CURRICULA OF B.TECH (ECE) PROGRAMME

CURRICULA AND SYLLABI

Bachelor of Technology
Electronics and Communication Engineering

August 15, 2024

Credit Distribution

Category	Course Description	Credits	Percentage
BSC	Basic Science Courses	12	8%
BEC	Basic Engineering Courses	12	8%
DMC	Design and Manufacturing Courses	12	8%
PMC	Professional Engineering Core Courses	60	60%
	Professional Engineering Elective Courses	10	
	Professional Major Project	10	
	Internship and Seminar Courses	6	
	Skill Development Courses	4	
OEC	Open/Free Elective Courses	12	8%
HMC	Entrepreneurship and management Courses	3	8%
	Financial management and Awareness	2	
	Technical and Professional Communication	2	
	Constitution of India	1	
	Self-Improvement Course	4	
	NCC/NSS/NSO (audit)	0	
		150	100%

2. Semester-wise Credit Distribution

2.1 First Semester

S.No.	Course Code	Course Name	Category Code	I	P	C
1	DS101	Differential and Integral Calculus	BSC	3	0	3
2	DS102	Engineering Physics	BSC	2	2	3
3	EC101 ME101	Basic Electrical and Electronics Engineering Engineering Mechanics	BEC	3	0	3
4	CS101	Problem Solving and Computer Programming	BEC	3	0	3
5	DS103	Technical and Professional Communication	HMC	1	2	2
3	CS102	Problem Solving and Computer Programming Practice	BEC	0	3	2
7	ME102	Engineering Skills Practice	BEC	0	2	1
8	DS107	Constitution of India	HMC	1	0	1
9	DS171	NSS/NSO/NCC	HMC	0	0	0
						18

2.2 Second Semester

S.No.	Course Code	Course Name	Category Code	I	P	C
1	DS102	Linear Algebra	BSC	3	0	3
2	DM102	Concepts in Engineering Design	DMC	3	0	3
3	ME101 EC101	Engineering Mechanics Basic Electrical and Electronics Engineering	BEC	3	0	3
4	DM104	Design Realization Practice	DMC	0	3	2
5	EC102	Electronics Devices and Circuits	PEC	3	0	3
6	EC152	Electronics Devices and Circuits Practice	PEC	0	3	2
7	AD102	Fundamentals of Artificial Intelligence	PEC	1	2	2
8	HM	NSS/NSO/NCC	HMC	0	0	0
						18

2.3 Third Semester

S.No	Course Code	Course Name	Category Code	I	P	C
1	DS20X	Probability and Random Process	BSC	3	0	3
2	EC201	Digital Logic Design	PEC	3	0	3
3	EC203	Analog Electronics	PEC	3	0	3
4	EC205	Electromagnetic Waves and Transmission Lines	PEC	3	0	3
5	EC211	Signal and Systems	PEC	3	0	3
3	EC251	Digital Logic Design Practice	PEC	0	3	2
7	EC253	Analog Electronics Practice	PEC	0	3	2
8	EC255	Electromagnetic Waves and Transmission Lines Practice	PEC	0	3	2
9	DS211	Self-Improvement Course	HMC	0	0	1
						22

2.4 Fourth Semester

S. No.	Course Code	Course Name	Category Code	I	P	C
1	DS202	Entrepreneurship, Management and Incubation	HMC	3	0	3
2	DM202	Smart Manufacturing	DMC	3	0	3
3	EC202	Analog and Digital Communications	PEC	3	0	3
4	EC204	Microprocessor and Computer Architecture	PEC	3	0	3
5	EC206	Control Systems	PEC	3	0	3
3	EC252	Analog and Digital Communications Practice	PEC	0	3	2
7	EC254	Microprocessor and Computer Architecture Practice	PEC	0	3	2
8	EC292	Skill Development Course I (Programming Skills)	PCD	1	2	2
9	DS212	Self-Improvement Course	HMC	0	0	1
						22

2.5 Fifth Semester

S. No.	Course Code	Course Name	Category Code	I	P	C
1	EC301	Digital Signal Processing	PEC	3	0	3
2	EC303	VLSI System Design	PEC	3	0	3
3	EC311	Profession Engineering Elective-I (Linear IC)	PEE	3	0	3
4	EC381	Open Elective-I	PEC	3	0	3
5	EC305	Electronic Packaging and Prototyping	PEC	3	0	3
6	EC351	Digital Signal Processing Practice	PEC	0	3	2
7	EC353	VLSI System Design Practice	PEC	0	3	2
8	EC355	Electronic Packaging and Prototyping Practice	PEC	0	3	2
9	DS311	Self-Improvement Course	HMC	0	0	1
						22

2.6 Sixth Semester

S. No.	Course Code	Course Name	Category Code	I	P	C
1	DM302	Product Design and Manufacturing	DMC	0	6	4
2	EC302	Wireless Communication	PEC	3	0	3
3	EC312	Profession Engineering Elective-II	PEE	3	0	3
4	EC314	Profession Engineering Elective-III	PEE	2	0	2
5	XX382	Open Elective-II	OEC	3	0	3
6	EC354	Professional Engineering Elective Laboratory	PEC	0	3	2
7	EC352	Wireless Communication Practice	PEC	0	3	2
8	EC392	Skill Development Course - II (Embedded Systems (Hardware))	PCD	0	3	2
9	DM312	Self-Improvement Course	HMC	0	0	1
						22

2.7 Seventh Semester

S. No.	Course Code	Course Name	Category Code	I	P	C
1	EC491	Project Phase-I	PRC	0	9	5
2	EC411	Professional Engineering Elective-IV	PEE	2	0	2
3	EC481	Open Elective-III	OEC	3	0	3
4	EC483	Open Elective-IV	OEC	3	0	3
5	DS401	Financial Awareness and Management	HMC	0	0	2
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2.8 Eighth Semester

S. No.	Course Code	Course Name	Category Code	I	P	C
1	EC492	Project Phase-II	PRC	0	9	5
2	EC494	Internship	ISC	0	0	5
3	EC496	Seminar	ISC	0	0	1
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A. List of Open Electives offered in the ECE Department:

S. No.	Course Code	Course Name	Category Code	I	P	C
1	**EC471**	Electric Vehicle Technology	OEC	3	0	3
2	**EC472**	Navigation Systems	OEC	3	0	3
3		Drone Technology	OEC	2	2	3
4		Sensors and Actuators	OEC	2	2	3

B. List of Professional Engineering Electives offered by the ECE Department:

S. No.	Course Code	Course Name	Category Code	I	P	C
1	**EC303**	Data Communication and Networking	PEE	2	2	3
2	**EC311**	Linear IC Applications	PEE	3	0	3
3	**EC352**	Information Theory and Coding	PEE	2	2	3
4	**EC401**	Analog and Mixed Signal Circuit Design	PEE	3	0	3
5	**EC404**	Cognitive Communication Networks	PEE	3	0	3
6	**EC407**	Detection and Estimation Theory	PEE	3	0	3
7	**EC408**	Digital Image Processing	PEE	3	0	3
8	**EC409**	Electrical Drives	PEE	1	3	3
9	**EC410**	Electromagnetic Interference and Compatibility	PEE	3	0	3
10	**EC411**	MIMO Communication Systems	PEE	3	0	3
11	**EC412**	Numerical Techniques in Electromagnetics	PEE	3	0	3
12	**EC413**	Power Electronics	PEE	3	0	3
13	**EC415**	Microwave Integrated Circuits	PEE	3	0	3
14	**EC416**	Satellite Communication	PEE	3	0	3
15	**EC417**	Sensing and Instrumentation	PEE	1	3	3
16	**EC419**	Software Defined Radio	PEE	3	0	3
17	**EC420**	Testing and Testability	PEE	3	0	3
18	**EC421**	Embedded System Design	PEE	2	2	3
19	**EC421**	VLSI Technology	PEE	3	0	3
20	**EC422**	Optoelectronics	PEE	3	0	3

C. List of Skill Development Courses offered by the ECE Department:

S. No.	Course Code	Course Name	Category Code	I	P	C
1		Programming Skills	PCD	1	2	2
2		Prototype Development using Arduino and Raspberry Pi	PCD	1	2	2

D. List of Two Credit Profession Engineering Elective-III Courses:

S. No.	Course Code	Course Name	Category Code	I	P	C
1	EC	5G Communication with Software-Defined Radio	PEE	2	0	2
2	EC	Drone Navigation using Visible Light Communication	PEE	2	0	2
3	EC	Fundamentals of Time Frequency and Wavelet Analysis	PEE	2	0	2
4		Electrical Drives		1	2	2
5		Sensing and Instrumentation		1	2	2
6		Design of Biomedical Devices and Systems		2	0	2
7		Signals and Systems for Digital Health		2	0	2
8		MEMS Design and Manufacturing		2	0	2

Detailed Syllabus

Department of Electronics and Communications Engineering

B. Tech Degree
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	Understand the electric circuits fundamentals.
CO2	Analyze AC and DC circuits by applying appropriate theorems.
CO3	Analyze the behaviour of the transient response in RL, RC, RLC circuits.
CO4	Evaluate two-port network parameters.
CO5	Understand PN junction diodes and its applications.

Syllabus:

Electrical circuit elements: voltage and current sources, characteristics of active and passive elements (R, L, and C), Kirchhoff's laws, Elements in series and parallel, superposition in linear circuits, controlled sources, energy and power in elements, energy stored in L, and C.

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.

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

Text Book(s):

1. Hayt. W. W, Kemmerly. J.E, and Durbin. S.M, Engineering Circuits Analysis, 10th edition, Tata McGraw Hill, 2024.
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.
4. M. E.Van Valkenburg "Network Analysis" 3rd edition, PHI, 2009.

Course Title	Course Code	Structure (I-P-C)		
Electronic Devices and Circuits	**EC102**	**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.

Syllabus:

Module 1:
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.

Module 2:

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.

Module 3:

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.

Module 4:

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.

Text Book(s):

1. Ben. G. Streetman, Sanjay Kumar Banergee, “Solid State Electronic Devices”, 7th 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)		
Electronics Devices and Circuits Practice	**EC152**	**0**	**3**	**2**

Pre-requisite, if any: -

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

CO1	Plot the characteristics of electronic devices to understand their behavior
CO2	Analyze the various device parameters on device characteristics

Experiments:

1. Forward bias and reverse bias of PN junction and Zener diode
2. Half wave and full wave rectifiers design
3. Diode based clipper circuits design
4. Diode based clamper circuits design
5. Voltage regulator design using Zener diode
6. RC Circuit Analysis
7. Self-biasing of BJT amplifier
8. Characteristics of CE amplifier
9. JFET amplifier analysis
10. Pass transistor logic using MOSFET
11. Biasing of Common source amplifier
12. Characteristics of CB and CC amplifier

Text Book(s):

1. Ben. G. Streetman, Sanjay Kumar Banergee, “Solid State Electronic Devices”, 7th 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)		
Probability Theory and Random Process	**DS20X**	**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 sample space.
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)		
Digital Logic Design	**EC201**	**3**	**0**	**3**

Pre-requisites if any: Electronic Devices & Circuits

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

CO1	Understand different number systems, Boolean algebra, basic concepts of Combinational and Sequential circuits
CO2	Solve problems related to number systems, switching functions using Karnaugh maps, combinational and sequential circuits.
CO3	Analyze different Combinational circuits using basic characteristics & synchronous circuits using state diagrams based on Moore and Mealy configurations.
CO4	Design both combinational and sequential logic circuits for the given specifications
CO5	Develop Verilog HDL programs for combinational and sequential logic circuits and realize product(s) for real time problem(s).

Syllabus:

Number systems and Codes: Number systems: Binary, octal and hexadecimal number systems, Methods of base conversions, Binary, octal and hexadecimal arithmetic; Representation of signed numbers, Fixed and floating-point numbers, Binary coded decimal codes, Gray codes.

Boolean algebra and Switching Functions: Boolean algebra- theorems, sum of product and product of sum simplification, canonical forms-minterm and maxterm, Simplification of Boolean expressions-Karnaugh map, completely and incompletely specified functions, Implementation of Boolean expressions using universal gates.

Combinational logic circuits- Adders, subtractors, BCD adder, ripple carry look ahead adders, parity generator, decoders, encoders, multiplexers, demultiplexers, Realization of Boolean expressions- using decoders-using multiplexers. Memories – ROM- organization, expansion. PROMs. Types of RAMs – Basic structure, organization, Static and dynamic RAMs.

Sequential circuits – latches, flip flops, edge triggering, asynchronous inputs. Shift registers, Universal shift register, applications. Binary counters – Synchronous and asynchronous up/down counters, mod-N counter, Counters for random sequence.

Synchronous circuit analysis and design: State tables and state diagrams, Modelling - Moore machine and Mealy machine – Sample design of sequential circuits, Hazards – Types of Hazards, elimination methods.

Introduction to Verilog HDL, Structural, Dataflow and behavioral modelling of combinational and sequential logic circuits.

Text Book(s):

1. D. D. Givone, “Digital Principles and Design”, Tata Mc-Graw Hill, New Delhi, 2003.
2. Wakerly J F, “Digital Design: Principles and Practices, Prentice-Hall”, 2nd Ed., 2002.
3. S. Brown and Z. Vranesic, “Fundamentals of Digital Logic with Verilog Design”, Tata McGraw Hill, 2008.

References & Web Resources:

1. M. M. Mano, “Digital Design”, 3rd ed., Pearson Education, Delhi, 2003.
2. D.P. Leach, A. P. Malvino, Goutam Guha, “Digital Principles and Applications”, Tata McGraw Hill, New Delhi, 2011.
3. R.J.Tocci and N.S.Widner, “Digital Systems - Principles & Applications”, PHI, 10th Ed., 2007.

Course Title	Course Code	Structure (I-P-C)		
Analog Electronics	**EC203**	**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	Learn the fundamentals of various amplifiers..
CO2	Understand the low and high frequency models of BJT and FETs.
CO3	Develop the analytical capability to analyze the feedback in amplifiers.
CO4	Determine the key parameters responsible for the performance of amplifiers and oscillators.

Syllabus:

Transistor at Low Frequencies: Two Port Devices and Hybrid Model, Transistor Hybrid Model, The h Parameters, Analysis of Transistor Amplifier Circuit Using h Parameters, Emitter Follower, Miller's Theorem and its Dual, Simplified Common Emitter Hybrid Model, Simplified Calculations for the Common Collector Configuration, Common Emitter Amplifier with an Emitter Resistance.
FET at low frequencies: Common Source, Common Drain and Common Gate amplifiers.

Transistor at High Frequencies: The Hybrid pi (π) Common Emitter Transistor Model, Hybrid Π Conductances, The Hybrid Π Capacitances, Validity of Hybrid π Model, Variation of Hybrid π Parameters. The CE ShortCircuits Current Gain, Current Gain with Resistive Load, Single Stage CE Transistor Amplifier Response, The Gain-Bandwidth Product, Emitter Follower at High Frequencies.
FET at High Frequencies: The Common Source FET Amplifier at High Frequencies and the Common Drain FET Amplifier at High Frequencies.

Differential and Multistage Amplifiers: Differential pair, common mode and differential mode operation. Small and large signal operation, CMRR, current mirror load. Classification of Amplifiers, Distortion in Amplifiers, Frequency Response of an Amplifier, Step Response of an Amplifier, BandPass of Cascaded Stages, The RC Coupled Amplifier, Effect of Emitter Bypass Capacitor on Low Frequency Response, High Frequency Response of Two Cascaded CE Transistor Stages, Multistage CE Amplifier Cascade at High Frequencies, cascode Amplifier.

Feedback Amplifiers: Classification of Amplifiers, The Feedback Concept, The Transfer Gain with Feedback, General Characteristics of Negative Feedback Amplifiers, Method of Analysis of a Feedback Amplifier, Voltage Series Feedback, Current Series Feedback, Current Shunt Feedback, Voltage Shunt Feedback.

Oscillators: Sinusoidal Oscillators, The Phase Shift Oscillator Using BJT, A General Form of Oscillator Circuit, The Wein Bridge Oscillator, Hartley & Colpitt's Oscillators Using BJT.

Text Book(s):

1. Jacob Millman and Christos C. Halkias, "Integrated Electronics", 2nd Edition, Tata McGraw Hill Publication.
2. B. Razavi, "Fundamentals of Microelectronics," Wiley Student Edition, 2010.

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.
3. R. Boylestad and L Nashelsky, “Electronic Devices and Circuit Theory,” 11th edition, Pearson Education India.
4. https://nptel.ac.in/courses/117/105/117105147/.
5. https://nptel.ac.in/courses/117/108/117108038/
6. https://onlinecourses.nptel.ac.in/noc21_ee86/preview

Course Title	Course Code	Structure (I-P-C)		
Electromagnetic Waves and Transmission Lines	**EC205**	**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 basic concepts of transmission lines, wave propagation, waveguides, and antennas.
CO2	Apply the basic principles to solve problems related to transmission line circuits, wave propagation, waveguide modes, and antenna radiation patterns.
CO3	Analyze impedance mismatches in transmission lines, field patterns in waveguides, and radiation patterns in antennas.
CO4	Derive the wave equation for symmetric structures, field expressions in waveguides, and expressions for antenna parameters.

Syllabus:

Transmission Lines: Physical Description of Transmission Line Propagation, Transmission Line Equations, Propagation of Sinusoidal Voltages, Complex Analysis of Sinusoidal Waves, Transmission Line Equations and Their Solutions in Phasor Form, Power Transmission, Problems of Transmission Lines of Finite Length, Graphical Methods: The Smith Chart, Transient Analysis, S-parameters.

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

Maxwell's Equations: Differential and integral forms and their interpretation, boundary conditions, wave equation, Poynting vector.

Plane Waves and Properties: Wave propagation through different media, Skin depth, Reflection and Refraction, polarization, phase and group velocity.

Guided Waves: Basic Waveguide Operation, Parallel-Plate Waveguide, Rectangular Waveguides, Optical Fibre.
Antennas: Antennas-radiation pattern, gain, Dipole and monopole antennas, linear antenna arrays.
Microwave signal sources: Reflex Klystron and Gunn Diode.

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)		
Signals and Systems	**EC211**	**3**	**0**	**3**

Pre-requisite, if any: Engineering Mathematics

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

CO1	Understand various properties of continuous-time & discrete-time signals, systems, basic concepts & properties of Fourier series, the Fourier Transform, the Laplace Transform, and the z-transform.
CO2	Solve problems related to signals, systems, Fourier series representation of continuous -time and discrete-time periodic signals, Continuous-time & Discrete-time Fourier Transforms, the Laplace and the z-transforms of signals and systems.
CO3	Analyze the impulse and frequency response of LTI systems, continuous-time & discrete-time filters described by differential and difference equations, the systems by making use of the properties of the Laplace and the z-transforms.
CO4	Develop solutions for complex problems on the impulse and frequency response of LTI systems by making use of all the transform techniques.
CO5	Perform simulations using MATLAB to understand the characteristics of various continuous and discrete signals and systems, and to analyze the impulse and frequency responses of LTI systems for different excitations.

Syllabus:

Introduction to Continuous-time & Discrete-time Signals and Systems: Signal Energy, power, Transformations of the independent variable, Exponential and Sinusoidal signals, the unit impulse and unit step functions. Continuous and discrete time systems – Basic properties, Problem solving.

Linear Time-Invariant (LTI) Systems (both Discrete-time & Continuous-time): The convolution sum, and the convolution integral - examples, Properties of LTI systems, Causal LTI systems described by differential and difference equations, Problem solving.

Fourier Series Representation of Periodic Signals (both Continuous-time & Discrete-time): Response of LTI systems to complex exponentials, Fourier series representation of continuous -time and discrete-time periodic signals, Properties of continuous-time & discrete-time Fourier series, Fourier series and LTI systems, Filtering, Examples of both continuous-time & discrete-time filters described by differential and difference equations respectively, Problem solving.

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

The Laplace Transform (LT): The Laplace transform for continuous-time signals and systems, Region of convergence, the inverse of the LT, System functions, Poles and zeros of system functions and signals, Properties of the LT, 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 Design Practice	**EC251**	**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 perspective
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	**EC253**	**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	Synthesize and evaluate single stage and two stage amplifiers.
CO2	Design and test differential amplifiers.
CO3	Design and analyze negative feedback amplifiers.
CO4	Design and analyze oscillators.

Experiments:

1. Measurement of h-parameters of CE amplifier.
2. Design and analysis of CS amplifier.
3. Design and analysis of Cascode amplifier.
4. Design of Voltage Series feedback Amplifier.
5. Design of Current Series feedback Amplifier
6. Design of Voltage Shunt feedback Amplifier.
7. Design of Current Shunt feedback Amplifier
8. Frequency response of two stage RC-coupled amplifier.
9. Design of RC Phase Shift Oscillator.
10. Design of Hartley Oscillator.
11. Design of Colpitts Oscillator.
12. Design of Wien Bridge Oscillator.
13. Mini project on Multistage/Differential/Feedback Amplifiers.

Text Book(s):

2. Jacob Millman and Christos C. Halkias, “Integrated Electronics”, 2nd Edition, Tata McGraw Hill Publication.
3. B. Razavi, “Fundamentals of Microelectronics,” Wiley Student Edition, 2010.

References & Web Resources:

1. Sedra and Smith, “Microelectronic Circuits,” 7th Edition, Oxford University Press.
2. D. A. Newman, “Electronic circuits,” 4th Edition, TMH.
3. R. Boylestad and L Nashelsky, “Electronic Devices and Circuit Theory,” 11th edition, Pearson Education India.

Course Title	Course Code	Structure (I-P-C)		
Electromagnetic Waves and Transmission Lines Practice	**EC255**	**0**	**3**	**2**

Pre-requisite, if any: Nil

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

CO1	Understand the high-frequency behavior of R, L, and C components.
CO2	Analyze the characteristics of transmission lines and waveguides.
CO3	Measure and evaluate S-parameters of RF components.
CO4	Design and Simulate Passive RF components.
CO5	Fabricate, and test Passive RF components.

Experiments:

1. **Non-Ideal Characteristics of R, L, and C Components at High Frequencies**
   Study how resistors, inductors, and capacitors deviate from their fundamental characteristics at high frequencies using an impedance analyzer.
2. **Study the Characteristics of Microstrip Lines and Coaxial Lines**
   Investigate and analyze the electrical and physical properties of microstrip and coaxial transmission lines.
3. **Study and Measurement of S-Parameters of Microstrip Filters**
   Measure the scattering parameters (S-parameters) of microstrip filters and analyze their frequency response.
4. **Study and Measurement of S-Parameters of Microstrip Couplers**
   Measure and evaluate the S-parameters of microstrip couplers to understand their coupling characteristics.
5. **Design and Simulation of Transmission Line Filters**
   Design a transmission line filter using a circuit simulator, simulate its performance in an electromagnetic (EM) simulator, and compare results.
6. **Fabrication and Measurement of Transmission Line Filters**
   Fabricate the designed transmission line filter, measure its S-parameters, and compare the results with EM simulation and circuit simulation.
7. **Study of Rectangular Waveguide Bench Setup**
8. **Rectangular Waveguide: Frequency vs. Guided Wavelength Study**
   Analyze the relationship between frequency and guided wavelength in a rectangular waveguide.
9. **Measurement of Radiation Pattern and Gain of Microstrip Antennas**
   Measure the radiation pattern and gain of a microstrip antenna to evaluate its performance.
10. **Study and Measurement of S-Parameters of Microstrip Antennas**
    Measure and analyze the S-parameters of microstrip antennas to assess their impedance matching and frequency response.
11. **Simulation, Fabrication, and Measurement of a Rectangular Patch Antenna**
    Simulate a rectangular patch antenna using an EM simulator, fabricate the antenna, and measure its S-parameters and radiation pattern.

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 and Digital Communications	**EC202**	**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)		
Microprocessor and Computer Architecture	**EC204**	**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)		
Control Systems	**EC206**	**3**	**0**	**3**

Prerequisite, if any: Signals and systems

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

CO1	**Understand** the fundamental concepts of open-loop and closed-loop systems, transfer function models, and feedback characteristics of control systems.
CO2	**Solve** problems related to time response analysis, steady-state error constants, and basic control actions such as proportional, integral, and derivative control.
CO3	**Analyze** the stability of control systems using Routh-Hurwitz criterion, root locus, Nyquist stability criterion, and frequency response techniques like Bode plots and polar plots.
CO4	**Design** control systems using root locus and frequency domain specifications to achieve desired stability and performance.
CO5	**Develop** state-space models for linear systems, assess system controllability and observability, and solve state equations for dynamic analysis and practical applications.

Syllabus:

Module-1

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

Module-2

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.

Module-3

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

Module-4

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.

Module-5

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)		
Analog and Digital Communications Practice	**EC252**	**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)		
Microprocessor and Computer Architecture Practice	**EC254**	**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)		
Digital Signal Processing	**EC301**	**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** discrete-time signals, systems, and their frequency domain representation, including Fourier transforms and properties of discrete-time random signals.
CO2	**Solve** problems involving frequency response of LTI systems, system functions, and the analysis of minimum phase and all-pass systems.
CO3	**Analyze** the discrete Fourier transform (DFT), its properties, and efficient computation methods such as the Fast Fourier Transform (FFT) and Goertzel algorithm.
CO4	**Design** digital filters using techniques like Butterworth and Chebyshev for analog filters, FIR filters using windowing and frequency sampling, and IIR filters using impulse invariance and bilinear transformation methods.
CO5	**Develop** efficient implementations of FIR and IIR filters, considering finite word length effects, and explore the functionality of DSP processors for real-world applications.

Syllabus:

Module-1

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.

Module-2

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.

Module-3

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.

Module-4

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

Module-5

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.

Module-6

Finite word length effects in FIR and IIR digital filters: Quantization, round off errors and overflow errors, Overview of DSP processors.

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)		
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 the EDA tool.
CO5	Understand the CMOS digital circuits.

Syllabus:

Module-1: Introduction to Digital VLSI

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

Module-2: Digital Circuits Design using CMOS Technology

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

Module-3: Timing Analysis

Timing optimization, Transient response, RC Delay Model, Linear Delay Model, Logical Effort of Paths. Statistical timing analysis.

Module-4: Power Dissipation

Sources of Power Dissipation, Dynamic Power, Static Power, Energy-Delay Optimization, Low Power Architectures.

Module-5: VLSI Testing

Stuck at faults, Testers, text fixtures, and Test Programs, BIST, Scan Chains, Design for Testability, Fault tolerant designs.

Module-6: Semiconductor Memory Design

SRAM, DRAM, ROM, EPROM, EEPROM, NAND Flash, NOR Flash, CAM, and TCAM designs

Module-7: VLSI Physical Design

CMOS Fabrication and Layout - Inverter Cross-section, Fabrication process, Layout Design Rules, Gate Layouts, Stick Diagrams. 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
3. Neil Westte and David Harris: CMOS VLSI Design, A Circuits and Systems Perspective, Pearson Publication, fourth edition, 2015.

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)		
Electronic Packaging and Prototyping	**EC305**	**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)		
Digital Signal Processing Practice	**EC351**	**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** the concepts of convolution, correlation, and their properties for discrete-time signals through practical implementation.
CO2	**Solve** problems related to the implementation of DFS, DFT, DTFT, and FFT algorithms, including DIT-FFT and DIF-FFT, and verify their properties.
CO3	**Analyze** the design and performance of FIR filters using various windowing techniques and IIR filters with analog approximation methods.
CO4	**Design** FIR and IIR filters and evaluate their performance for different signal processing applications.
CO5	**Develop** skills to read, process, and analyze audio, image, and video signals, and compare the characteristics of mono and stereo audio, binary and grayscale images, color images, and video signals.

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 filters with various windowing techniques.
9. IIR filter design.
10. Analysis of IIR filters 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)		
VLSI system design Practice	**EC353**	**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 and PMOS transistors from its characteristics.
2. Design and synthesis of digital CMOS circuits with full custom ASIC using EDA tool.
3. Physical design of CMOS circuits with full custom ASIC using EDA tool.
4. Implementation of digital circuits using FPGA
5. Design and synthesis of digital circuits with semi custom ASIC using Verilog in EDA tools
6. Simulate the static and dynamic SRAM cells.

Text Book(s):

1. Weste and Eshraghian: Principles of CMOS VLSI design, Addison Wesley, 4th Edn, 2011.
2. Samir Palnitkar: Verilog HDL, A Guide to Digital Design and Synthesis, Pearson Publications, 2003

References & Web Resources:

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

Course Title	Course Code	Structure (I-P-C)		
Electronic Packaging and Prototyping Practice	**EC355**	**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)		
Wireless Communication	**EC302**	**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	Define the key components and techniques for modelling and analyzing wireless communication systems
CO2	Apply the theoretical knowledge to analyze and design wireless communication systems.
CO3	Analyze the capacity and performance metrics of various wireless channels..
CO4	Evaluate the performance and capacity aspects of different wireless communication channels.
CO5	Develop an Wireless Communication system with the current day requirements.

Syllabus:

Module-1: Introduction to Wireless Communication: Evolution of wireless communication systems, Key features of wireless communication, Applications of wireless technologies,Overview of wireless standards (e.g., GSM, LTE, Wi-Fi, 5G)

Module-2: Wireless Transmission Fundamentals: Wireless channel characteristics: path loss, shadowing, and fading, Radiofrequency spectrum and regulations, Antenna basics: types, parameters, and radiation patterns, Propagation Models: Free-space propagation model, Multipath propagation and its effects, Large-scale fading: Path loss and shadowing models, Small-scale fading: Multipath propagation and Doppler effect, Coherence time, coherence bandwidth, and delay spread; Statistical channel models: Rayleigh, Rician, and Nakagami fading models; Jakes' model and wireless channel correlation

Module-3: Capacity of Wireless Channels: Information theory and channel capacity, Capacity of flat fading channels: Channel State Information (CSI) and its impact,Capacity with receiver diversity; Capacity of frequency-selective fading channels, Water-filling algorithm and its application in wireless communication

Module-4: Cellular and Mobile Communications: Introduction to cellular and mobile concepts, Frequency reuse and channel assignment strategies, Handoff strategies and interference management, Trunk and grade services.

Module-5: Wireless Security: Security challenges in wireless networks, Encryption and authentication mechanisms, Threats: eavesdropping, jamming, and spoofing, Secure communication techniques

Module-6: Modern Wireless Technologies: Multiple-Input Multiple-Output (MIMO) systems, Diversity and spatial multiplexing gain, Massive MIMO, OFDM in modern wireless systems, Applications in LTE and 5G,Cognitive Radio and spectrum sensing

Module-7: Wireless Communication standards: IEEE 802.11 (Wi-Fi) family of protocols, Bluetooth and Zigbee standards, Cellular standards: 3G, 4G, 5G,IoT and LPWAN protocols (LoRa, NB-IoT)

Module-8: Simulation and Case Studies: Wireless system design and analysis using MATLAB: Channel modeling and simulation (Rayleigh, Rician fading), Performance analysis of modulation and coding schemes; Network simulation using NS2/NS3: Protocol performance evaluation, Simulation of MAC and routing protocols in wireless networks, Case studies: 5G NR deployment scenarios, IoT communication using LPWAN (LoRa, NB-IoT), Vehicular Ad Hoc Networks (VANETs)

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.

Additional Details:

- Regular quizzes and assessments to ensure continuous evaluation of student learning.
- Hands-on projects to apply theoretical concepts to practical scenarios.
- Guest lectures by industry experts to provide real-world insights.
- Encourage students to stay updated with the latest advancements in wireless communication technologies through research assignments and discussions.

Course Title	Course Code	Structure (I-P-C)		
Wireless Communication Practice	**EC352**	**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

Open Electives Offered in the ECE Department

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, and J.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.

Course Title	Course Code	Structure (I-P-C)		
Drone Technology		3	2	4

Pre-requisite, if any: Nil

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

CO1	Apply the concept of Flight dynamics for building Quadcopter
CO2	Assemble and Program the Quadcopter
CO3	Perform Testing and Control operations on the Quadcopter
CO4	Implement Quadcopter for real world applications
CO5	Design and Develop the Drone

Syllabus:

Flight Dynamics of Aerial Vehicles

Definitions of Drone, UAV, RPA, Quad copters -Basic Components and Categories – Principles of Flight - Flight Maneuvers – Airframes - Creating a Frame: Materials, Different Frame Shapes – Building Airframes - Flight dynamics - Applications - Future potential - Comparison with other aerial vehicles

Hardware Anatomy of Quadcopter

Power Train – Propellers, Motors- Total Lift - Electronic Speed Controllers – Flight Battery – Radio transmitter and receiver – Flight Controller – GPS, Compass, Camera Assembling for Quad copter – Connectors, Mounting of Propellers and Powering up.

Testing And Maintenance of Quadcopter

Key Flight Safety Rules - Preflight Checklist and Flight Log Information – Flight Instructions - Repair and Maintenance: Crash analysis, Common issues, Voltage testing.

Test and troubleshoot Flight Controller Board (FCB), Electronic Speed Controller (ESC), and its associated peripherals.

Perform programming and configure the flight control board (FCB). Identify, explore, and test the interconnectivity of different peripherals with FCB. Establish connection of FCB with motor, GPS, ESC, and sensors. Configure, test, and record FCB with battery to monitor battery level and perform return to home operation Perform and carry out drone leveling using IMU sensor. Perform calibration of the compass, Lidar, and gyro sensor. The test communication link between FCB and RF transceiver. Write and upload computer code to FCB to test sensor results. Test and record data of motor connectivity with ESC. Perform motor rotation using FCB and ESC. Test signal flow into the drone to test ESC parameters on FCB to check its operation. Write and upload computer code to FCB to ESC working.

Real World Applications and Case Studies

Beneficial Drones, Aerial Photography, Mapping and Surveying, Precision Agriculture, Search and Rescue, Infrastructure Inspection, and Conservation. Case Studies: Agriculture Weed Classification, Microdrone surveillances.

Drone Technology

1. Familiarization with Drone Parts
2. Assembling of Drone
3. Preparation for Drone for Flight, making flight plan and basic drone flight training

4. Debugging and repairing of the drone
5. Operation of Drone for different Applications

Text Book(s):

1. Reg Austin "Unmanned Aircraft Systems UAV design, development and deployment", Wiley, 2010.
2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.
3. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007
4. Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAV Systems", UAV Systems, Inc, 1998
5. Dr. Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics

Course Title	Course Code	Structure (I-P-C)		
Smart Sensors and Actuators		**3**	**2**	**4**

Pre-requisite, if any: Embedded Systems, Computer Networks, C programming, and microprocessor/microcontrollers

Course Aim: This course introduces the basic components of IoT and their interdependencies, deployment models, and fundamental concepts of IoT networking. This will be followed by more IoT network topics such as data and communication protocols. To have an in-depth understanding of data handling in IoT, this course has lectures on data handling, analytics, and data management for IoT devices.

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

CO1	Interpret physical principles applied in sensors and actuators
CO2	To model and design sensors with desired physical and chemical properties
CO3	Identify various types of sensors including thermal, mechanical, electrical, electromechanical and optical sensors
CO4	To implement Actuators for different IoT Applications
CO5	To Design Signal conditioning circuits for different sensors suitable for IoT

Syllabus

Sensor characteristics:

Definitions, terminology, classification, Static vs dynamic properties of transducers, Transfer functions, Ideal and realistic transducer models, Resolution, linearization, dynamic range, detection threshold, Selectivity & sensitivity, Calibration, Errors of the experimental measurements, Noise: electronics, environmental & internal

Physical Principle of Sensing:

Capacitance, Magnetism, Induction, Resistance, Piezoelectric effect, Pyroelectric effect, Hall Effect, Thermoelectric effect, Temperature and thermal properties of materials and heat transfer, Optics, Fibber optics and waveguides

Sensor Interface and Applications:

Input characteristics of interface circuits, Amplifiers, Light to voltage converters, Capacitance to voltage converters, Bridge Circuits, Excitation circuits. Case Studies: Inertial Sensors, Healthcare Sensors and Smart building Sensors

Smart Sensors and Actuators:

Sensor's with Integrated Electronics, functions of Integrated Electronics, Electrical Actuator, Piezoelectric Actuators, and Machine to machine Communication: Introduction, Node types and M2M Applications, Integration of Sensors, and Actuators for Implementation of IoT, Nanotechnology and miniaturization of sensing and Actuating devices.

Smart Sensors and Actuators Practice

1. Signal Conditioning Circuits for resistive, Capacitive and Inductive Sensor
2. Measurement of Voltage and Current in various ranges
3. Signal Conditioning Circuits for sensor which gives voltage, current and charge as output
4. Selection of signal conditioning ICs for various physical sensor

5. Design of various drivers for actuators

References

1. cv Jacob Fraden, (2010), Handbook of Modern Sensors, 5th Edition, Springer.
2. J. W. Gardner, (1996), Microsensors, Principles and Applications, 1st Edition, Wiley.
3. S. M. Sze, (1994), Semiconductor Sensors, 1st Edition, Wiley.
4. Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland.
5. John G Webster, “Measurement, Instrumentation and sensor Handbook”, 2017, 2nd edition,CRC Press, Florida.

Professional Engineering Electives offered by the ECE Department

Course Title	Course Code	Structure (I-P-C)		
Data Communication and Networking	**EC303**	**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 sublayer: 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)		
Linear IC Applications	**EC311**	**3**	**0**	**3**

Pre-requisite, if any: Nil

CO1	Design op-amp circuits to perform arithmetic operations.
CO2	Analyze and design linear and non-linear applications using op-amps.
CO3	Analyze and design oscillators and filters using functional ICs.
CO4	Choose appropriate A/D and D/A converters for signal processing applications.

Syllabus:

Introduction to Op Amp: Introduction to op-amps, ideal Characteristics, Pin configuration of 741 op-amps. Bias, offsets and drift, bandwidth and slew rate. Offset and Frequency compensation. Inverting and non-inverting amplifiers and their analysis, Applications: inverting and non-inverting summers, difference amplifier, differentiator and integrator, solving differential equations.

Op-Amp Applications: Instrumentation amplifier, RC-phase shift oscillator, Wein 's bridge oscillator, Log and antilog amplifiers. Analog IC Multipliers and dividers, Comparators, Schmitt triggers, Square wave Generators, Triangular wave- generators. Active Filters, Low pass, High pass, Band pass and Band Reject filters, Butterworth, Chebyshev filters, Different first and second-order filter Topologies,

Timer: 555 Timer functional diagram, monostable and astable operation, applications.

ADCs and DACs: Weighted resistor DAC, R-2R DAC. IC DAC-08. counter type ADC, successive approximation ADC, Flash ADC, dual slope ADC, conversion times of typical IC ADC

Other Linear ICs: Voltage Regulators Voltage Regulator Series op amp regulator, Three terminal IC voltage regulator exercise problems. IC 723 general purpose regulator, Switching Regulator. Phase Locked Loop PLL- basic block diagram and operation, capture range and lock range; IC 565, VCO IC 566.

Text Books:

1. Sergio Franco, Design with Operational Amplifier and Analog Integrated Circuits, TMH, 2017, 4th Edition.
2. Roy Choudary D. and Shail B. Jain, Linear Integrated circuits, New Age International Publishers, 2017, 4th Edition.
3. Ramakant A.Gayakward, Op-Amps and Linear Integrated Circuits, PHI, 2015, 4th Edition.

References & Web Resources:

1. Operational Amplifiers & Linear Integrated Circuits, R.F. Coughlin & Fredrick F. Driscoll, PHI, 2000,6th Edition.
2. Denton J. Daibey, Operational Amplifiers & Linear Integrated Circuits: Theory & Applications, TMH.

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 code length, 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, Akademiai Kiado, 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)		
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. Behzad Razavi, 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. Behzad Razavi, 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)		
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. Ahamed Khattab, 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)		
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

Course Title	Course Code	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	Understand how power electronic converters and inverters operate.
CO2	Possess an understanding of feedback control theory.
CO3	Analyze and compare the performance of DC and AC machines.
CO4	Design control algorithms for electric drives which achieve the regulation of torque, speed, or position in the above machines.

Syllabus:

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

Experiments are conducted to introduce the concept of control of conventional electric motors 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, “Electric Motor Drives: Modeling, Analysis, and Control,” PrenticeHall, 2001.
2. Mohan, “Electric Drives: An Integrative Approach,” 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-layer PCB 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

Course Title	Course Code	Structure (I-P-C)		
Power Electronics	**EC413**	**3**	**0**	**3**

Pre-requisite, if any: Electronic Devices

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

CO1	Understand basic operation of various power semiconductor devices and passive components
CO2	Understand the basic principle of switching circuits.
CO3	Design AC/DC rectifier, DC/DC converter and DC/AC inverter circuits.
CO4	Understand the role power electronics play in the improvement of energy usage, efficiency and the development of renewable energy technologies.
CO5	Design different power converters

Syllabus:

Introduction to power electronics; applications and role of power electronics.

Introduction to power semiconductor devices, operating characteristics of Power Diode,SCR, Power BJT, Power MOSFET and IGBT; Driver circuits and Snubber circuits.

Introduction to AC/DC rectifiers, principle of operation of phase controlled rectifiers, single phase and three phase AC-DC line commutated converters, dual converter, and introductionto unity power factor converters. Applications: DC motor drives and Battery 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.

Introduction to DC/AC inverters, PWM techniques, Principle of operation of single phase and three phase DC-AC inverters, Applications: AC motor drives, UPS, active filters, CFL, renewable power generation, induction and dielectric heating.

Text Book:

1. N. Mohan, T. Undeland, and W. Robbins, “Power Electronics: Converters,Applications, and Design,” 3rd Edition, Wiley, 2003.
2. M. Rashid, “Power Electronics: Circuits, Devices & Applications,” Prentice Hall, 3rdEdition, 2003.

References & Web Resources:

1. J. P. Agrawal, “Power Electronic Systems: Theory and Design,” Pearson, 2013.
2. Batarseh, “Power Electronic Circuits,” John Wiley, 2004. 2. R. W. Erickson andD.Maksimovic , “Fundamentals of Power Electronics,” 2 nd Edition, Springer, 2001.
3. R. W. Erickson and D. Maksimovic , “Fundamentals of Power Electronics,” 2ndEdition, Springer, 2001.

Course Title	Course Code	Structure (I-P-C)		
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 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. Behzad Razavi, 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, 2^{nd} 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

Course Title	Course Code	Structure (I-P-C)		
Sensing and Instrumentation	**EC417**	**1**	**3**	**3**

Pre-requisite, if any: Nil

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

CO1	Build systems which would sense the different physical signal
CO2	Process the signals in the required analog or digital formats
CO3	Calibrate sensors according to the required applications.
CO4	Understand the characteristics of transducers.

Syllabus:

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

Measurement of non-electrical quantities such as displacement, velocity, acceleration, pressure, force, flow and temperature, calibration of sensors, Data acquisition and detection techniques, Signal conversion, PC-based Instrumentation System.

Practice includes experiments from following topics:

Signal generation – Instrumentation amplifiers – Signal conversion and processing – Characteristics of Transducers - Calibration of sensors – Measurement of physical quantities.

Text Book(s):

1. Alan S. Morris, Measurement and Instrumentation Principles, Elsevier, 2001.
2. Sawhney. A. K, Course in Electrical & Electronics Measurement & Instrumentation, Dhanpat Rai, 2007.

References & Web Resources:

1. Howard Austerlitz, Data acquisition techniques using PCs, Academic Press, 2ndEd. 2002.
2. Bruce Mihura, LabVIEW for Data Acquisition (National Instruments Virtual Instrumentation Series), Prentice Hall, 2001.

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”, Hüseyin Arslan, 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)		
Embedded System Design	**EC421**	**3**	**2**	**4**

Pre-requisite, if any: Microprocessors and Microcontrollers

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

CO1	Understand the basic elements of embedded systems such as I/O and interfaces.
CO2	Understand embedded system design using the ARM Cortex-M microcontroller with the Launch pad IDE in C.
CO3	Develop the rapid prototype of embedded systems using microcontrollers.
CO4	Build wireless networked embedded systems using Arduino shields and modules (e.g., GPS, GSM/GPRS, Bluetooth, RFID, and ZigBee).
CO5	Exploit the advanced concepts such as networking and wireless communications, real- time operating systems and control, and Internet of Things in the real time embedded systems.
CO6	Develop the hardware-software co-design with parallel threads
CO7	Conduct experiments in Internet of Things

Syllabus:

Theory

1. Introduction to Embedded Systems: Elements of embedded systems (such as microcontrollers, GPIO, communication, interrupts, ADC, and DAC); overview of microcontroller; Comparison between Hardware, Software, and Firmware; Comparison between Hard, Soft, Firm, and Hybrid real time systems; applications of embedded systems; classification of embedded systems; characteristics of embedded systems; hardware-software partitioning; (5 hours)

2. RTOS: Software aspects of embedded systems; Real-time operating system (RTOS) - mutual exclusion using semaphore; deadlock; critical section; event-driven scheduling; time sharing; earliest deadline first scheduling; preemptive scheduling; non-pre-emptive scheduling; multi- tasking; multi-threading; inter-process communication using mboxes, and pipes; priority inversion; (10 hours)

3. Prototyping: Rapid prototyping of embedded systems with advanced microcontroller boards; (5 hours)

4. IoT: Basic elements of IoT; IoT systems design using advanced microcontroller boards; (10 hours)

5. Communication Protocols: I2C, CAN, PCIe, SPI, UART, USB (10 hours)

Practice

1. Experiments in GPIO such as switches, LEDs, LCD, Key pad, Seven Segment Display, Buzzer, and relay; (5 hours)
2. Serial and parallel interfacing; data acquisition with ADC, audio, and video; timer interrupts; Various bus inter connects such as I2C, UART, SPI, and so on; (5 hours)
3. DAC Experiments in control of RC servos, stepper motors, and DC motors; (5 hours)
4. Data acquisition and real-time control with uC boards, FPGA boards; (5 hours)
5. Add-on boards Experiments in wireless networked systems with GPS, GSM/GPRS, ZigBee, Bluetooth, and RFID; (5 hours)
6. Hardware-software co-design experiments using FPGA boards. (5 hours)
7. Experiments in IoT for smart automation using sensors, microcontrollers, and cloud. (5 hours)

8. Free RTOS based applications and PSoC trainer board based experiments. (8 hours)

Text Book(s):

1. D. Gajski, F. Vahid, S. Narayan, and J. Gong. “Specification and Design of Embedded Systems”, Prentice Hall.

References & Web Resources:

1. J. W. Valavano, “Embedded Systems: Introduction to Arm Cortex-M Microcontrollers", 2nd edition, Create Space, 2012. ISBN: 978-1477508992.
2. J. W. Valavano, “Embedded Systems (Vol-2): Real-Time Interfacing to ARM Cortex-M Microcontrollers", 2nd edition, Create Space, 2011, ISBN: 978-1463590154.
3. J. W. Valavano, “Embedded Systems (Vol-3): Real-Time Operating Systems for Arm Cortex M Microcontrollers", 2nd edition, Create Space, 2012. ISBN: 978-1466468863.
4. A. McEwen and H. Cassimally, “Designing the Internet of Things”, 1st edition, Wiley, 2013. ISBN: 978-8126556861.

Course Title	Course Code	Structure (I-P-C)		
VLSI Technology	**EC421**	**3**	**0**	**3**

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:

Introduction to VLSI Design, MOSFET Fabrication.

Crystal Structure of Si, Defects in Crystal, Crystal growth.

Epitaxy, Vapour phase Epitaxy, Doping during Epitaxy, Molecular beam Epitaxy. Oxidation – Kinetics, Rate constants, Dopant Redistribution, Oxide Charges.

Diffusion-Theory of Diffusion, Doping Profiles, Diffusion Systems Ion Implantation - Process, Annealing of Damages, Masking during Implantation.

Lithography, immersion lithography, e-beam lithography.

Etching-Wet Chemical Etching, Dry Etching, Plasma Etching, Si, SiO2, SiN and other materials.

Deposition-Plasma Deposition, Metallization, Problems in Aluminium Metal contacts, Copper interconnects.

IC BJT - LOCOS, Trench isolation, Poly-emitter-poly-base-BJT and its suitability for high-speed applications.

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.

Text Book(s):

1. S. K. Ghandhi, “VLSI Fabrication Principles- Silicon and Gallium Arsenide”, Wiley Publications.
2. S. M. Sze, “VLSI Technology”, Tata McGraw Hill, 2008

References & Web Resources:

1. J. Plummer, M. D. Deal, and P. B. Griffin, “Silicon V
2. LSI Technology, Fundamentals, Practice and Modeling”, Pearson Higher Education, 2000.
3. Y. Taur and T. H. Ning, “Fundamentals of Modern VLSI Devices”, Cambridge University Press, 1998.

Course Title	Course Code	Structure (I-P-C)		
Optoelectronics	**EC422**	**3**	**0**	**3**

Pre-requisite, if any: Electronic Devices

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

CO1	Understand the basics of optical generation and recombination mechanisms in semiconductors.
CO2	Understand the governing equations to be able to perform calculations to characterize the performance of the devices.
CO3	Understand the trade-offs when using optoelectronic devices in their respective applications.

Syllabus:

Recap of Semiconductors: Introduction to semiconductors, Doping, Alloy Semiconductors, Electron-hole pair formation and recombination, Energy bands in solids

Optical Processes in Semiconductors: Absorption in semiconductors – indirect intrinsic transitions, exciton absorption, donor acceptor and impurity band absorption, effect of electric field on absorption, Radiation in Semiconductors- Relation between absorption and emission spectra, near band gap radioactive transitions

Optoelectronic detectors: Photoconductors, junction Photodiodes, PIN Photodiodes, heterojunction diodes, avalanche Photodiodes, Phototransistors, modulated barrier Photodiode, metal- semiconductor -metal photodiode.

Photovoltaic devices: Solar energy spectrum, device principles, I-V characteristics, equivalent circuit, temperature effects, materials, devices and efficiencies.

Light emitting diode: Electroluminescent process, choice of LED materials, device configuration and efficiency, light output from LED, LED structure, heterojunction LED, Surface emitting LED, device performance characteristics, frequency response and modulation bandwidth.

Laser diode: Junction laser operating principles, threshold current, heterojunction lasers, distributed feedback lasers, cleaved coupled cavity laser, quantum well lasers, modulation of lasers- rate equations, steady state solution, transient phenomena and frequency response, relaxation oscillations and oscillating output, high frequency modulation of laser diodes.

Optical fiber: Introduction, Structure of optical fiber, Propagation of light through a numerical aperture, Pulse broadening, advantages and disadvantages of fiber optics.

Text Books:

1. S.M. Sze, Semiconductor Devices - Physics and Technology, Wiley, New York.
2. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw Hill.
3. P. Bhattacharya, Semiconductor Optoelectronic Devices, Pearson Education,

References:

1. J. Singh, Optoelectronics: An Introduction to Materials and Devices, Tata McGraw Hill.
2. Donald A. Neamen, Semiconductor physics and devices, McGraw-Hill, 3rd Edition.

Skill Development Courses offered by the ECE Department

Two Credit Profession Engineering Elective-III Courses

Course Title	Course Code	Structure (I-P-C)		
5G Communication with Software-Defined Radio	**ECXXX**	**2**	**0**	**2**

Prerequisite, if any: Communication Systems

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

CO1	Understand the key technologies and concepts of 5G communication systems.
CO2	Design and analyze waveforms like OFDM, GFDM, and FBMC used in 5G.
CO3	Implement and test 5G communication techniques using Software-Defined Radio (SDR).

Syllabus:

Introduction to 5G communication: Key features, architecture, and requirements. Overview of physical layer technologies in 5G: OFDM, GFDM, FBMC, UFMC. Multi-carrier modulation: principles, advantages, and implementation. Channel estimation and equalization for 5G systems.

Massive MIMO and beamforming: Concepts, spatial multiplexing, and diversity. Millimeter-wave communication: challenges and solutions. Software-Defined Radio (SDR): architecture, hardware platforms, and programming basics. Implementing 5G physical layer functionalities on SDR.

Advanced topics in 5G: Non-Orthogonal Multiple Access (NOMA), network slicing, and edge computing. Laboratory experiments: Implementing OFDM on SDR, simulating beamforming, and testing 5G waveforms in a real-time environment.

Text Book(s):

1. Andrea Goldsmith, “Wireless Communications,” Cambridge University Press.
2. Erik Dahlman, Stefan Parkvall, and Johan Skold, “5G NR: The Next Generation Wireless Access Technology,” Academic Press.

References & Web Resources:

1. Ian Sharp, “Wireless Positioning: Principles and Practice,” Cambridge University Press.
2. Behrouz A. Forouzan, “Data Communications and Networking,” McGraw Hill.

Course Title	Course Code	Structure (I-P-C)		
Drone Navigation using Visible Light Communication	**ECXXX**	**2**	**0**	**2**

Prerequisite, if any: Communication Systems

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

CO1	Understand the principles and applications of Visible Light Communication (VLC) in drone navigation.
CO2	Analyze and design VLC-based positioning and navigation systems
CO3	Implement and evaluate VLC systems in practical drone navigation scenarios.

Syllabus:

Introduction to drone navigation systems: GPS, vision-based, sensor fusion, and limitations in indoor environments. Fundamentals of Visible Light Communication (VLC): system architecture, modulation techniques (OOK, PPM, OFDM), hardware components (LEDs, photodiodes, optical filters). VLC positioning techniques: Received Signal Strength (RSS), Angle of Arrival (AoA), Time of Flight (ToF), and localization algorithms (trilateration, multilateration).

Integration of VLC with drone systems: design of VLC transmitters and receivers, interfacing VLC with UAV control modules, path planning algorithms, and obstacle detection using VLC. Challenges in VLC-based navigation: signal interference, mobility constraints, and energy efficiency. Advances in hybrid VLC-RF communication systems, and emerging technologies like quantum VLC.

Text Book(s):

1. Zhaocheng Wang et al., “Visible Light Communication: Theory and Applications,” Wiley Publications.
2. Rafael Yanushevsky, “Fundamentals of UAV Navigation and Guidance,” CRC Press.

References & Web Resources:

1. Ian Sharp, “Wireless Positioning: Principles and Practice,” Cambridge University Press.
2. Joachim Sachs et al., “Visible Light Communication,” Springer

Course Title	Course Code	Structure (I-P-C)		
Electrical Drives	**EC409**	**1**	**2**	**2**

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 how power electronic converters and inverters operate.
CO2	Possess an understanding of feedback control theory.
CO3	Analyze and compare the performance of DC and AC machines.
CO4	Design control algorithms for electric drives which achieve the regulation of torque, speed, or position in the above machines.

Syllabus:

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

Experiments are conducted to introduce the concept of control of conventional electric motors 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, “Electric Motor Drives: Modeling, Analysis, and Control,” PrenticeHall, 2001.
2. Mohan, “Electric Drives: An Integrative Approach,” MNPERE, 2001.

Course Title	Course Code	Structure (I-P-C)		
Sensing and Instrumentation	**EC417**	**1**	**2**	**2**

Pre-requisite, if any: Nil

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

CO1	Build systems which would sense the different physical signal
CO2	Process the signals in the required analog or digital formats
CO3	Calibrate sensors according to the required applications.
CO4	Understand the characteristics of transducers.

Syllabus:

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

Measurement of non-electrical quantities such as displacement, velocity, acceleration, pressure, force, flow and temperature, calibration of sensors, Data acquisition and detection techniques, Signal conversion, PC-based Instrumentation System.

Practice includes experiments from following topics:

Signal generation – Instrumentation amplifiers – Signal conversion and processing – Characteristics of Transducers - Calibration of sensors – Measurement of physical quantities.

Text Book(s):

1. Alan S. Morris, Measurement and Instrumentation Principles, Elsevier, 2001.
2. Sawhney. A. K, Course in Electrical & Electronics Measurement & Instrumentation, Dhanpat Rai, 2007.

References & Web Resources:

1. Howard Austerlitz, Data acquisition techniques using PCs, Academic Press, 2ndEd. 2002.
2. Bruce Mihura, LabVIEW for Data Acquisition (National Instruments Virtual Instrumentation Series), Prentice Hall, 2001.

Course Title	Course Code	Structure (I-P-C)		
Fundamentals of Time-Frequency and Wavelet Analysis	**ECXXX**	**2**	**0**	**2**

Prerequisite, if any: Digital Signal Processing

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

CO1	Demonstrate a clear understanding of the mathematical principles and significance of time-frequency analysis techniques, including STFT and Wavelet Transform.
CO2	Utilize STFT and Wavelet Transform to analyze non-stationary signals and interpret time-frequency representations effectively.
CO3	Develop and implement solutions for practical applications such as speech processing, biomedical signal analysis, and fault diagnosis using time-frequency methods.

Syllabus:

Module 1: Introduction to Time-Frequency Analysis

- Limitations of classical Fourier analysis for non-stationary signals.
- Basics of time-frequency analysis: motivation and applications.
- Overview of different techniques: STFT, Wavelet Transform, Wigner-Ville Distribution, etc.

Module 2: Short-Time Fourier Transform (STFT) Mathematical formulation of STFT.

- Choice of window function: trade-offs between time and frequency resolution.
- Spectrogram: visualization of STFT.
- Applications of STFT in speech, audio, and biomedical signal analysis.
- Hands-on implementation using MATLAB/Python.

Module 3: Wavelet Transform Concept of wavelets: differences from Fourier basis.

- Continuous Wavelet Transform (CWT): mathematical formulation and properties.
- Discrete Wavelet Transform (DWT): multiresolution analysis and filter banks.
- Popular wavelets: Haar, Daubechies, Symlets, etc.
- Applications in image compression, fault diagnosis, and biomedical signals.
- Hands-on implementation using MATLAB/Python.

Text Book(s):

1. Stéphane Mallat, "A Wavelet Tour of Signal Processing," 3rd edition Academic Press.
2. D. Sundararajan, "Discrete Wavelet Transform: A Signal Processing Approach," Wiley Press

References & Web Resources:

1. Lokenath Debnath, "Wavelet Transform and Time-Frequency Signal Analysis," Springer

Course Title	Course Code	Structure (I-P-C)		
Design of Biomedical Devices and Systems		**2**	**0**	**2**

Pre-requisite, if any:

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

CO1	**Analyze**: Analyze the design requirements and constraints for creating biomedical devices and systems for diverse clinical applications
CO2	**Evaluate**: Critically assess existing biomedical devices and suggest improvements in their design and functionality.
CO3	**Create**: Design innovative biomedical devices or systems tailored to solve specific clinical problems, integrating engineering principles and patient needs.

Introduction: biomedical engineering design, engineering approaches to clinical challenges, clinical problems requiring implants/devices for solution

Materials for biomedical implants and devices; Implantable devices and systems: Vascular and cardiovascular devices, pacemakers, heart valves, stents, synthetic grafts, orthopedic implants, intraocular lens implants, cochlear implants

Wearable devices: Assistive devices for the blind, foetal movement, finger movement, gait analyzer, ventricular assist devices, energy harvesting; Implantable neural prostheses and nerve stimulation: Brain, visual prosthesis, cochlear implants, spinal cord stimulation, cardiology system, artificial limbs

Minimally invasive devices and techniques: Instrumentation for Laparoscopic Surgery, Ocular Surgery; Imaging and image-guided techniques: endoscopy, medical ultrasound devices, medical X-rayimaging, imaging-aided design of personalized devices and assistive reproduction technology

Rehabilitation Engineering: Deafness, blindness, passive and active Orthoses and Prostheses.

Texts/Reference Books:

1. Andrés D. Lantada. Handbook on Advanced Design and Manufacturing Technologies for Biomedical Devices. Springer London 2013
2. Aimé Lay-Ekuakille and Subhas C. Mukhopadhyay, Wearable and Autonomous Biomedical Devices and Systems for Smart Environment. Springer-Verlag Berlin, 2010
3. David D. Zhou and Elias Greenbaum. Implantable Neural Prostheses 1. Devices and Applications. Springer, London, 2009
4. Gail D. Baura. Medical Device Technologies: A Systems Based Overview Using Engineering Standards Academic Press, Oxford, UK 2012
5. Paul H. King, Richard C. Fries. Design of Biomedical Devices and Systems. CRC press, Boca Raton, 2009
6. James Moore and George Zouridakis. Biomedical Technology and Devices Hand Book. CRC press, Washington DC, 2004
7. Martin Culjat, Rahul Singh, Hua Lee. Medical Devices: Surgical and Image-Guided Technologies, John Wiley & Sons, Inc New Jersey, 2013
8. ASM Handbook Volume 23, Materials for Medical Devices
9. Joseph D. Bronzino, Donald R. Peterson. Medical Devices and Human Engineering, CRC Press, New York, 2015
10. Frank E. Johnson, Katherine S. Virgo, The Bionic Human: Health Promotion for People with Implanted Prosthetic Devices, Humana Press Inc., New Jersey, 2006

Course Title	Course Code	Structure (I-P-C)		
Signals and Systems for Digital Health		**2**	**0**	**2**

Pre-requisite, if any:

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

CO1	**Analyze**: Analyze real-world case studies in digital health to identify challenges and propose data-driven solutions.
CO2	**Evaluate**: Assess the quality and effectiveness of biomedical signal processing methods in specific healthcare applications.
CO3	**Create:** Design and develop innovative solutions using wearable devices and digital health frameworks to address specific healthcare needs.

Digital Health - Introduction: Need, case studies, basics - mHealth and eHealth, Impact, Informatics: Health Level Seven (HL7), Integrating the Healthcare Enterprise (IHE), Vendor Neutral Archives (VNAs), Open source/ data/innovation – opportunities, Regulatory Affairs in Digital Health (FDA/DCGI), and Ayushman Bharat Digital Mission

Signals and Systems: Signals and Systems Review, LTI Systems, Signal Processing Review: DFT and its properties, Nyquist Sampling Theorem, Low-Pass Filtering, Filters - Chebyschev Filter and Butterworth Filter, Multi-resolution analysis, Filter Banks, Wavelets, Reconstruction of Bandlimited Signals.

Biomedical Signals and Systems: Basics of Physiology (brain, heart and muscle), ECG Signal Acquisition (Electrical activity of heart, chest leads/montage, action potential in pacemaker and other regions; action potential relation to ECG Waveform; Reading ECG); EEG Signal Acquisition (Neural activity in the brain, Action potential, post-synaptic potential, Signal Propagation in the brain, EEG montage, EEG Signal Acquisition); Basics of phonocardiography; EEG and ECG data processing, ECG and EEG signal processing (EEGLab).

Biomedical Wearable Devices: Wearable Sensors for health monitoring: Accelerometers (data acquisition and interpretation), glucose sensing (acquisition methods and comparison), Wearable ECG & EEG based on dry electrodes, pulse-oximeter. Medical regulatory approvals.

Reference

1) S. Haykin and B. V. Veen, “Signals and Systems”, 2nd Edition, Wiley Publisher (2007).
2) K. Najarian, and R. Splinter, “Biomedical Signal and Image Processing,” 2nd Edition, CRC Press (2012).
3) Journal Papers, Case Reports, and Review Articles

Course Title	Course Code	Structure (I-P-C)		
MEMS Design and Manufacturing		**2**	**0**	**2**

Pre-requisite, if any:

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

CO1	Understand the fundamental principles and applications of MEMS
CO2	Design and simulate MEMS devices for specific applications.
CO3	Analyze fabrication techniques and integrate them into MEMS manufacturing processes.
CO4	Assess the reliability and performance of MEMS devices.

Introduction to MEMS: Fundamentals of MEMS and Microsystems,Applications of MEMS in automotive, biomedical, and communication fields, Overview of MEMS materials (silicon, polymers, metals, and ceramics)

MEMS Design: MEMS design principles: Scaling laws and miniaturization,Modeling and simulation of MEMS devices, Software tools (e.g., COMSOL Multiphysics, ANSYS) Common MEMS devices: Micro-sensors (pressure, accelerometers, gyroscopes), Micro-actuators (thermal, electrostatic, piezoelectric) Design case studies: MEMS-based accelerometers and pressure sensors

MEMS Fabrication Techniques: Bulk micromachining: Etching techniques (wet and dry etching) Surface micromachining: Deposition techniques (CVD, PVD, sputtering) Lithography: Photolithography and advanced lithography techniques MEMS packaging and assembly methods: Wafer bonding, hermetic sealing Overview of cleanroom practices

Testing and Characterization: MEMS testing techniques: Electrical, mechanical, and thermal testing Characterization tools: SEM, AFM, and profilometers Reliability issues in MEMS: Fatigue, fracture, and wear

Applications and Future Trends: Emerging applications of MEMS in IoT, wearable devices, and biomedical systems, MEMS in RF systems, energy harvesting, and microfluidics Current challenges and research directions in MEMS

Text /ReferenceBooks

1. *MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering* by Tai-Ran Hsu
2. *Fundamentals of Microfabrication: The Science of Miniaturization* by Marc J. Madou
3. *Microsystem Design* by Stephen D. Senturia
4. *introduction to Microelectromechanical Systems Engineering* by Nadim Maluf and Kirt Williams