCB for different Power Supply Circuits
2. Regulator Circuit Design using IC 723, IC78XX, and IC79XX, Designing of power supplies
3. Switching power Supply, DC to DC Converter, Buck Converter, Boost Converter, and Buck- Boost Converter
4. Designing of Analog circuits
5. Signal Conditioning circuit, Current Source, V to I circuits
6. Designing Analog and Digital Circuits
7. Designing with Microcontroller
8. Mini Project- Fabrication of PCB using Printing, Milling, and Etching Methods

Textbooks:

1. R. T. Rao, Fundamentals of Microsystems Packaging, McGraw Hill, 2001, ISBN- 10: 0071371699, ISBN-13: 978-0071371698. 2. J. Axelson, Making Printed Circuit Boards, TAB/McGraw Hill, 1993, ISBN- 10: 0070027994, ISBN-13: 978-0070027992.
2. J. Axelson, Making Printed Circuit Boards, TAB/McGraw Hill, 1993, ISBN- 10: 0070027994, ISBN-13: 978-0070027992.

References:

1. R. K. Ulrich, W. D. Brown, Advanced Electronic Packaging, : IEEE Press Series on Microelectronic Systems, 2 nd edition, 2006, Wiley-IEEE Press; ISBN-10: 0471754501, ISBN-13: 978-0471754503
2. J. Varteresian, Fabricating Printed Circuit Boards (Demystifying Technology) 1 st edition, Newnes, 2002. ISBN-10: 1878707507, ISBN-13: 978-1878707505
3. R. A. Reis, Electronic project design and fabrication, 6 th edition, Prentice Hall, 2004, ISBN-10: 0131130544, ISBN-13: 978-0131130548
4. K. Mitzner Complete PCB Design Using OrCad Capture and Layout, Elsevier, 2009, ISBN :9780750689717.
5. J. H. Lau, C. P. Wong, J. L. Prince, Electronic Packaging: Design, Materials, Process, and Reliability Electronic Packaging and Interconnection Series, 1 st edition, McGraw- Hill Professional, 1998. ISBN-10: 0070371350, ISBN-13: 978-0070371354

Course Title	Course Code	Structure (I-P-C)		
VLSI system design Practice	EC307	**0**	**3**	**2**

Pre-requisite, if any: Digital Logic Design

Course Outcomes: At the end of the course, the students will be able to:

CO1	Demonstrate the knowledge of digital circuit design flow
CO2	Analyse the process of simulation of combinational sequential circuits
CO3	Validate and demonstrate the results of digital circuits
CO4	Design of CMOS digital circuits
CO5	Implementation of digital circuits using FPGA

Experiments:

1. Simulate the parameters of NMOS, PMOS transistors from its characteristics.
2. Design and simulate the Symmetrical CMOS inverter.
3. Simulate and compare the performance of CMOS inverter over NMOS inverter.
4. Design and simulate the two input CMOS NAND/NOR gate.
5. Design and simulate the 4- bit CMOS adder Design and simulate Carry bypass adder.
6. Design and simulate the D-Flip Flop using transmission gates
7. Simulate the static and dynamic SRAM cells.
8. Layout design of CMOS inverter
9. Design and synthesis of digital CMOS circuits using EDA tool.
10. Implementation of digital circuits using FPGA
11. Implementation of digital circuits with semi custom ASIC

Text Book(s):

1. Weste and Eshraghian: Principles of CMOS VLSI design, Addison Wesley, 4th Edn, 2011.

References & Web Resources:

1. CMOS Logic Circuit Design, John P Uyemura, 2009, Springer

Course Title	Course Code	Structure (I-P-C)		
Antenna and Microwave Circuits Design	EC351	**3**	**0**	**3**

Pre-requisite, if any: Electromagnetic waves and Transmission Lines

Course Outcomes: At the end of the course, the students will be able to:

CO1	Analyse various passive and active microwave circuits
CO2	Analyse a given antenna and find out its fundamental parameters.
CO3	Plan the link budget for microwave systems
CO4	Design Antennas with the given specification
CO5	Design microwave components like a filter, coupler, amplifier, mixer, oscillator and LNA.

Syllabus:

Microwave Network Analysis: Impedance and Equivalent Voltages and Currents, Impedance and Admittance Matrices, Reciprocal Networks, Lossless Networks, The Scattering Matrix, and The Transmission (ABCD) Matrix.

Microwave Passive Circuits: Power dividers and directional couplers, microwave filters, Noise and nonlinear distortion.

Microwave Active Circuits: Active RF and Microwave Devices, amplifier design, oscillators and mixers.

Microwave Systems: Link Budget and Link Margin of wireless communication systems, Radio Receiver Architectures, Noise Characterization of a Receiver.

Types of Antennas, Radiation Mechanism of Antenna, Fundamental Parameters and Figures-of-Merit of Antennas Radiation Integrals and Auxiliary Potential Functions.

Linear Wire Antennas, Loop Antennas, Microstrip and Mobile Communications Antennas, Array antennas.

Antenna Synthesis and Continuous Sources, Integral Equations, Moment Method, and Self and Mutual Impedances.

Text Book(s):

1. Pozar, David M. Microwave engineering. John wiley& sons, 2011.
2. Balanis, Constantine A. Antenna theory: analysis and design. John wiley& sons, 2015.

References & Web Resources:

1. Stutzman, Warren L., and Gary A. Thiele. Antenna theory and design. John Wiley & Sons, 2012.
2. Collin, Robert E. Foundations for microwave engineering. John Wiley & Sons, 2007.

Course Title	Course Code	Structure (I-P-C)		
Information Theory and Coding	**EC352**	**3**	**0**	**3**

Pre-requisite, if any:

Course Outcomes: At the end of the course, the students will be able to:

CO1	Analyze different sources in terms of entropy
CO2	Analyze different channels in terms of mutual information
CO3	Design data compression for various sources
CO4	Compute the capacity of different channels
CO5	Analyze AWGN channels

Syllabus

Information - Fundamentals: Entropy, joint entropy and conditional entropy, relative entropy and mutual information, chain rules for entropy, relative entropy, and mutual information, Jensen's inequality, log sum inequality, sufficient statistics, Fano's inequality

Asymptotic Equipartition Property (AEP): AEP, consequence of AEP - data compression, typical set.

Data Compression: Kraft inequality, optimal codes and bounds on optimal codelength, Kraft inequality for uniquely decodable codes, Huffman codes, Shannon-Fano-Elias coding (

Channel Capacity: (Binary) Symmetric Channels, Jointy typical sequences, the channel coding theorem, Fano's inequality and the converse to the coding theorem, Hamming codes, joint source-channel coding theorem.

Gaussian Channel: Differential entropy, coding theorem for Gaussian channels

Textbooks

1. T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, John-Wiley & Sons, 2006. ISBN: 978-0471241959

References & Web Resources:

1. I. Csiszar and J. Korner, Information Theory: Coding Theorems for Discrete Memoryless Systems, 1st edition, AkademiaiKiado, 1997. ISBN: 978-9630574402

2. R. G. Gallager, Information Theory and Reliable Communication, 1st edition, Wiley, 1968, ISBN: 978-0471290483

Course Title	Course Code	Structure (I-P-C)		
Antenna and Microwave Circuits Design Practice	EC353	**0**	**3**	**2**

Pre-requisite, if any: Electromagnetic waves and Transmission Lines

Course Outcomes: At the end of the course, the students will be able to:

CO1	Measure of the fundamental parameters of the given antennas
CO2	Measure the s-parameters of various microwave circuits
CO3	Design various antennas using computational softwares, fabricate and measure their performance.
CO4	Design various microwave passive components like filters, couplers using computational softwares, fabricate and measure their s-parameters..
CO5	Design various microwave active components like amplifier, mixer, oscillator and LNA using computational softwares.

Experiments:

1. Measure the fundamental parameters of various antennas like dipole, horn, and microstrip antennas.
2. Measure the s-parameters of various couplers, filters, and Amplifiers.
3. Design wireless antenna for 4G and 5G applications, fabricate, and test its performance.
4. Design microwave passive components, fabricate, and test.
5. Design a microwave active component.

Text Book(s):

1. Pozar, David M. Microwave engineering. John wiley& sons, 2011.
2. Balanis, Constantine A. Antenna theory: analysis and design. John wiley& sons, 2015.

References & Web Resources:

1. Stutzman, Warren L., and Gary A. Thiele. Antenna theory and design. John Wiley & Sons, 2012.
2. Collin, Robert E. Foundations for microwave engineering. John Wiley & Sons, 2007.

Course Title	Course Code	Structure (I-P-C)		
Information Theory and Coding Practice	**EC354**	**0**	**3**	**2**

Pre-requisite, if any: Information Theory and Coding

Course Outcomes: At the end of the course, the students will be able to:

CO1	To understand the programming of Entropies and Mutual Information
CO2	To understand the programming of Entropies and Mutual Information
CO3	To develop MATLAB codes for Block codes, Cyclic codes and Convolutional codes.
CO4	Analysis of Differential entropy, coding theorem for Gaussian channels
CO5	Analyze AWGN channels with practical knowledge

List of Experiments

1. Write a program for determination of various entropies and mutual information of a given channel.
2. Write a program for generation and evaluation of variable length source coding using C/MATLAB a) Shannon – Fano coding and decoding b) Huffman Coding and decoding c) Lempel Ziv Coding and decoding
3. Write a Program for coding & decoding of Linear block codes.
4. Write a Program for coding & decoding of Cyclic codes.
5. Write a program for coding and decoding of convolutional codes.
6. Write a program for coding and decoding of BCH and RS codes.
7. Write a simulation program to implement source coding and channel coding for transmitting a text file.

Textbooks

1. T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, John-Wiley & Sons, 2006. ISBN: 978-0471241959

References & Web Resources:

1. I. Csiszar and J. Korner, Information Theory: Coding Theorems for Discrete Memoryless Systems, 1st edition, AkademiaiKiado, 1997. ISBN: 978-9630574402

2. R. G. Gallager, Information Theory and Reliable Communication, 1st edition, Wiley, 1968, ISBN: 978-0471290483

Free Electives offered by ECE department.

Course Title	Course Code	Structure (I-P-C)		
Design of IoT System	EC470	**3**	**0**	**3**

Pre-requisite, if any: Microprocessors and Microcontrollers.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the networking with IoT, its enabling technologies, and explore a young, but rich, body of exciting ideas, solutions, and paradigm shifts.
CO2	Understanding the potential of IoT devices, support for networking according to the protocol standards, and being able to program them, would be useful for real time applications.
CO3	Develop the rapid prototypes of IoT based embedded systems using sensors, cloud.
CO4	Develop the IoT system using Arduino, Raspberry Pi, BeagleBone Black, and Intel Edison/Galileo.
CO5	Implement an IoT System with Cloud

Syllabus:

Introduction to IoT: Definition, Trend, IoT applications, Sensing and Actuation, IoT Devices and deployment models, Power awareness of IoT, LDO in IoT.

IoT Networking: Basic IoT Components, Interdependencies, Service Oriented Architecture.

IoT Data Protocols: MQTT, SMQTT, CoAP, XMPP, AMQP.

IoT Communication Protocols and their applications: IEEE 802.15.4, ZigBee6LoWPAN, Wireless HART, Z-Wave, ISA 100, Bluetooth, and Bluetooth low energy (BLE), NFC, RFID, WiFi for IoT communications.

Data Handling, Analytics, Data management for IoT: Data cleaning and processing, Data storage models, Searching in IoT, Deep Web Semantic Sensor Web, Semantic web data management, Real-time and Big data analytics for IoT, High-dimensional data processing, Parallel and Distributed data processing.

Interoperability in IoT: Low power Interoperability for IPV6 IoT.

Cloud-Centric IoT: Architecture, Open Challenges, Energy efficiency, QoS, QoE.

Industrial IoT (IIoT): Industrial IoT and its benefits, Future of IIoT, Challenges, Examples.

IoT System Management and Virtualization: IoT environment management over Cloud computing framework, Fog Computing paradigm for IoT with case studies, Softwarized control and virtualization technologies for IoT network and computation resource management.

Case Studies: Sensor body-area-network, Smart cities and Smart homes, Agriculture.

IoT Network Framework: Wireless Network Fundamental for IoT communication tutorials with demonstrations and hands-on: 802.11 and 802.15.4 MAC Fundamentals, Management Operations, Security Overview, Network Core Protocols, Tizen Network Stack Architecture, Introduction, CAPI Architecture Overview, Sync/Async Operation Sequence, Interaction of Network Core Components, P2P Core Component Overview, OEM Layer, Supplicant Plugin Architecture overview.

Text Book(s):

1. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, by EethurumRaj and Anupama C. Raman (CRC Press).
2. Internet of Things: A Hands-on Approach, by ArshdeepBahga and Vijay Madisetti (Universities Press).

References & Web Resources:

1. AdrianMcEwen, HakimCassimally, Designing the Internet of Things,Wiley,Nov 2013, (1st edition)
2. Martin Charlier, Alfred Lui, Claire Rowland, Elizabeth Goodman, Ann Light, Designing Connected Products, May 2015, O'Reilly Media.

Course Title	Course Code	Structure (I-P-C)		
Electric Vehicle Technology	EC471	**3**	**0**	**3**

Pre-requisite, if any: Basic Electrical and Electronics Engineering

Course Outcomes: At the end of the course, the students will be able to:

CO1	To understand about basics of electric vehicle
CO2	To understand drives and control.
CO3	Select battery, battery indication system for EV applications
CO4	Design battery charger for an EV
CO5	Design a basic Electric Vehicle

Syllabus:

Introduction to Electric Vehicle : Review of Conventional Vehicle: Introduction to Electric Vehicles: Types of EVs, Electric Drive-train, Tractive effort in normal driving.

Electric Drives : Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switched Reluctance Motor drives, drive system efficiency.

Energy Storage : Introduction to Energy Storage Requirements in Electric Vehicles: - Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system, Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

Energy Management System : Energy Management Strategies, Automotive networking and communication, EV charging standards, V2G, G2V, V2B, V2H. Business: E-mobility business, electrification challenges, Business- E-mobility business, electrification challenges.

Mobility and Connectors : Connected Mobility and Autonomous Mobility- case study E-mobility Indian Roadmap Perspective. Policy: EVs in infrastructure system, integration of EVs in smart grid, social dimensions of EVs. Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards.

Text Book(s):

1. Emadi, A. (Ed.), Miller, J., Ehsani, M., "Vehicular Electric Power Systems" Boca Raton, CRC Press, 2003
2. Husain, I. "Electric and Hybrid Vehicles" Boca Raton, CRC Press, 2010.

References & Web Resources:

1. Larminie, James, and John Lowry, "Electric Vehicle Technology Explained" John Wiley and Sons, 2012
2. Tariq Muneer and Irene IllescasGarcía, "The automobile, In Electric Vehicles: Prospects and Challenges", Elsevier, 2017
3. Sheldon S. Williamson, "Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles", Springer, 2013
4. Patents of TESLA

Course Title	Course Code	Structure (I-P-C)		
Navigation System	EC472	**3**	**0**	**3**

Pre-requisite, if any: Nil

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the concept of GNSS, AGNSS, Radio Positioning and Integration of Navigation technique.
CO2	Analyze navigation in various terrestrial situations.
CO3	Find the exact location of an object in the navigation system.
CO4	Design precision navigation systems.

Syllabus:

INTRODUCTION TO NAVIGATION: What Is Navigation, Position Fixing, Dead Reckoning, Inertial Navigation, Radio and Satellite Navigation, Terrestrial Radio Navigation, Satellite Navigation, Feature Matching, The Complete Navigation System.

NAVIGATION MATHEMATICS: Coordinate Frames, Kinematics, and the Earth: Coordinate Frames, Kinematics, Earth Surface and Gravity Models, Frame Transformations, Coriolis force.

INERTIAL NAVIGATION: Inertial-Frame Navigation Equations, Earth-Frame Navigation Equations, Local-Navigation-Frame Navigation Equations, Navigation Equations Precision, Initialization and Alignment, INS Error Propagation, Platform INS, Horizontal-Plane Inertial Navigation.

PRINCIPLES OF RADIO POSITIONING: Radio Positioning Configurations and Methods, Positioning Signals, User Equipment, Propagation, Error Sources, and Positioning Accuracy.

GNSS: FUNDAMENTALS, SIGNALS, AND SATELLITES: Fundamentals of Satellite Navigation, The Systems: Global Positioning System, GLONASS, Galileo, Beidou, REGIONAL NAVIGATION SYSTEMS: Beidou and Compass, QZSS, IRNSS, GNSS INTEROPERABILITY: Frequency Compatibility, User Competition, Multi-standard User Equipment Augmentation Systems, System Compatibility, GNSS Signals, Navigation Data Messages.

ADVANCED SATELLITE NAVIGATION: Differential GNSS, Carrier-Phase Positioning and Attitude, Poor Signal-to-Noise Environments, Multipath Mitigation, Signal Monitoring, Semi-Codeless Tracking.

TERRESTRIAL RADIO NAVIGATION: Point-Source Systems, Loran, Instrument Landing System, Urban and Indoor Positioning, Relative Navigation, Tracking, Sonar Transponders. (

FEATURE MATCHING: Terrain-Referenced Navigation, Sequential Processing, Batch Processing, Performance, Laser TRN, Barometric TRN, Sonar TRN, Image Matching, Scene Matching by Area Correlation, Continuous Visual Navigation, Map Matching, Other Feature-Matching Techniques, Stellar Navigation, Gravity Gradiometry, Magnetic Field Variation. (6 hours)
INS/GNSS Integration: Integration Architectures, System Model and State Selection, Measurement Models, Advanced INS/GNSS Integration.

Text Book(s):

1. Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems, Paul D. Groves Artech House, 2008 and 2013 Second Edition.
2. B.HofmannWollenhof, H.Lichtenegger, andJ.Collins, “GPS Theory and Practice”, Springer Wien, new York, 2000.

References & Web Resources:

1. Pratap Misra and Per Enge, “Global Positioning System Signals, Measurements, and Performance,” Ganga-Jamuna Press, Massachusetts, 2001.
2. Ahmed El-Rabbany, “Introduction to GPS,” Artech House, Boston, 2002.
3. Bradford W. Parkinson and James J. Spilker, “Global Positioning System: Theory and Applications,” Volume II, American Institute of Aeronautics and Astronautics, Inc., Washington, 1996.

Departmental Electives

Course Title	Course Code	Structure (I-P-C)		
Analog and Mixed Signal Circuit Design	EC401	**3**	**0**	**3**

Pre-requisite, if any: Analog Electronics

Course Outcomes: At the end of the course, the students will be able to:

CO1	Design and analyze complex analog integrated circuits using industry level analog IC Design tools
CO2	Design and analyze ADC and DAC using EDA tools
CO3	Design and analyze various MOSFET based arithmetic circuits.
CO4	Learn the various methods of power optimization in analog circuits.
CO5	Learn various circuits of design of Operational Amplifier

Syllabus:

Introduction: Review of single state MOS amplifiers, current mirrors, cascode current mirrors, active current mirrors, biasing techniques.

Op-amp design: Differential pair with current mirror load, single stage op-amp characteristics, single stage op-amp tradeoffs, telescopic cascode op-amp, folded cascode op-amp, two stage op-amp, fully differential single stage op-amp.

Data converter fundamentals: Analog versus digital (or discrete time) signals, converting analog signals to data signals, sample and hold circuits, sample and hold characteristics, switched capacitor circuits, DAC specifications, ADC specifications.

Data converters: DAC architectures – digital input code, R-2R ladder networks, current steering, charge scaling DACs, cyclic DAC, pipeline DAC, ADC architectures – flash ADC, 2-step flash ADC, pipeline ADC, integrating ADC, successive approximation ADC.

Phase locked loop: simple PLL, frequency/phase detectors, charge pump PLL, application as frequency multiplier.

Text Book(s):

1. BehzadRazavi, Design of Analog CMOS Integrated Circuits McGraw-Hill International Edition 2016.
2. Baker, R. Jacob, CMOS: Circuit design, Layout, and Simulation. John Wiley & Sons, 2019.

References & Web Resources:

1. Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.
2. BehzadRazavi, Fundamentals of Microelectronics, Second edition, Wiley, 2013
3. P. R. Gray, P. J. Hurst, S. H. Lewis and R. G. Meyer, Analysis And Design Of Analog Integrated Circuits, 5th edition, John Wiley & Sons, Inc., 2009.

Course Title	Course Code	Structure (I-P-C)		
Artificial Intelligence and Machine Learning	EC402	**3**	**0**	**3**

Pre-requisite, if any: Linear Algebra, Probability Theory, and Statistics

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the applications of Linear Algebra and Probability in Machine Learning
CO2	Familiarize with traditional and modern learning paradigms with their applications in the real-world systems
CO3	Adapt human training for the development of intelligent machines
CO4	Model any real-world practical problem in a machine-learning domain
CO5	Grasp the artificial neural networks with an understanding of the modern deep-learning techniques

Syllabus:

Introduction to machine learning: learning systems, classification, clustering, regression, separability of problems; introduction to learning paradigms: supervised, unsupervised, semi supervised, active, reinforcement with examples; cross-validation; performance evaluation metrics for classification and clustering; curse of dimensionality, feature selection, reduction and expansion, computation of Eigen co-ordinates and principle component analysis.

Recognition systems and design cycle, Non-linearly separable problems: solutions through Cover's theorem with examples, parametric learning mechanisms like Maximum likelihood, expectation maximisation, aposteriori probabilities, Instance-based learning, Lazy learning with K-nearest neighbour, Eager learning with basis functions, non-parametric learning using support vector machines (SVMs).

Artificial neural networks: Analogy of biological neural network with artificial neural network; Perceptron learning; gradient descent algorithm; multi-layer perceptrons; backpropagation algorithm; activation functions, delta rule, learning curves: overfitting and underfitting of models; Hebbian learning, self-organising feature map, radial basis function neural networks.

Deep neural networks: Introduction and advent of deep learning paradigm, solutions to vanishing and exploding gradient problems, regularisation, activation functions for deep learning, deep feed forward network, convolutional neural network (CNN), pretrained CNN models, attention network, generative models like auto-encoders and adversarial learning, recurrent neural networks, problem solving through deep learning and open areas of research**.**

Text Book(s):

1. T. M. Mitchell, Machine Learning, McGraw-Hill, 1997.
2. S. Haykin, Neural Networks: A Comprehensive Foundation. Prentice-Hall of India, 2007.

Reference Book(s):

1. R. O. Duda, P.E. Hart, D. G. Stork, Pattern Classification, John Wiley, 2001
2. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016

Course Title	Course Code	Structure (I-P-C)		
Circuits for Electronic System Design	**EC403**	**3**	**0**	**3**

Pre-requisite, if any: Analog Electronics and Digital Logic Circuits

Course Outcomes: At the end of the course, the students will be able to:

CO1	Apply concepts of Analog circuits for signal conditioning, signal processing, controller circuits, and driver circuits for power electronic circuits.
CO2	Design transformer and different power sources for various applications
CO3	Understand the interface of various modules to microcontroller and learn various communication protocols
CO4	Perform descriptive error analysis for the circuits
CO5	Demonstrate key concepts in electronics circuit design, including tools, approaches, and application scenarios

Syllabus:

1. Introduction to Op-Amps: Op-amp Characteristics, Negative feedback, Gain of the Op-Amp
2. Analog Signal conditioning circuits**:** Buffering, scaling, level translation, filtering applications, Analog math circuits - arithmetic circuits, log circuits, trigonometric circuits and applications Timer circuits, pulse width modulation circuits, P, PI and PID controller circuits, protection circuits, base and gate drive circuits for power transistors, MOSFETs and IGBTs, relay and contactor drive circuits. Design and error budget analysis of signal conditioners for low level AC and DC applications. Error Analysis.
3. Power supply circuits:Board level power supply circuits to generate +/-12V, 5V, 3.3V, 1.8V. Linear regulators, low drop out regulators, charge pumps, switched mode power converters.
4. Interfacing circuits**:** A to D, D to A, A to A and D to D interfaces, serial and parallel DACs, sampling, RS-232, USB, I2C, LCD, serial memory, SPI, CAN, wireless (RF, WiFi) Ethernet, RFID, SD card, SIM card, GPS, Touchscreen interfaces.

Digital circuit essentials**:**Digital filters, moving average, numeric formats, scaling, normalizing, arithmetic, log, exponential, square root, cube root, hypotenuse, sine, 3 phase waves, PWM etc.

References & Web Resources:

1. Franco, S., Design with operational amplifiers and analog integrated circuits. Mc. GrawHillbook Co. 1988.
2. Horowitz, P., and Hill, W., The art of electronics (2nd edition), Cambridge University Press. 1992.
3. Abraham Pressman, Keith Billings, Taylor Morey, Switching Power Supply Design, McGraw-Hill Education, 2009
4. Warwick A. Smith, ARM Microcontroller Interfacing: Hardware and Software, Elektor Electronics Publishing, 2010
5. Datasheets and Application notes of different Integrated circuits.

Course Title	Course Code	Structure (I-P-C)		
Cognitive Communication Networks	EC404	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the Cognitive Communication and networking as per applications.
CO2	Detects the desired signal in the scrambled spectrum.
CO3	Understand algorithms for cognitive networks.
CO4	Understand the MAC protocols in cognitive networks.

Syllabus:

Introduction to Cognitive Radio: Introduction –Software Defined Radio: Architecture–Digital Signal Processor and SDR Baseband architecture – Reconfigurable Wireless Communication Systems – Digital Radio Processing –Cognitive Radio: Cognitive radio Framework – Functions – Paradigms of Cognitive Radio.

Spectrum Sensing: Introduction –Spectrum Sensing – Multiband Spectrum Sensing – Sensing Techniques – Other algorithms – Comparison – Performance Measure & Design Trade-Offs: Receiver operating characteristics – Throughput Performance measure –Fundamental limits and trade-offs.

Cooperative Spectrum Acquisition: Basics of cooperative spectrum sensing–Examples of spectrum acquisition techniques – cooperative transmission techniques – sensing strategies– Acquisition in the Presence of Interference: Chase combining HARQ –Regenerative cooperative Diversity–spectrum overlay– spectrum handoff.

MAC Protocols and Network Layer Design: Functionality of MAC protocol in spectrum access – classification –Interframe spacing and MAC challenges – QOS – Spectrum sharing in CRAHN – CRAHN models – CSMA/CA based MAC protocols for CRAHN – Routing in CRN– Centralized and Distributed protocols – Geographical Protocol.

Text Book(s):

1. Mohamed Ibnkahla, "Cooperative Cognitive Radio Networks:The complete Spectrum Cycle" I edition.
2. AhamedKhattab, Dmitri Perkins,BagdyByoumi,"Cognitive Radio Networks from Theory to Practice " 2013th edition.

References & Web Resources:

1. Kwang-Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks, Wiley Publications
2. Alexander M.Wyglinski,MaziarNekovee, ThomasHou," Cognitive Radio Communications and Networks". I edition.

Course Title	Course Code	Structure (I-P-C)		
Communication Protocols for Electronic System Design	**EC405**	**3**	**0**	**3**

Pre-requisite, if any: NIL

Course Aim: To teach fundamentals of communication protocols for designing electronic systems.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Quantitative analysis of individual components of industrial data communications.
CO2	Analysis and specification of serial communication protocol standards.
CO3	Understanding the error detection, cable shielding techniques to avoid stray pickups, noise.
CO4	Systematic understanding and development of industrial communication protocols.
CO5	Implement the different communication protocols for different applications

Syllabus:

Overview: Standards, OSI model, Protocols, Physical standards, Modern instrumentation and control systems, PLCs, Smart instrumentation systems, Communication principles and modes, error detection, Transmission, UART.

Serial communication standards: Standards, serial data communication interface standards, EIA-RS232 interface standard, RS-449, RS-422, RS-423 and RS-485 standards, Troubleshooting and testing with RS-485, GPIB standard, USB interface.

Error Detection, Cabling and Electrical Noise: Errors, Types of error detection, control and correction, copper and fiber cables, sources of electrical noise, shielding, cable ducting and earthling.

Modems and Multiplexers: Synchronous and Asynchronous modes, flow control, modulation techniques, types of a modem, modem standards, terminal and statistical multiplexers.

Communication Protocols: Flow control protocols, XON/XOFF, BSC, HDLC and File transfer protocols, OSI model and layers, ASCII protocols, Modbus protocol.

Industrial Protocols: Introduction to HART protocol, Smart instrumentation, HART physical layer, HART data link layer, HART application layer, ASD_i interface, Seriplex, CANbus, Device net, Profibus, FIP bus, Fieldbus.

Local Area Networks: Circuit and packet switching, Network topologies, Media access control mechanisms, LAN standards, Ethernet protocol, Token ring protocol.

References & Web Resources:

1. Practical data communications for instrumentation and control, John Park, Steve Mackay, Edwin Wright, Elsevier Newnes Publisher, 2008.

2. Computer Networks,AndrewTanenbaum, Prentice Hall Professional Technical Reference, 2002.

CourseTitle	CourseCode	Structure (I-P-C)		
Design of Switched Mode Power Supplies	EC406	**3**	**0**	**3**

Pre-requisite, if any: Basic Electrical and Electronics Engg., and Control System

Course Outcomes: At the end of the course, the students will be able to:

CO1	Able to do the Steady-State Analysis of DC-DC power converters
CO2	Design switched-mode DC-DC power converters
CO3	Apply corresponding control techniques
CO4	Design transformer and different power sources for various DC-DC Applications
CO5	Demonstrate proficiency with computer skills (e.g., PSPICE and MATLAB) for the analysis and design of switched mode power converters.

Syllabus:

Switching devices: Ideal and real characteristics, control, drive and protection.

Design constraints of reactive elements in Power Electronic Systems: Design of inductor, transformer and capacitors for power electronic applications, Input filter requirement.

Switching power converters: Circuit topology, operation, steady-state model, dynamic model. PWM DC - DC Converters (CCM and DCM) - operating principles, constituent elements, characteristics, comparisons and selection criteria.

Soft-switching DC - DC Converters: Zero-voltage-switching converters, zero-current switching converters, multi-resonant converters and Load resonant converters.

Pulse Width Modulated Rectifiers: Properties of ideal rectifier, realization of near ideal rectifier, control of the current waveform, single phase and three-phase converter systems incorporating ideal rectifiers and design examples.

Review of linear control theory. Closed-loop control of switching power converters. Sample designs and construction projects.

Text Books:

1. R. W. Erickson and D. Maksimovic, Fundamentals of Power Electronics, 2nd Kluwer Academic Publishers, 2000. ed.,

References:

1. Marian K. Kazimierczuk, ‘Pulse-width Modulated DC-DC Power Converters’ John Wiley & Sons Ltd., 1st Edition, 2008.

2. Philip T Krein, ‘Elements of Power Electronics’, Oxford University Press, 2nd Edition, 2012.

3. Batarseh, ‘Power Electronic Circuits’, John Wiley, 2nd Edition, 2004.

4. H. W. Whittington, B. W. Flynn, D. E. Macpherson, ‘Switched Mode Power Supplies’, John Wiley & Sons Inc., 2nd Edition, 1997.

Course Title	Course Code	Structure (I-P-C)		
Detection and Estimation Theory	EC407	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Random Process, Communication Systems

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the discrete-time and continuous-time signal theory for finding unknown signal parameters.
CO2	Extract useful information from random observations in communications.
CO3	Design and analyze optimum detection schemes.
CO4	Estimate the error in wireless communication.
CO5	Understand the performance parameters in practical applications

Syllabus:

Detection Theory: Detection Theory in Signal Processing; the Detection Problem; the Mathematical Detection Problem; Hierarchy of Detection Problems; Role of Asymptotics.

Statistical Detection Theory: Neyman-Pearson Theorem , Receiver Operating Characteristics, Minimum Probability of Error, Multiple Hypothesis Testing, Minimum Bayes Risk Detector - Binary Hypothesis.

Deterministic Signal: Matched Filters – Development of Detector, Performance of Matched Filter; Multiple Signals – Binary case, Performance of Binary Case, M-ary case.

Random Signals: Estimator-Correlator – Energy Detector; Linear Model - Rayleigh Fading Sinusoid, Incoherent FSK for a Multipath Channel.

Estimation Theory: Estimation in Signal Processing; Mathematical Estimation Problem; Assessing Estimator Performance.

Minimum Variance Unbiased Estimation: Unbiased Estimators; Minimum Variance Criterion; Existence of the Minimum Variance Unbiased Estimator; Finding the Minimum Variance Unbiased Estimator. Estimator Accuracy Considerations; Cramer-Rao Lower Bound; General CRLB for Signals in AWGN.

Estimation Techniques: Linear Model, General Minimum Variance Unbiased Estimation, Best Linear Unbiased Estimators, Maximum Likelihood Estimation, Least Squares, Estimation.

Text Book(s):

1. Steven M. Kay, Fundamentals of Statistical signal processing, volume-1: Estimation theory. Prentice Hall 2011.
2. Steven M. Kay, Fundamentals of Statistical signal processing, volume-2: Detection theory, Prentice Hall 2011.

References & Web Resources:

1. Harry L. Van Trees, Detection, Estimation, and Modulation Theory, Part I, John Wiley & Sons, Inc. 2011.
2. A. Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and stochastic processes, 4e. The McGraw-Hill 2010.

Course Title	Course Code	Structure (I-P-C)		
Digital Image Processing	EC408	**3**	**2**	**4**

Pre-requisite, if any: Digital Signal Processing

Course Outcomes: At the end of the course, the students will be able to:

CO1	Analyse the properties of various images
CO2	Manipulate the operations between the images
CO3	Transform the given images
CO4	Detect the objects in the images
CO5	Enhance the resolution of the images

Syllabus:

Theory

1. Digital Image Fundamentals: elements of visual perception, image acquisition and display, image sampling and quantization, pixel relationship, arithmetic operations between images and super resolution (4 hours)

2. Image Transformation and Enhancement: geometric transformation, intensity transformation, spatial domain filtering, DFT, DCT, KLT and frequency domain filtering (8 hours)

3. Image and Video coding: run length coding, Huffman coding, compression using DCT, H.264/MPEG-4 advanced video coding (4 hours)

4. Image Restoration and Reconstruction: models for image degradation and restoration process, Wieners' filter, principles of Computed Tomography (CT), Image reconstruction from projections using inverse Radon transform and binary image reconstruction using network flow (6 hours)

5. Color Image Processing: color models, pseudo and full-color image processing, smoothing and sharpening in color images and segmentation based on color (4 hours)

6. Morphological Image Processing: erosion and dilation, opening and closing, boundary extraction, hole filling, connected component extraction, thinning and thickening, and grayscale morphology (6 hours)

7. Image Segmentation: point, line and edge detection, Hough transform, thresholding using Otsu's method, region based segmentation, watershed segmentation algorithm and graph-cut based segmentation (7 hours)

8. Representation, Description and Recognition of Objects: chain codes, polygonal approximation approaches, signatures, boundary segments, boundary descriptors, regional descriptors, recognition based on decision–theoretic methods, matching shape numbers and string matching (7 hours)

Text Book(s):

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson Education, 3rd Edition, 2009

References & Web Resources:

1. William K Pratt, "Digital Image Processing", John Willey, 4th edition, 2006.
2. A.K. Jain, "Fundamentals of Digital Image Processing", Prentice Hall of India, 1995.

3. Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins, “Digital Image Processing using MATLAB”, Pearson Education, 2nd Edition, 2009.
4. B. Chanda and D. Dutta Majumder, “Digital Image Processing and Analysis”, Prentice Hall of India, 2008

CourseTitle	CourseCode	Structure(I-P-C)		
Electrical Drives	**EC409**	**1**	**3**	**3**

Pre-requisite, if any: Basic Electrical and Electronics Engineering

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understandhowpowerelectronicconvertersandinvertersoperate.
CO2	Possessanunderstandingoffeedbackcontroltheory.
CO3	Analyze andcomparetheperformanceofDCandACmachines.
CO4	Designcontrolalgorithmsforelectricdriveswhichachievetheregulation oftorque, speed,or position inthe abovemachines.

Syllabus:

Experiments conducted in this course bring out the basic concepts of different types of electrical machines and their performance.

Experimentsareconductedtointroducetheconceptofcontrolofconventionalelectri cmotors such as DC motor, AC Induction motor and also special machines such as Stepper motor, Permanent magnet brushless motors, Servo motor.

Speed-Torque characteristics of various types of load and drive motors are also discussed.

The working principle of various power electronic converters is also studied by conducting experiments.

References & Web Resources:

1. R.Krishnan,"ElectricMotorDrives:Modeling,Analysis,andControl,"Pre nticeHall, 2001.
2. .Mohan,"ElectricDrives:AnIntegrativeApproach,"MNPERE,2001.

Course Title	Course Code	Structure (I-P-C)		
Electromagnetic Interference and Compatibility	EC410	**3**	**0**	**3**

Pre-requisite, if any: Electromagnetic Waves and Transmission Lines

Course Outcomes: At the end of the course, the students will be able to:

CO1	Gain knowledge to understand the concept of EMI / EMC related to product design.
CO2	Understand the various standards of EMI/EMC.
CO3	Diagnose and solve various electromagnetic compatibility problems.
CO4	Understand the sources of EMI and various coupling methods.
CO5	Learn the various methods of doing the pre-compliance measurement techniques.

Syllabus:

Introduction to EMI and EMC: Various EMC requirements and standards-Need for EMC and its importance in electronic product design - sources of EMI - few case studies on EMC.

Conducted and radiated emission: power supply line filters-common mode and differential mode current-common mode choke-switched mode power supplies.

Shielding techniques: shielding effectiveness-shield behaviour for the electric and magnetic field - aperture-seams-conductive gaskets- conductive coatings.

Grounding techniques: signal ground-single point and multi-point grounding-system ground common impedance coupling -common mode choke-Digital circuit power distribution and grounding.

Contact protection: arc and glow discharge-contact protection network for inductive loads-C, RC, RCD protection circuit- inductive kickback.

RF and transient immunity: transient protection network- RFI mitigation filter-power line disturbance- ESD- human body model- ESD protection in system design.

PCB design for EMC compliance: PCB layout and stack up- multi-layerPCB objectives Return path discontinuities-mixed signal PCB layout.

EMC pre-compliance measurement: conducted and radiated emission test-LISN- Anechoic chamber.

Text Book(s):

1. H. W. Ott, Electromagnetic Compatibility Engineering, 2nd edition, John Wiley & Sons, 2011, ISBN: 9781118210659.
2. C. R. Paul, Introduction to Electromagnetic Compatibility, 2nd edition, Wiley India, 2010, ISBN: 9788126528752.

References & Web Resources:

1. K. L. Kaiser, Electromagnetic Compatibility Handbook, 1st edition, CRC Press, 2005. ISBN: 9780849320873.

Course Title	Course Code	Structure (I-P-C)		
MIMO Communication Systems	EC411	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital Communications, and Wireless Communication.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the concept of MIMO communication techniques, Channel Capacity, MIMO algorithms.
CO2	Understand power allocation strategies for practical MIMO systems.
CO3	Design algorithms of MIMO to improve the bit rate.
CO4	Understand MIMO in 5G communication.
CO5	Understand the MIMO reception in various channel conditions

Syllabus:

Introduction: Diversity-multiplexing trade-off, transmit diversity schemes, advantages and applications of MIMO systems.

Analytical MIMO channel models: Uncorrelated, fully correlated, separately correlated and keyhole MIMO fading models, parallel decomposition of MIMO channel.

Power allocation in MIMO systems:Uniform, adaptive and near optimal power allocation.

MIMO channel capacity: Capacity for deterministic and random MIMO channels, Capacity of i.i.d., separately correlated and keyhole Rayleigh fading MIMO channels.

Space-Time codes: Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel, Space-time turbo codes.

MIMO detection: ML, ZF, MMSE, ZF-SIC, MMSE-SIC, LR based detection.

Advances in MIMO wireless communications: Spatial modulation, MIMO based cooperative communication and cognitive radio, multiuser MIMO, cognitive-femtocells and large MIMO systems for 5G wireless.

Text Book(s):

1. R. S. Kshetrimayum, Fundamentals of MIMO Wireless Communications, Cambridge University Press, 2017.
2. A. Chokhalingam and B. S. Rajan, Large MIMO systems, Cambridge University Press, 2014.

References & Web Resources:

1. B. Kumbhani and R. S. Kshetrimayum, MIMO Wireless Communications over Generalized Fading Channels, CRC Press, 2017
2. T. L. Marzetta, E. G. Larsson, H. Yang and H. Q. Ngo, Fundamentals of Massive
3. MIMO, Cambridge University Press, 2016.

Course Title	Course Code	Structure (I-P-C)		
Numerical Techniques in Electromagnetics	EC412	**3**	**0**	**3**

Pre-requisite, if any: Electromagnetic Waves and Transmission Lines

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand how to computational solve different structures using Maxwell equations.
CO2	Understand various computational techniques and their pros and cons.
CO3	Understand which software works best in terms of speed, and accuracy for analysing a given structure
CO4	Develop codes to analyze the EM structures.
CO5	Gain knowledge need to develop EM simulation software tools

Syllabus:

Review of vector calculus, Overview of computational electromagnetics, Review of Maxwell's equations.
Analytical techniques in Electromagnetics.
Finite Difference Time Domain methods: Analysis, convergence, accuracy and numerical dispersion, incorporating dielectric and dispersive materials, absorbing boundary conditions, perfectly matched layers (PML), sources.

Moment Methods: Integral equations (EFIE,MFIE), Green's Functions, MOM.

Finite element methods: Formulation and Absorbing boundary conditions (FEM).

Applications of computational electromagnetic: Specific Absorption Rate, Radar RCS, Periodic structures, Eddy current calculations, capacitance and inductance calculations, Microwave inverse imaging, Antenna radiation problems, Calculating the modes of a waveguide structure using the integral equation method.

Text Book(s):

1. Numerical Techniques in Electromagnetic, Second Edition Hardcover – Import, 12 July 2000, by Matthew N.O. Sadiku
2. Analytical and Computational Methods in Electromagnetic, Artech House Electromagnetic Analysis, 30 September 2008, by Ramesh Garg, Raj Mittra

References & Web Resources:

1. Computational Electromagnetics for RF and Microwave Engineering, 28 October 2010, by David B. Davidson
2. Advanced Engineering Electromagnetics Paperback - 8 October 2008, by Constantine A. Balanis
3. Computational Methods for Electromagnetics: 4 (IEEE Press Series on Electromagnetic Wave Theory) Hardcover – Import, 12 December 1997, by Andrew F. Peterson, Scott L. Ray, Raj Mittra

CourseTitle	CourseCode	Structure(I-P-C)		
PowerElectronics	**EC513**	**3**	**0**	**3**

Pre-requisite,ifany: Electronic Devices

CourseOutcomes: Atthe endofthe course,thestudentswillbeableto:

CO1	Understand basic operation of various power semiconductor devices andpassive components
CO2	Understandthebasicprinciple ofswitchingcircuits.
CO3	DesignAC/DCrectifier,DC/DCconverterandDC/ACinvertercircuits.
CO4	Understandtherolepowerelectronicsplayintheimprovementofenergyusage,efficiencyandthedevelopmentofrenewableenergytechnologies.
CO5	Design different power converters

Syllabus:

Introduction topowerelectronics; applicationsandroleofpowerelectronics.

Introductiontopowersemiconductordevices,operatingcharacteristicsofPowerDiode,SCR,Power BJT, PowerMOSFET andIGBT;DrivercircuitsandSnubbercircuits.

Introduction to AC/DC rectifiers, principle of operation of phase controlled rectifiers, singlephaseandthreephaseAC-DClinecommutatedconverters,dualconverter,andintroductiontounitypowerfactorconverters. Applications: DCmotordrivesandBattery chargers.

Introduction to DC/DC converters, Principle of operation of DC/DC (Buck, Boost, Buck-Boost, Cuk, Fly-back and Forward) converters. Applications: Power supply, DC motor drivesand SMPS.

Introductionto DC/AC inverters, PWMtechniques, Principleof operationof single phaseand three phase DC-AC inverters, Applications: AC motor drives, UPS, active filters, CFL,renewable power generation,inductionanddielectricheating.

Text Book:

1. N.Mohan,T.Undeland,andW.Robbins,“PowerElectronics:Converters,Applications, andDesign,”3rdEdition,Wiley,2003.
2. M.Rashid,“PowerElectronics:Circuits,Devices&Applications,”Prentice Hall,3rdEdition,2003.

References & Web Resources:

1. J.P.Agrawal,“PowerElectronic Systems:TheoryandDesign,”Pearson,2013.
2. Batarseh,“PowerElectronicCircuits,”JohnWiley,2004.2.R.W.EricksonandD.Maksimovic,“Fundamentals ofPowerElectronics,”2ndEdition,Springer,2001.
3. R.W.EricksonandD.Maksimovic,“FundamentalsofPowerElectronics,” 2ndEdition,Springer,2001.

Course Title	Course Code	Structure (I-P-C)		
Reliable Digital Communication System Design	EC414	**3**	**0**	**3**

Pre-requisite, if any: Communication Systems, Digital Logic Design

Course Outcomes: At the end of the course, the students will be able to:

CO1	Learn the functional behaviour of various cryptography, intrusion detection, and error correction algorithms.
CO2	Learn to develop hardware architectures of various cryptography, intrusion detection, and error correction algorithms.
CO3	Develop the countermeasure prototypes of adversary attacks
CO4	Develop the crypto co-processors using FPGA.
CO5	Understand the algorithms of cryptography.

Syllabus:

Information theory, Entropy, Properties of Entropy

Goals of Relilable Digital Communication: first level of defense (integrity, confidentiality, authenticity, and availability) and second level of defense (resilience to attacks).

Galois Field Arithmetic: Introduction to Group, Ring, and Fields, Prime/Polynomial field representation, Irreducible polynomial, primitive polynomial, minimal polynomial, Galois field addition, LSB first/MSB first/Montgomery Galois field multiplication architectures-bit serial, bit parallel, digit serial, systolic, and scalable architectures, Modular exponentiators-Square-multiply algorithm and Montgomery Ladder algorithm, Extended Euclidean algorithm/Fermat's little theorem based multiplicative inverse architectures.

Symmetric Encryption/Decryption Architectures: DES, 3-DES, and AES (fully folded, parameterized parallel, and fully parallel architectures).

Asymmetric Encryption/Decryption Architectures: ECC (right-to-left, left-to-right, Montgomery based scalar multiplication in affine/projective co-ordinates) and RSA.

HASH architectures: SHA512 and SHA3.

Key exchange protocols: DiffieHelmen, Elgamal, Neuro crypto key exchange protocol.

Authentication schemes: Yang Shieh and EijiOkamato.

Pseudo random number generators, Stream ciphers.

Physical unclonable functions: RO PUF, larger decoder memory based PUF, and XOR PUF.

Intrusion Detection: Universal HASH functions, Cuckoo hashing, and Bloom filter.

Error detection codes: CRC, LRC, and parity check, Error correction codes-Hamming, BCH, Reed Solomon, LDPC, Convolutional, Turbo product, and concatenated codes,
Hardware/software co-design analogous between ASIC/FPGA/hardware-software co-designs, need for crypto accelerators (or coprocessors), and hardware/software partitioning based AES/ECC architectures.

Side channel analysis: Power attack, Bit masking, and Cache template attack.

Text Book(s):

1. Doug R. Stinson , Cryptography Theory and Practice, Third Edition, CRC Press, 2006.
2. Shu Lin and Daniel J Castello, Error Control Coding, Second Edition, Printice Hall, 2004.
3. Haykin, An Introduction to Analog and Digital Communications, wiley Vol 2, 2008.

References & Web Resources:

1. A. J. Menezes, P. C. van Oorshot, and S. A. Vanstone, Handbook of Applied Cryptography, CRC Press, 1996.
2. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press, 2015.
3. DebdeepMukhopadhyay and RajatSubhra Chakraborty, Hardware Security: Design, Threats and Safeguards, CRC Press, 2014.

Course Title	Course Code	Structure (I-P-C)		
RF and Microwave Integrated Circuits	EC415	**3**	**0**	**3**

Pre-requisite, if any: Electromagnetic Waves and Transmission Lines,and Analog Electronics

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the differences in designing low frequency ICs, RFICs, and MMICs.
CO2	Analyse high frequency filters, couplers, amplifier, oscillators and mixer circuits.
CO3	Design high frequency filters, couplers, amplifiers.
CO4	Develop RFICs.
CO5	Develop MMICs.

Syllabus:

Electromagnetic Theory Review: Maxwell’s Equations, Fields in Media and Boundary Conditions, The Wave Equation, General Plane Wave Solutions, Energy and Power, Transmission lines and waveguide solutions.

Transmission Line Theory: The Lumped-Element Circuit Model for a Transmission Line, Field Analysis of Transmission Lines, The Terminated Lossless Transmission Line, The Smith Chart, The Quarter-Wave Transformer, Generator and Load Mismatches, Lossy Transmission Lines, Transients on Transmission Lines.

Microwave Network Analysis: Impedance and Equivalent Voltages and Currents, Impedance and Admittance Matrices, The Scattering Matrix, The Transmission (ABCD) Matrix.

Impedance matching and tuning, Microwave filter design.

Noise and nonlinear distortion, active rf and microwave devices.

Microwave Power Amplifier, Low Noise Amplifier, Oscillator and Mixer Design.

Introduction to microwave systems.

Text Book(s):

1. David M Pozar, Microwave Engineering, 4th Edition, Wiley, 2013.
2. BehzadRazavi, RF Microelectronics, 2nd Edition, Pearson, 2011.

References & Web Resources:

1. Robert E Collin, Foundations for Microwave Engineering, 2nd Edition, Wiley, 2007.
2. I.D. Robertson , S. Lucyszyn, RFIC and MMIC Design and Technology: 13 (Materials, Circuits and Devices), Institution of Engineering and Technology, 2001.

Course Title	Course Code	Structure (I-P-C)		
Satellite Communication	EC416	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the satellite communication.
CO2	Understand the orbits and space of satellite communication.
CO3	Understand the optical communication.
CO4	Develop the packet switched networks.
CO5	Understand the importance of Optical technology in space applications

Syllabus:

OVERVIEW OF SATELLITE SYSTEMS, ORBITS AND LAUNCHING METHODS: Introduction, Frequency Allocations for Satellite Services, Intelsat, U. S. Domsats Polar Orbiting Satellites, Problems, Kepler's First Law, Kepler's Second Law, Kepler's Third Law, Definitions of Terms for Earth-orbiting Satellites, Orbital Elements, Apogee and Perigee Heights, Orbital Perturbations, Effects of a Non-spherical Earth, Atmospheric Drag, Inclined Orbits, Calendars, Universal Time, Julian Dates, Sidereal Time, The Orbital Plane, The Geocentric, Equatorial Coordinate System, Earth Station Referred to the IJK Frame, The Top centric-Horizon Co-ordinate System, The Sub-satellite Point, Predicting Satellite Position.

GEOSTATIONARY ORBIT & SPACE SEGMENT: Introduction, Antenna Look Angels, The Polar Mount Antenna , Limits of Visibility , Near Geostationary Orbits, Earth Eclipse of Satellite, Sun Transit Outage, Launching Orbits, Problems, Power Supply, Attitude Control, Spinning Satellite Stabilization, Momentum Wheel Stabilization, Station Keeping, Thermal Control, TT&C Subsystem , Transponders, Wideband Receiver, Input De-multiplexer, Power Amplifier, Antenna Subsystem, Morelos, Anik-E, Advanced Tiros-N Spacecraft.

OPTICAL NETWORK ARCHITECTURES: Introduction to Optical Networks; Layered Architecture- Spectrum partitioning, Network Nodes, Network Access Stations, Overlay Processor, Logical network overlays, Connection Management and Control; Static and Wavelength Routed Networks; Linear Light wave networks; Logically Routed Networks; Traffic Grooming; The Optical Control Plane- Architecture, Interfaces, Functions; Generalized Multiprotocol Label Switching – MPLS network and protocol stack, Link management, Routing and Signaling in GMPLS.

OPTICAL PACKET SWITCHED NETWORKS: Network Architectures- Unbuffered Networks, Buffering Strategies; OPS enabling technologies, Test beds; Optical Burst Switching, Switching protocols, Contention Resolution, Optical Label Switching, OLS network test beds, Control and Management – Network management functions, Configuration management, Performance management, Fault management, Optical safety, Service interface; network Survivability- Protection in SONET / SDH and IP Networks, Optical layer Protection, Interworking between layers.

FREE SPACE OPTICAL COMMUNICATION: Analog and digital FSOC data link, atmospheric attenuation, scattering, scintillation index, beam wandering, beam wave front aberration, adaptive optics, active optics, deformable mirror control, RoFSO, atmospheric channel models, estimation of refractive index, modulation and demodulation techniques, error control techniques.

Text Book(s):

1. Satellite Communications, Dennis Roddy, McGraw-Hill Publication Third edition2001

2. Satellite Communications – Timothy Pratt, Charles Bostian and Jeremy Allnutt, WSE, Wiley Publications, 2nd Edition, 2003.

References & Web Resources:

1. Timothy Pratt – Charles Bostian& Jeremy Allmuti, Satellite Communications, John Willy & Sons (Asia) Pvt. Ltd. 2004
2. Wilbur L. Pritchars Henri G. SuyderHond Robert A. Nelson, Satellite Communication Systems Engineering, Pearson Education Ltd., Second edition 2003.
3. Satellite Communications: Design Principles – M. Richharia, BS Publications, 2nd Edition, 2003.
4. J. Gower, "Optical Communication System", Prentice Hall of India, 2001
5. Rajiv Ramaswami, "Optical Networks ", Second Edition, Elsevier, 2004.
6. Satellite Communications Engineering – Wilbur L. Pritchard, Robert A Nelson and Henri G. Suyderhoud, 2nd Edition, Pearson Publications, 2003.
7. Optical Fiber Communication – John M. Senior – Pearson Education – Second Edition. 2007
8. Optical Fiber Communication – Gerd Keiser – McGraw Hill – Third Edition. 2000

CourseTitle	CourseCode	Structure(I-P-C)		
Sensing and Instrumentation	**EC417**	**1**	**3**	**3**

Pre-requisite, if any: Nil

CourseOutcomes: Atthe endofthe course,thestudentswillbeableto:

CO1	Buildsystemswhichwouldsensethedifferentphysicalsignal
CO2	Processthesignalsintherequiredanalogordigitalformats
CO3	Calibratesensorsaccordingtherequiredapplications.
CO4	Understandthecharacteristicsoftransducers.

Syllabus:

Transducers, transducer sensing and functions, Passive and active – Resistance, inductanceand capacitance,Strain Gauges, Hall Effect sensors, Opticalsensors.

Measurementofnon-electricalquantitiessuchasdisplacement,velocity,acceleration,pressure, force, flow and temperature, calibration of sensors, Data acquisition and detectiontechniques, Signalconversion, PC-based Instrumentation System.

Practiceincludesexperimentsfromfollowingtopics:

Signal generation – Instrumentation amplifiers – Signal conversion and processing –CharacteristicsofTransducers-Calibrationofsensors–Measurementofphysicalquantities.

Text Book(s):

1. AlanS.Morris,MeasurementandInstrumentationPrinciples,Elsevier,2001.
2. Sawhney. A. K, Course in Electrical & Electronics Measurement &Instrumentation, DhanpatRai, 2007.

References & Web Resources:

1. Howard Austerlitz,Dataacquisitiontechniquesusing PCs, AcademicPress, 2ndEd.2002.
2. BruceMihura,LabVIEWforDataAcquisition(NationalInstrumentsVirtualInstrumentation Series), PrenticeHall,2001.

CourseTitle	CourseCode	Structure(I-P-C)		
Signal and Power Integrity	**EC418**	**3**	**0**	**3**

Pre-requisite, if any: Nil

CourseOutcomes: Atthe endofthe course,thestudentswillbeableto:

CO1	Understand the design guidelines to be followed in PCB design and IC packagingto prevent Signal and Power Integrity issues.
CO2	Analyze the physical structure and dimensions of the PCB elements and fit an appropriate circuit model.
CO3	Analyze the measured voltages and currents in the PCB and find the causes of the signal integrity issues.
CO4	Analyze the measured voltages and currents in the PCB and find the causes of the power integrity issues.
CO5	Design an optimal layout for a PCB to avoid signal and power integrity issues.

Syllabus:

Signal Integrity Is in Your Future: What Are Signal Integrity, Power Integrity, and Electromagnetic Compatibility?, Signal-Integrity Effects on One Net, Cross Talk, Rail-Collapse Noise, Electromagnetic Interference (EMI, Two Important Signal-Integrity Generalizations, Trends in Electronic Products, The Need for a New Design Methodology, A New Product Design Methodology.

Time and Frequency Domains: The Time Domain, Sine Waves in the Frequency Domain, Shorter Time to a Solution in the Frequency Domain, Sine-Wave Features, The Spectrum of a Repetitive Signal, The Spectrum of an Ideal Square Wave, Frequency Domain to the Time Domain, Effect of Bandwidth on Rise Time, Bandwidth and Rise Time, Bandwidth of Real Signals, Bandwidth and Clock Frequency, Bandwidth of a Measurement, Bandwidth of a Model, Bandwidth of an Interconnect.

Impedance and Electrical Models, The Physical Basis of Resistance, Capacitance, Inductance, and Transmissions lines.

Transmission Lines and Reflections, Lossy Lines, Rise-Time Degradation, and Material Properties, Cross Talk in Transmission Lines.

Differential Pairs and Differential Impedance, S-Parameters for Signal-Integrity Applications, The Power Distribution Network (PDN)

Text Book(s):

1. Bogatin, Eric. Signal and power integrity-simplified. Pearson Education, 2010.

References & Web Resources:

1. Johnson, Howard, Howard W. Johnson, and Martin Graham. High-speed signal propagation: advanced black magic. Prentice Hall Professional, 2003.
2. Johnson, Howard W., and Martin Graham. High-speed digital design: a handbook of black magic. Vol. 155. Englewood Cliffs, NJ: Prentice Hall, 1993.

Course Title	Course Code	Structure (I-P-C)		
Software Defined Radio	EC419	**3**	**0**	**3**

Pre-requisite, if any: Signals and Systems, Analog and Digital, Wireless Communication Techniques.

Course Outcomes: At the end of the course, the students will be able to:

CO1	Understand the SDR, CR, and their applications.
CO2	Understand the signal processing architectures used in the SDR.
CO3	Develop the FPGA based SDR.
CO4	Develop microcontroller based SDR.

Syllabus:

INTRODUCTION TO SDR: What is Software-Defined Radio, The Requirement for Software-Defined Radio, Legacy Systems, The Benefits of Multi-standard Terminals, Economies of Scale, Global Roaming, Service Upgrading, Adaptive Modulation and Coding, Operational Requirements, Key Requirements, Reconfiguration Mechanisms, , Handset Model, New Base-Station and Network, Architectures, Separation of Digital and RF, Tower-Top Mounting, BTS Hoteling, Smart Antenna Systems, Smart Antenna System Architectures, Power Consumption Issues, Calibration Issues, Projects and Sources of Information on Software Defined Radio.

BASIC ARCHITECTURE OF A SOFTWARE DEFINED RADIO: Software Defined Radio Architectures, Ideal Software Defined Radio Architecture, Required Hardware Specifications, Digital Aspects of a Software Defined Radio, Digital Hardware, Alternative Digital Processing Options for BTS Applications, Alternative Digital Processing Options for Handset Applications, Current Technology Limitations, A/D Signal-to-Noise Ratio and Power 343 Consumption, Derivation of Minimum Power Consumption, Power Consumption Examples, ADC Performance Trends, Impact of Superconducting Technologies on Future SDR Systems.

SIGNAL PROCESSING DEVICES AND ARCHITECTURES: General Purpose Processors, Digital Signal Processors, Field Programmable Gate Arrays, Specialized Processing Units, Tilera Tile Processor, Application-Specific Integrated Circuits, Hybrid Solutions, Choosing a DSP Solution. GPP-Based SDR, Non real time Radios, High-Throughput GPP-Based SDR, FPGA-Based SDR, Separate Configurations, Multi-Waveform Configuration, Partial Reconfiguration, Host Interface, Memory-Mapped Interface to Hardware, Packet Interface, Architecture for FPGA-Based SDR, Configuration, Data Flow, Advanced Bus Architectures, Parallelizing for Higher Throughput, Hybrid and Multi-FPGA Architectures, Hardware Acceleration, Software Considerations, Multiple HA and Resource Sharing, Multi-Channel SDR.

COGNITIVE RADIO : TECHNIQUES AND SIGNAL PROCESSING:History and background, Communication policy and Spectrum Management, Cognitive radio cycle, Cognitive radio architecture, SDR architecture for cognitive radio, Spectrum sensing Single node sensing: energy detection, cyclostationary and wavelet based sensing- problem formulation and performance analysis based on probability of detection vs SNR. Cooperative sensing: different fusion rules, wideband spectrum sensing- problem formulation and performance analysis based on probability of detection vs SNR.

COGNITIVE RADIO: HARDWARE AND APPLICATIONS: Spectrum allocation models. Spectrum handoff, Cognitive radio performance analysis. Hardware platforms for Cognitive radio (USRP, WARP), details of USRP board, Applications of Cognitive radio.

Text Book(s):

1. "RF and Baseband Techniques for Software Defined Radio" Peter B. Kenington, ARTECH HOUSE, INC © 2005.
2. "Implementing Software Defined Radio", Eugene Grayver, Springer, New York Heidelberg Dordrecht London, ISBN 978-1-4419-9332-8 (eBook) 2013.

References & Web Resources:

1. "Cognitive Radio Technology", by Bruce A. Fette, Elsevier, ISBN 10: 0-7506-7952-2, 2006.
2. "Cognitive Radio, Software Defined Radio and Adaptive Wireless Systems", HüseyinArslan, Springer, ISBN 978-1-4020-5541-6 (HB), 2007.

Course Title	Course Code	Structure (I-P-C)		
Testing and Testability	EC420	**3**	**0**	**3**

Pre-requisite, if any: Digital Logic Design

Course Outcomes: At the end of the course, the students will be able to:

CO1	Identify the significance of testable design
CO2	Understand the concept of yield and identify the parameters influencing the same
CO3	Specify fabrication defects, errors and faults.
CO4	Implement combinational and sequential circuit test generation algorithms
CO5	Identify techniques to improve fault coverage

Syllabus:

Role of testing in VLSI Design flow, Testing at different levels of abstraction, Fault error, defect, diagnosis, yield, Types of testing, Rule of Ten, Defects in VLSI chip. Modelling basic concepts, Functional modelling at logic level and register level, structure models, logic simulation, delay models.

Various types of faults, Fault equivalence and Fault dominance in combinational sequential circuits. Fault simulation applications, General fault simulation algorithms- Serial, and parallel, Deductive fault simulation algorithms. Combinational circuit test generation, Structural Vs Functional test, ATPG, Path sensitization methods.

Difference between combinational and sequential circuit testing, five and eight valued algebra, and Scan chain based testing method. D-algorithm procedure, Problems, PODEM Algorithm, Problems on PODEM Algorithm. FAN Algorithm, Problems on FAN algorithm, Comparison of D, FAN and PODEM Algorithms. Design for Testability, Ad-hoc design, Generic scan based design.

Classical scan based design, System level DFT approaches, Test pattern generation for BIST, and Circular BIST, BIST Architectures, and Testable memory design-Test algorithms-Test generation for Embedded RAMs.

Fault Diagnosis Logic Level Diagnosis - Diagnosis by UUT reduction - Fault Diagnosis for Combinational Circuits - Self-checking design - System Level Diagnosis.

Text Book(s):

1. M. Abramovici, M. Breuer, and A. Friedman, “Digital Systems Testing and Testable Design, IEEE Press, 1990
2. Stroud, “A Designer’s Guide to Built-in Self-Test”, Kluwer Academic Publishers, 2002

References & Web Resources:

1. M. Bushnell and V. Agrawal, “Essentials of Electronic Testing for Digital, Memory & Mixed-Signal VLSI Circuits”, Kluwer Academic Publishers, 2000
2. V. Agrawal and S.C. Seth, Test Generation for VLSI Chips, Computer Society Press.1989.
3. M. Abramovici, M.A. Breuer and A.D. Friedman, "Digital Systems and Testable Design", Jaico Publishing House.
4. M.L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers.
5. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002.
6. A.L. Crouch, "Design Test for Digital IC's and Embedded Core Systems", Prentice Hall International.

Course Title	Course Code	Structure (I-P-C)		
VLSI Technology	EC421	**3**	**2**	**4**

Pre-requisite, if any: Electronic Devices

Course Outcomes: At the end of the course, the students will be able to:

CO1	Appreciate the intricacies involved in VLSI circuit fabrication.
CO2	Understand the various processes needed to fabricate the VLSI devices.
CO3	Learn fabrication steps for existing and coming generation devices.

Syllabus:

Theory

1. Introduction to VLSI Design, Bipolar Junction Transistor Fabrication, MOSFET Fabrication. (3 hours)

2. Crystal Structure of Si, Defects in Crystal, Crystal growth (3 hours)

3. Epitaxy, Vapour phase Epitaxy, Doping during Epitaxy, Molecular beam Epitaxy (3 hours)

4. Oxidation – Kinetics, Rate constants, Dopant Redistribution, Oxide Charges (3 hours)

5. Diffusion-Theory of Diffusion, Doping Profiles, Diffusion Systems Ion Implantation - Process, Annealing of Damages, Masking during Implantation (3 hours)

6. Lithography, immersion lithography, e-beam lithography (3 hours)

7. Etching-Wet Chemical Etching, Dry Etching, Plasma Etching, Si, SiO2, SiN and other materials (3 hours)

8. Deposition-Plasma Deposition, Metallization, Problems in Aluminium Metal contacts, Copper interconnects (3 hours)

9. IC BJT - LOCOS, Trench isolation, Poly-emitter-poly-base-BJT and its suitability for high-speed applications (3 hours)

10. MOSFET - Metal gate vs. Self-aligned Poly-gate, Tailoring of Device Parameters, CMOS Technology, Latch - up in CMOS, MOSFET structures with strained channels and high-k gate dielectrics, Bi-CMOS Technology, introduction to FINFETs (3 hours)

11. Small-Dimension Effects of MOSFET: Modelling for Circuits Simulation- Quantum-Mechanical Effects; Gate Current, Junction Leakage, Scaling and New Technologies, Approaches, and Properties of Good Models, Model Formulation Considerations, Parameter Extraction, Compact Models, Benchmark Tests (7 hours)

12. Small-Signal Modelling of MOSFET: Conductance Parameter Definitions and Equivalent Circuits, Conductance Parameters Due to Gate and Body Leakage, Transconductance, Source-Drain and Output Conductance, Capacitance Definitions and Equivalent Circuits, Capacitance Evaluation and Properties, y-Parameter Model, RF Models (6 hours)

Practice

1. Simulation of various properties of Si, SiO2, SiN and other materials (40 hours)

Text Book(s):

1. S. K. Ghandhi, "VLSI Fabrication Principles- Silicon and Gallium Arsenide", Wiley Publications.

2. Y. Tsividis and C. McAndrew, "MOSFET modelling for Circuit Simulation", Oxford University Press, 2011

References & Web Resources:

1. S. M. Sze, "VLSI Technology", Tata McGraw Hill, 2008

2. J. Plummer, M. D. Deal, and P. B. Griffin, "Silicon VLSI Technology, Fundamentals, Practice and Modeling", Pearson Higher Education, 2000

3. T. A. Fjeldly, T. Yetterdal, and M. Shur, "Introduction to Device Modeling and Circuit Simulation", John Wiley, 1998.

4. Y. Taur and T. H. Ning, "Fundamentals of Modern VLSI Devices", Cambridge University Press, 1998.