Department of Electronics and Communication Engineering
Faculty of Technology
University of Delhi

Detailed Course Structure and Curriculum of B.Tech. (ECE) Second Year

Department of Electronics and Communication Engineering
Faculty of Technology
University of Delhi

Course Structure of B. Tech (ECE) Second Year
Second Year

Semester – III

S. No.	Course Domain	Course Title	Credits*			Total Credits
			L	T	P	
1.	DSC-7	Electronic Devices and Circuits	3	0	1	4
2.	DSC-8	Network Analysis and Synthesis	3	0	1	4
3.	DSC-9	Digital Electronics - I	3	0	1	4
4.	DSE-1 or GE-3	Select a course from the specified list of DSE-1 or Select a course from the specified list of GE-3				4
5.	AEC	Select a course from the specified list of AECs				2
6.	SEC or IAPC	Choose one SEC or Internship/Apprenticeship/Project/Community Outreach (IAPC)				2
7.	VAC	Select a course from the specified list of VACs				2
Total Credits						22

Semester – IV

S. No.	Course Domain	Course Title	Credits*			Total Credits
			L	T	P	
1.	DSC-10	Signals and Systems	3	0	1	4
2.	DSC-11	Electromagnetic Theory (EMT)	3	0	1	4
3.	DSC-12	Linear Integrated Circuits	3	0	1	4
4.	DSE-2 or GE-4	Select a course from the specified list of DSE-2 or Select a course from the specified list of GE-4				4
5.	AEC	Select a course from the specified list of AECs				2
6.	SEC or IAPC	Choose one SEC or Internship/Apprenticeship/Project/Community Outreach (IAPC)				2
7.	VAC	Select a course from the specified list of VACs				2
Total Credits						22

**Credits*
L (01 Credit) is equivalent to 01 contact hour per week
T (01 Credit) is equivalent to 01 contact hour per week
P (01 Credit) is equivalent to 02 contact hours per week

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Pool of DSEs offered by the Department

S. No.	Semester	DSE	Course Title
1.	III	DSE - 1	Computational Methods
2.			PCB based System Design
3.	IV	DSE - 2	Interfacing Electronics
4.			Modeling Electronic Circuits

List of SECs offered by the Department

S. No.	Semester	Course Title
1.	III	Advanced Electronics Workshop
2.	IV	SimCircuits Workshop

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Specialization and Minors offered by the Department

Semester	DSE/ GE	ECE Minor (Open only for CSE/ EE)	Specializations for ECE/ Minors for EE and CSE			
			Telecommunication Networks	VLSI Technology and System Design	IoT System Design	Computer Vision
III	DSE-1/ GE-3	Fundamentals of Analog Electronics	Introduction to Analog Communication	VLSI Technology and Design	Introduction to IoT	Fundamentals of Image Processing
IV	DSE-2/ GE-4	Introduction to Signals and Systems	Fundamentals of Digital Communication	Microelectronics Design	Introduction to IoT System Design	Image Filtering and Restoration

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Detailed Syllabus of Discipline Specific Core (DSC) Courses for B. Tech. (ECE) – Semester 3

Electronic Devices and Circuits (DSC - 7)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electronic Devices and Circuits	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
- To introduce basic semiconductor devices, their characteristics and their application
- To understand the analysis and design of a simple diode circuit.
- To learn to analyze the PN junction behavior at the circuit level and its role in the operation of diodes and active device.

Course Outcomes:
After completing the course, the students should be able to:
1. Analyze PN junctions in semiconductor devices under various conditions.
2. Design and analyze simple rectifiers and voltage regulators using diodes.
3. Describe the behavior of special purpose diodes.
4. Design and analyze simple BJT and MOSFET circuits.

Unit - I
Junction Diode Characteristics: Open circuited p-n junction, Biased p-n junction, p-n junction diode and current components in PN junction Diode, diode equation, Diode capacitance, and energy band diagram of PN junction Diode. V-I Characteristics of PN junction and Zener Diode, Zener diode as Voltage Regulator. Switching Devices: LED, Varactor diode, Tunnel Diode, UJT-characteristics. Photo diode, SCR, Diac, Triac.
Rectifiers: Half wave rectifier, full wave rectifier, bridge rectifier
Filters: Capacitor filter, Inductor filter, LC filter.

Unit - II
BJT: Junction transistor, transistor current components, transistor configurations, transistor as a switch, and characteristics of transistor in Common Base, Common Emitter and Common Collector configurations, early effect, punch through/ reach through.
FET: FET types, construction, operation, characteristics, parameters, MOSFET-types, construction, operation, characteristics, comparison between JFET and MOSFET.

Unit - III
Transistor Biasing and Thermal Stabilization: Need for biasing, operating point, load line analysis, BJT biasing- methods, basic stability, fixed bias, collector to base bias, self-bias, Stabilization concepts, Stability factors, Compensation, Thermal runaway, heat sinks, Thermal stability

Unit - IV
Small Signal Low Frequency Transistor Amplifier Models: BJT: Two port network, Transistor hybrid model, determination of h-parameters, generalized analysis of transistor amplifier model, Analysis of CB, CE and CC amplifiers using exact and approximate analysis, Comparison of transistor amplifiers, FET small signal model and their analysis of different configuration. High Frequency Analysis.

Suggested Readings

1. Electronic Devices and Circuits- J. Millman, C. Halkias, Tata Mc-Graw Hill, Fourth Edition 2015.
2. Electronic Devices and Circuits – Salivahanan, N Suresh Kumar, Tata Mc-Graw Hill, Fifth Edition 2022.
3. Microelectronic Circuits – Sedra and Smith, Oxford Series.
4. Introduction to PSpice Using OrCAD for Circuits and Electronics – M. H. Rashid, Pearson.
5. Electronic Devices and Circuit Theory – Robert L. Boylestad, Pearson

List of Experiments (Hardware on Breadboard / Software using NI Multisim)

1. Obtain I-V characteristics of Silicon/Germanium based PN Junction Diode and extract diode parameters such as ideality factor, richardson's constant, and leakage components.
2. Obtain I-V characteristics of Zener Diode and observed Line and Load Regulation.
3. Obtain I-V characteristics of Varactor Diode.
4. Obtain I-V characteristics of Tunnel Diode.
5. Obtain I-V characteristics of SCR.
6. Obtain I-V characteristics of Diac and Triac.
7. Obtain the UJT Characteristics.
8. Obtain the Input and Output characteristics of BJT in CB configuration.
9. Obtain the Input and Output characteristics of BJT in CE configuration.
10. Perform parameter extraction of BJT using S – parameters (based on VNA)
11. Obtain the Input and Output Characteristics of JFET.
12. Obtain the Input and Output Characteristics of MOSFET.
13. Obtain the Frequency response of CE amplifier (based on Spectrum Analyzer).
14. Obtain the Frequency response of Emitter Follower (CC amplifier - based on Spectrum Analyzer).

(Note: Course instructor may add/update new experiments in addition to the above suggested practical exercises.)

Network Analysis and Synthesis (DSC - 8)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	**Tutorial**	**Practical**	
Network Analysis and Synthesis	4	3	0	1	Introduction to Electrical and Electronics Engineering

Course Hours: L – 03, T – 00, P - 02

Course Objectives:

- To introduce fundamentals of Engineering Circuit Analysis and Design.
- To make the students capable of analyzing any given electrical network.
- To make the students learn how to synthesize an electrical network from a given impedance/admittance function.

Course Outcomes:

After completing the course, the students should be able to:

1. Apply the knowledge of basic circuital law and simplify the network using reduction techniques.
2. Analyze the circuit using Kirchhoff's law and Network simplification theorems.
3. Infer and evaluate transient response, Steady state response, network functions.
4. Obtain the maximum power transfer to the load, and analyse the series resonant and parallel resonant circuit.
5. Evaluate two-port network parameters, design attenuators and equalizers

Unit - I

Review of network elements: Linear versus nonlinear, time-variant and time invariant, passive verses active, causal and non-anticipated, stable and unstable networks, Network theorems: superposition, Thevenin and Norton's, maximum power transfer, Star-Delta transformation.

Unit - II

Network graph theory, notations and definitions, incidence matrix, cut-sets and fundamental loops, fundamental cutsets matrix, Kirchoff voltage law, Kirchoff current law, interrelationship between matrices of a graph, Tellegen's theorem and its application

Unit - III

Analysis of linear time invariant networks, transform methods in circuit analysis, Laplace transform of common signals, concept of transformed impedance, network functions, poles and zeros, impulse response, step response, convolution.

Unit - IV

Two-port network parameters: driving point and transfer functions. conversion, various inter connections, analysis using various two port parameters.

State equations for networks. State variable analysis of circuits, formulation of state equations, solution of state equations. Transient Response of RC, RL, RLC Circuits to various excitation signals such as step, ramp, impulse and sinusoidal excitations using Laplace Transform. Steady state sinusoidal analysis.

Network synthesis, positive real functions, driving point synthesis (RC, RL, LC) Introduction to passive filter.

Suggested Readings

1. Network Analysis by M.E. Van Valkenburg, Pearson
2. Engineering Circuit analysis by Hyat Jr. and Kemmerly, McGraw Hill
3. Network Analysis and Synthesis by Franklin F. Kuo, Wiley
4. Introduction to Modern Network Synthesis by M. E. Valkenburg, Wiley

List of Experiments (Hardware on Breadboard / Software using NI Multisim)

1. Determine Z and Y Parameters of two – port network.
2. Determine ABCD parameters of two – port network.
3. Determine h – parameters of two – port network.
4. Determine time constant of RC circuit.
5. To verify RC/RL circuit as differentiator and integrator.
6. To study step response of series RC and RL circuit.
7. To study resonance in RLC circuit.
8. To determine equivalent parameters of parallel connections of two – port network.
9. To synthesize a network of a given network function and verify its response.
10. Study of step response of RC and RL Network.
11. Design a Low Pass Filter (Butterworth Approximation) and study its frequency response.
12. Design a Low Pass Filter (Chebyshev Approximation) and study its frequency response.

(Note: Course instructor may add/update new experiments in addition to the above suggested practical exercises.)

Digital Electronics – I (DSC - 9)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Digital Electronics-I	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
- Understand digital logic fundamentals, Boolean algebra, and circuit design.
- Analyze combinational and sequential circuits.
- Develop practical skills through hands-on projects.

Course Outcomes:
After completing the course, the students should be able to:
1. Interpret, convert and represent different number systems.
2. Manipulate and examine Boolean algebra, logic operations, Boolean functions and their simplification.
3. Design and analyze combinational and sequential logic circuits.

Unit - I
Boolean algebra, Switching Function, minimization of switching function: Karnaugh map method and Tabulation Method don’t care terms and applications with respect to code converters and Digital Comparators, etc.
Introduction to Number Systems and Codes: Switching properties of Diodes, BJT and FET, Logic gates, DTL, TTL, ECL, I2L, CMOS Gates and their parameters and comparisons, Applications of switching transistors in bistable, monostable, astable and Schmitt trigger circuits.

Unit - II
Gated Flip Flops, Master Slave Flip Flop, Ripple and Parallel Counter, Up-Down Counter, Shift Registers and Ring Counter, designing the combinational circuits of the counters through Excitation Table.
Introduction to the circuits for Arithmetic Unit: Serial and parallel Binary Adders, 2’s compliment and principle of subtraction, Carry-Look Ahead Adder, and BCD adder: Principles of multiplication, division in ALU.

Unit - III
Semiconductor memories: ROM, PROM, EPROM, EEPROM, Bipolar RAM, static and dynamic RAM. Encoder and Decoder, Demultiplexer, multiplexer, Designing combinational circuits with multiplexer, ROM, PAL and PLA.

Unit - IV
Analog-to-Digital conversion: dual slope integration method and voltage to frequency conversion, principal of DVM., counter type, successive approximation type, Flash ADC, D-A converter: weighted resistors type, R2R ladder type.

Suggested Readings

1. Modern Digital Electronics by R. P. Jain (TMH)
2. Digital Principles and Application by Malvino and Leach (TMH)
3. Digital Design by M. Mano and Michael D. Ciletti (Pearson)
4. Introduction to System Design Using Integrated Circuits by B. S. Sonde (New Age International)

List of Experiments (Hardware on Breadboard / Software using NI Multisim)

1. Characterization of Logic Family (Use Universal NAND Gates) on Breadboard.
    a. Find out logic threshold values and noise margins.
    b. Propagation delay time measurement of inverter using ring oscillator with 3,5,7,9, and 11 inverter elements.
2. Design, Implement, and verify a: Half – Adder, and Full Adder.
3. Design, Implement, and verify a: Half – Subtractor, and Full Subtractor.
4. Design, Implement, and verify a 2 – bit binary comparator using basic gates.
5. Design, Implement, and verify a 3 × 8 decoder and 8 × 1 multiplexer using basic gates.
6. Design, Implement, and verify a 4 – bit binary counter and a decimal counter using basic gates. Demonstrate output on LEDs.
7. Design, Implement, and verify all the Flip Flops using basic gates.
8. Design, Implement, and verify the Schmitt Trigger circuit.

(Note: Course instructor may add/update new experiments in addition to the above suggested practical exercises.)

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Detailed Syllabus of Discipline Specific Elective (DSE) Courses for B. Tech. (ECE) – Semester 3

Computational Methods (DSE – 1)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Computational Methods	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
- To familiarize different numerical methods to solve engineering problems.
- To write computer programs and use tool boxes in the software packages.
- To select a specific numerical method to solve practical problems.

Course Outcomes:
After completing the course, the students should be able to:
1. To understand numerical methods to find roots of functions and first order unconstrained minimization of functions.
2. To introduce concept of interpolation methods and numerical integration.
3. To understand numerical methods to solve systems of algebraic equations and curve fitting by splines.
4. To understand numerical methods for the solution of Ordinary and partial differential equations.

Unit - I
Taylor Series, Rolle's Theorem and Mean Value Theorem, Approximations and Errors in numerical computations, Data representation and computer arithmetic, Loss of significance in computation Location of roots of equation: Bisection method (convergence analysis and implementation), Newton Method (convergence analysis and implementation), Secant Method (convergence analysis and implementation). Unconstrained one variable function minimization by Fibonacci search, Golden Section Search and Newton's method. Multivariate function minimization by the method of steepest descent, Nelder- Mead Algorithm.

Unit - II
Interpolation: Assumptions for interpolation, errors in polynomial interpolation, Finite differences, Gregory-Newton's Forward Interpolation, Gregory-Newton's backward Interpolation, Lagrange's Interpolation, Newton's divided difference interpolation Numerical Integration: Definite Integral, Newton Cote's Quadrature formula, Trapezoidal Rule, Simpson's one-third rule, simpson's three-eight rule, Errors in quadrature formulae, Romberg's Algorithm, Gaussian Quadrature formula.

Unit - III

System of Linear Algebraic Equations: Existence of solution, Gauss elimination method and its computational effort, concept of Pivoting, Gauss Jordan method and its computational effort, Triangular Matrix factorization methods: Dolittle algorithm, Crout's Algorithm, Cholesky method, Eigen value problem: Power method Approximation by Spline Function: First-Degree and second-degree Splines, Natural Cubic Splines, B Splines, Interpolation and Approximation.

Unit - IV

Numerical solution of ordinary Differential Equations: Picard's method, Taylor series method, Euler's and Runge-Kutta's methods, Predictor-corrector methods: Euler's method, Adams Bashforth method, Milne's method.

Numerical Solution of Partial Differential equations: Parabolic, Hyperbolic, and elliptic equations.

Suggested Readings

1. E. Ward Cheney and David R. Kincaid, "Numerical Mathematics and Computing," Cengage.
2. R. L Burden and J. D. Faires, "Numerical Analysis," Cengage.
3. S. D. Conte and C. de Boor, "Elementary Numerical Analysis: An Algorithmic Approach," McGraw Hill.
4. E. Balagurusamy, "Numerical Methods," McGraw Hill.
5. Laurence V. ausett, "Applied Numerical Analysis using MATLAB," Pearson

List of Experiments (Software Based)

1. To implement Bisection method for finding roots of a given quadratic equation.
2. To implement Regula Falsi method for finding roots of a given quadratic equation.
3. To implement Secant method for finding roots of a given quadratic equation.
4. To implement Newton's method for finding roots of a given quadratic equation.
5. To implement Newton's method for solving a system of linear equations.
6. To implement Gauss Thomas method for tri-diagonal system.
7. To implement Jacobi method for solving a system of linear equations.
8. To implement Gauss-Seidel method for solving a system of linear equations.
9. To implement Linear Spline Interpolation.
10. To implement Cubic Spline Interpolation.
11. To approximate finite integrals using Romberg Integration.
12. To approximate finite integrals using Gaussian Quadrature.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

PCB based System Design (DSE – 1)
(Credit Distribution and Prerequisites of the Course)

<table>
<tr><th rowspan="2">Course Title</th><th rowspan="2">Credits</th><th colspan="3">Credit Distribution of the Course</th><th rowspan="2">Prerequisite of the course (if any)</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>PCB based System Design</td><td>4</td><td>3</td><td>0</td><td>1</td><td>NIL</td></tr>
</table>

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
The main aim of this course is to make students learn different PCBs for analog, digital, biomedical, wearable electronics, high frequency and power electronics applications. They will learn the electronic manufacturing and packaging aspects with the electrical, mechanical and thermal design considerations required for optimize designing of PCB.

Course Outcomes:
After completing the course, the students should be able to:

1. Learn electronic manufacturing and packaging aspect.
2. Understand electronic packaging, hierarchy, and methods for various environments.
3. Understand the material requirement and optimization process of PCB Design.
4. Design and develop PCB with MSI circuits for different applications.

Unit - I
PCB Fundamentals: PCB Advantages, components of PCB, Electronic components, IC's, Surface Mount Devices (SMD). Classification of PCB - single, double, multilayer and flexible boards, Manufacturing of PCB, PCB standards.

Unit - II
Technology OF PCB: Design automation, Design Rule Checking; Exporting Drill and Gerber Files; Drills; Footprints and Libraries Adding and Editing Pins, copper clad laminates materials of copper clad laminates, properties of laminates (electrical and physical), types of laminates, soldering techniques. Film master preparation, Image transfer, photo printing, Screen Printing, Plating techniques etching techniques, Mechanical Machining operations, Lead cutting and Soldering Techniques, Testing and quality controls.

Unit - III
Overview of Electronic Systems Packaging: Definition of a system and history of semiconductors, Products and levels of packaging, Packaging aspects of handheld products, Definition of PWB, Basics of Semiconductor and Process flowchart, Wafer fabrication, inspection and testing, Wafer packaging; Packaging evolution; Chip connection choices, Wire bonding, TAB and flip chip,

Schematic and Layout Design: Schematic diagram, General, Mechanical and Electrical design considerations, Placing and Mounting of components, Conductor spacing, routing guidelines, heat sinks and package density, Net list, creating components for library, Tracks, Pads, Vias, power plane, grounding.

Unit - IV
PCB design for EMC compliance: Return path discontinuities-mixed signal PCB layout, Filtering circuit placement, decoupling and bypassing, Electronic discharge protection, Thermal management Experiments Design and development of PCBs using different simulator tools and prototyping.

Suggested Readings

1. Jon Varteresian, “Fabricating Printed Circuit Boards,” Newnes.
2. R. S. Khandpur, “Printed Circuit Board Design, Fabrication Assembly and Testing,” McGraw.
3. K. Mitzner, “Complete PCB Design Using OrCad Capture and Layout,” Elsevier.
4. Walter C. Bosshart, “Making Printed Circuit Boards,” J. Axelson, McGraw.
5. Xing-Chang Wei, “Modeling and Design of Electromagnetic Compatibility for High-Speed Printer Circuit Boards and Packaging,” CRC Press.

List of Experiments (Based on Hardware/ Simulation)

The experiments in this DSE will involve the layout designing of different circuits already analyzed by students during 1st Year on CAD tools. The GDS file of the layout will be used for actual fabrication of the PCB through PCB Machine and/or Toner Transfer technique.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

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Detailed Syllabus of Discipline Specific Core (DSC) Courses for B. Tech. (ECE) – Semester 4

Signals and Systems (DSC - 10)

(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Signals and Systems	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:

- To describe various signals and systems mathematically and understand how to perform mathematical operations on them.
- Also familiar with commonly used signals such as the unit step, ramp, and impulse function, sinusoidal signals, complex exponentials and their operations.
- Analysis using Fourier series and Fourier transform for a given signal.

Course Outcomes:

After completing the course, the students should be able to:

1. Understand and analyse the mathematical modeling of various signals and systems.
2. Analyse continuous and discrete time linear time invariant systems
3. Evaluate and analyse various signals in terms of Fourier and Laplace transform.
4. Evaluate and analyse the reconstruction of signals.

Unit - I

Introduction: Basic concepts and definitions of continuous and discrete time Signals and their classification, continuous and discrete time system and their properties, elementary Signals. Linear time invariant systems response for continuous time systems and discrete time systems. Properties of continuous and discrete LTI systems. System representation through differential equations and difference equations.

Unit - II

Introduction to Fourier Transform Analysis: continuous and discrete time Fourier series and its properties, Fourier Transform for continuous and discrete time signals/system. Concept of bandwidth estimation for signal and system. Magnitude and phase spectra of continuous and discrete time signal, response of LTI system using Fourier transform. Application of Fourier transform as linear filtering.

Unit - III

The Laplace Transform. The Region of Convergence for Laplace Transforms. The Inverse Laplace Transform. Geometric Evaluation of the Fourier Transform from the Pole-Zero Plot. Properties of the Laplace Transform. Some Laplace Transform Pairs. Analysis and Characterization of LTI Systems Using the Laplace Transform. System Function Algebra and Block Diagram Representations. The Unilateral Laplace Transform.

Z-Transform: Basic principles of z-transform, z-transform definition, Relationship between z-transform and Fourier transform, Region of Convergence, Properties of ROC, Properties of z-transform, Poles and Zeros, Inverse z-transform using Contour integration, Residue Theorem, Power Series expansion and Partial fraction expansion.

Unit - IV

Sampling: Representation of continuous time signals by its sample – Types of sampling, sampling theorem, aliasing, decimation, interpolation. Reconstruction of a Signal from its samples. Mathematical Background: Representation of signals using ortho-normal basis functions. Power and Energy spectral density. Correlation functions. Hilbert Transform and its properties. Pre-envelope and Complex Envelope. Band pass signals and Band pass systems.

Suggested Readings

1. Signals and Systems by Alan V. Oppenheim (Pearson Education)
2. Signals and Systems by Simon Haykin (John Wiley and Sons)
3. Linear Systems and Signals by B. P. Lathi (Oxford Publication)
4. Fundamentals of Signal and Systems using the Web and MATLAB by Kamen (Pearson)
5. Schaum's Outline of Signals and Systems by Hwei P. Hsu (TMH)

List of Experiments (Software using MATLAB)

1. Generation of Continuous Time and Discrete Time signals.
2. Implementation of Fourier Transform and Inverse Fourier Transform.
3. Implementation of Laplace Transform and Inverse Laplace Transform.
4. Implementation of Z – Transform and Inverse Z - Transform.
5. Implementation of Digital Filter (IIR and FIR Filters)

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Electromagnetic Theory (DSC - 11)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Electromagnetic Theory	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P – 02

Course Objectives:

- To understand Maxwell's Equation and apply to the basic electromagnetic problem.
- To interpret the given problem, and solve it using Maxwell's equations.
- To analyze boundary conditions, and understand the field at the interface of two different media.
- To analyze time varying electric and magnetic fields, wave propagation in different media.
- To understand transmission line fundamentals and apply them to the basic problem.
- To understand the fundamentals of electromagnetic theory and transmission lines

Course Outcomes:
After completing the course, the students should be able to:

1. Recognize and classify the basic Electrostatic theorems and laws and to derive them.
2. Discuss the behavior of Electric fields in matter and Polarization concepts.
3. Classify the basic Magneto static theorems and laws and infer the magnetic properties of matter.
4. Summarize the concepts of electrodynamics and to derive and discuss the Maxwell's equations.
5. Students are expected to be familiar with Electromagnetic wave propagation and wave polarization.

Unit - I
Introduction to Coordinate System - Cartesian, Cylindrical and Spherical Coordinates, Electrostatic Fields: Electric field, Gauss's Law and its Applications, Electric field due to continuous charge distributions, Electric potential, an electric Dipole and flux lines, Energy density in electrostatic fields, Dielectric Materials, Polarization in Dielectrics, Dielectric Constant, Linear, Homogeneous and Isotropic Dielectric, Boundary Conditions. Poisson's Equation and Laplace's Equation: Poisson's and Laplace's equation, Uniqueness Theorem, Examples of Laplace's Equation in Cartesian, Cylindrical and Spherical Coordinates. Magnetostatics: BiotSavart's law, Ampere's Circuital Law, Magnetic Flux and Magnetic Flux Density, Scalar and Vector Magnetic Potentials, forces due to magnetic fields, Magnetic Dipole, magnetization in materials and Magnetic Boundary Conditions, Magnetic Energy.

Unit - II
Maxwell's Equations: Faraday's laws, Transformer and motional E.M.F, displacement current, Maxwell Equation in differential and integral form, constitutive relations and Boundary Conditions. Electromagnetic Wave Propagation: the wave equation, Uniform Plane Wave, Wave Polarisation, Wave propagation in Dielectrics, Poynting's theorem, Propagation in Good Conductors, Skin Effect, Reflection of uniform Plane Waves at normal incidence, Plane Wave reflection at Oblique Incidence, Wave propagation in dispersive media, concept of phase velocity and group velocity.

Unit - III
Transmission Lines: Typical Transmission lines- Co-axial, Two Wire, Microstrip, Coplanar and Slot Lines, Transmission Line Parameters, Transmission Line Equations, Wave propagation in Transmission lines, lowloss, lossless line, Distortionless line, Input Impedance, Standing Wave Ratio, Power. and lossy lines, Shorted Line, Open-Circuited Line, Matched Line, Smith Chart, Transmission Line Applications.

Unit - IV

Waveguides and Antennas: Rectangular waveguide, Field Equations for TM and TE modes, Wave Propagation in Waveguide, Propagation Characteristics, Power Transmission and Attenuation, Waveguide Current and Excitation, Rectangular Cavity Resonators, Radiation of Electromagnetic Waves and Retarded Potentials, Hertzian dipole, Types of antenna- yagi, microstrip, parabolic antenna's, Antenna characteristics.

Suggested Readings

1. Matthew N.O. Sadiku, "Principles of electromagnetics" 4th edition, Oxford university Press, 2014.
2. Hayt Jr, William H., John A. Buck, and M. Jaleel Akhtar, "Engineering Electromagnetics| (SIE)", McGraw-Hill Education, 2020.
3. Karl E. Longren, Sava V. Savov, Randy J. Jost., "Fundamentals of Electromagnetics with MATLAB", PHI (For MATLAB experiments)
4. D. C. Cheng, "Field and Wave Electromagnetics," Pearson Education (2001)
5. J. A. Edminster, "Electromagnetics," Schaum Series, Tata McGraw Hill (2006)
6. N. Narayanrao, "Elements of Engineering Electromagnetics," Pearson Education (2006)

List of Experiments (Hardware Based)

1. To study electric field pattern between two circular electrodes.
2. To study the electric field between parallel conductors.
3. To study Electric Field and Potential Inside the Parallel Plate Capacitor
4. To study Capacitance and Inductance of Transmission Lines.
5. To study Magnetic Field Outside a Straight Conductor.
6. To study Magnetic Field of Coils.
7. To study Magnetic Inductions.
8. Hertz's Experiment to demonstrate the production and reception of radio waves
9. Wireless RF Transmitter and Receiver
10. Simple AM Transmitter and Receiver.
11. Using a Slotted Waveguide study Standing Waves, Travelling Waves and find SWR for each case.
12. Given a Slotted Waveguide connected with source and voltmeter. Find practical Maximas and Minima under following load conditions (a) Short Circuit, and (b) Matched Load.

List of Experiments (Software Based using MATLAB)

1. WAP to find gradient of a scalar field.
2. WAP to find divergence of a vector field.
3. WAP to find curl of a vector field.
4. WAP to:
    a. Transform cylindrical coordinates to cartesian coordinates.
    b. Transform spherical coordinates to cartesian coordinates.
    c. Transform cartesian coordinates to cylindrical coordinates.
    d. Transform cartesian coordinates to spherical coordinates.
5. WAP to represent electric field lines due to a point charge at origin.
6. WAP to plot equipotential contours and electric field due to dipole.
7. WAP to plot magnetic flux density due to current carrying wire.
8. WAP to show that a given potential distribution satisfied Possion's Equation. Plot graphs of charge and electric potential distributions.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Linear Integrated Circuits (DSC – 12)
(Credit Distribution and Prerequisites of the Course)

<table>
<tr><th rowspan="2">Course Title</th><th rowspan="2">Credits</th><th colspan="3">Credit Distribution of the Course</th><th rowspan="2">Prerequisite of the course (if any)</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>Linear Integrated Circuits</td><td>4</td><td>3</td><td>0</td><td>1</td><td>NIL</td></tr>
</table>

Course Hours: L – 03, T – 00, P - 02

Course Objectives:

- To introduce the basic building blocks of linear integrated circuits.
- To teach the linear and non - linear applications of operational amplifiers.
- To introduce the theory and applications of analog multipliers and PLL.
- To teach the theory of ADC and DAC.
- To introduce the concepts of waveform generation and introduce some special function ICs.
- To understand and implement the working of basic digital circuits.

Course Outcomes:
After completing the course, the students should be able to:

1. Understand the internal operation of Op-Amp and its specifications.
2. Analyze and design linear applications like adder, subs tractor, instrumentation amplifier and etc. using Op-Amp.
3. Classify various active filter configurations based on frequency response and construct using 741 OpAmp.
4. Operate 555 timers in different modes like bistable, monostable and astable operations and study their applications.
5. Determine the lock range and capture range of PLL and use in various applications of communications.

Unit - I
Operational Amplifier: The ideal Op Amp, Building blocks of analog ICs: current mirrors and repeaters, current and voltage sources, differential amplifiers, input stages, active load, gain stages, output stages, level shifters, non ideal parameters, Monolithic IC operational amplifiers, specifications, slew rate and methods of improving slew rate.

Unit - II
Linear applications of IC op-amps: Inverting and non-inverting amplifier configurations, integrators, differentiators, summers, effect of infinite GBP, stability consideration, active and passive compensation of op amp. Non-Linear applications of IC op-amps: Log/ antilog modules, Precision Rectifier, Op-amp as comparator, Schmitt Trigger, Square and Triangular wave generator, mono stable and astable multivibrators.

Unit - III
Analog filter design: Basics second order functions, op-amp RC and active filter design, immittance converters and inverters, generalized impedance converter, inductance simulation, Sinusoidal oscillators, amplitude stabilization and control. Operational Transconductance Amplifier (OTA), Basic building blocks using OTA, Application examples.

Unit - IV
Analog Multiplier and its applications: Gilbert multiplier cell 2-quadrant and 4-quadrant operations, IC analog multiplier AD534, modulation, demodulation and frequency changing, voltage-controlled filters and oscillators

IC timer and phase locked loop: the IC 555 timer, operational modes, time delay, astable and monostable operations, voltage-controlled oscillators, IC PLL: basic PLL principle, three modes of operation, PLL as AM detector, FM detector, frequency synthesis, FM demodulator, PLL motor speed control and voltage to frequency converter.

Suggested Readings

1. Applications and Design with Analog Integrated Circuits by J. Michel Jacob (PHI)
2. Design with Operational Amplifiers and Analog Integrated Circuits by Sergio Franco (TMH).
3. Analysis and Design of Analog Integrated Circuits by Paul R. Gray and Robert G. Meyer (Wiley).
4. Microelectronic Circuits: Analysis and Design by M. H. Rashid (CENGAGE)
5. OP-Amps and Linear Integrated Circuits by R. A. Gayakwad (Pearson)

List of Experiments (Hardware and Software using NI Multisim)

1. To study op-amp characteristics: CMRR and Slew rate.
2. To design an amplifier of given gain for an inverting amplifier and observed its frequency response.
3. To design an amplifier of given gain for a non - inverting amplifier and observed its frequency response.
4. To design an integrator using op-amp for a given specification and stud its frequency response.
5. To design a differentiator using op-amp for a given specification and study its frequency response.
6. To study IC555 as an astable multivibrator.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Department of Electronics and Communication Engineering
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Detailed Syllabus of Discipline Specific Elective (DSE) Courses for B. Tech. (ECE) – Semester 4

Interfacing Electronics (DSE – 2)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Interfacing Electronics	4	2	0	2	NIL

Course Hours: L – 02, T – 00, P - 04

Course Objectives:
The objective of this course is to familiarize the students in Embedded System Design using Arduino and Raspberry pi.

Course Outcomes:
After completing the course, the students should be able to:
1. Understand how the Arduino platform works in terms of the physical board and libraries.
2. Understand the working of Raspberry Pi, its features and how various components can be used with Pi.
3. Program the development boards using C and use I/O pins for interfacing.

Unit - I
Embedded System design: Basics. Introduction to embedded systems, Components of embedded system. Advantages and applications of embedded systems, Examples of real time embedded systems and how they are manufactured industry ready, Different Microcontroller Architectures (CISC, RISC, ARISC), Internal Resources and Hardware Chips in Details, History of AVR Microcontrollers and Features, Memory Architectures (RAM/ROM).

Unit - II
Learning Arduino Platform: Introduction to ARDUINO, ARDUINO History and Family, General Programming and Hardware Interfacings with Arduino, The basic sensors and actuators using Arduino, Controlling embedded system based devices using Arduino.

Unit - III
Getting Started with Raspberry Pi: Basic functionality of the Raspberry Pi board and its Processor, setting and configuring the board, differentiating Raspberry Pi from other platform like arduino, begal, asus thinker etc., Overclocking, Component overview.

Unit - IV
Programming the Raspberry Pi: Introducing to Python programming language: Python Programming Environment, Python Expressions, Strings, Functions, Function Arguments, Lists, List Methods, Control Flow, Numpy, PIP (Python Installation Package) and customized libraries. Communication facilities on raspberry Pi (I2C, SPI, UART), working with RPil. GPIO library, Interfacing of Sensors and Actuators.

Suggested Readings

1. M. Margolid, "Arduino Cookbook: Recipes to begin, expand, and enhance your projects," O'Reilly Media.
2. A. N. Sloss, "ARM System Developer's Guide – Designing and Optimizing System Software," Elsevier.
3. Mark Lutz, "Learning Python," O'Reilly Media.
4. The Official Raspberry Pi Projects Book: https://www.raspberrypi.org/magpi-issues/Projects_Book_v1.pdf
5. Raspberry Pi Assembly Language RASPBIAN Beginners, 3rd Edition, CreateSpace Independent Publishing Platform.

List of Experiments (Based on Hardware/ Simulation)

1. Connect an LED to GPIO pin 24 and a Switch to GPIO 25 and control the LED with the switch. The state of LED should toggle with every press of the switch.
2. To interface DHT11 sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings.
3. To interface motor using relay with Arduino/Raspberry Pi and write a program to turn ON motor when push button is pressed.
4. To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth.
5. To interface Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when '1'/'0' is received from smartphone using Bluetooth.
6. Create a traffic light signal with three colored lights (Red, Orange and Green) with a duty cycle of 5-2-10 seconds.
7. Create an application that has three LEDs (Red, Green and white). The LEDs should follow the cycle (All Off, Red On, Green On, White On) for each clap (use sound sensor).
8. Write a program on Arduino/Raspberry Pi to upload/retrieve temperature and humidity data using ThingSpeak cloud.
9. Write a program on Arduino/Raspberry Pi to publish/subscribe temperature data using MQTT broker.
10. To install MySQL database on Raspberry Pi and perform basic SQL queries.
11. Write a program to create TCP server on Arduino/Raspberry Pi and respond with humidity data to TCP client when requested.
12. Create a web application for the above applications wherever possible with functionalities to get input and send output

In addition to above, course instructor will assign various projects to a group of students based on interfacing various types of sensors and actuators for a particular problem statement. The emphasis will be towards maximizing the practical component.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Modeling Electronic Circuits (DSE – 2)
(Credit Distribution and Prerequisites of the Course)

<table>
<tr><th rowspan="2">Course Title</th><th rowspan="2">Credits</th><th colspan="3">Credit Distribution of the Course</th><th rowspan="2">Prerequisite of the course (if any)</th></tr>
<tr><th>Lecture</th><th>Tutorial</th><th>Practical</th></tr>
<tr><td>Modeling Electronic Circuits</td><td>4</td><td>2</td><td>0</td><td>2</td><td>NIL</td></tr>
</table>

Course Hours: L – 02, T – 00, P - 04

Course Objectives:
The objective of this course is to familiarize the students in SPICE modeling of various electronic circuits.

Course Outcomes:
After completing the course, the students should be able to:
1. Model electronic devices and circuits using SPICE modeling.
2. Understand the fundamentals of SPICE simulation and modeling.
3. Perform various types of circuit analysis using SPICE.
4. Develop accurate SPICE models for semiconductor devices.
5. Apply SPICE simulation techniques to real-world circuit design and optimization.

Unit - I
Introduction to SPICE, Description of SPICE, Types of SPICE (Introduction to LTspice, PSice, and other variants), File Types, SPICE Platforms, Limitations. Writing SPICE circuit files – SPICE Directives (dot commands: .end, .FUNC, .NET, .OPTIONS, etc.).

Unit - II
DC Operation and Circuit Analysis: Modeling of elements, operating temperature, independent DC sources, dependent sources, DC Output Variables, Passive Devices, Types of Output (.PRINT, .PLOT, .PROBE, .WIDTH) statements and significances, Tyes of DC Analysis (.OP, .TF, .DC, .PARAM – parameter sweep) commands and their uses, and DC Sweep.
AC Circuit Analysis: AC Output Variables, Independent AC Sources, AC Analysis, Magnetic Elements, group delay, phase angle of voltage and current, Transfer Function Analysis.
Advanced Components and Models: Diodes, Transistors (BJT and MOSFET), Operational Amplifiers, Behavioral Modeling, Statistical Analysis for Circuit Reliability (Monte Carlo Analysis)

Unit - III
Transient Analysis: Capacitors and Inductors, Modeling of Transient Sources (Exponential Source, Pulse Source, Piecewise Linear Source, Sinusoidal Source), Independent Voltage Source, Independent Current Source, Transient Response (.IC, .TRAN, .WAVE) commands and their uses.
Transient Circuits and Laplace Transforms, Transfer Functions, Fourier Analysis (.FOUR)
Noise Analysis: total RMS noise at output node, equivalent noise at the input node (.NOISE)
Device Modeling Fundamentals: SPICE Model Parameters, BJT Model (Ebers – Moll Model, Gummel – Poon Model), Parameter Extraction and Model Fitting, MOSFET Modeling (Level 1,2, and 3, BSIM3, BSIM4, Parameter Extraction), and other semiconductor devices, Temperature Effects.

Unit - IV (12 Hours)
Developing simple circuit files for CE Amplifier, Passive Linear/ Non – Linear Circuits, Circuits with R, L, C Components, Diodes).
Developing Component Models, sub – circuits in SPICE (,model, .subckt, .lib, .inc, .ends directives). Using datasheet to develop component models – (BJTs, MOSFETs).
Subcircuit Modeling and Hierarchical Design, Mixed Signal Simulation (Co – Simulation of Analog and Digital Circuits), RF and High Frequency Simulation (S – Parameter Analysis, RF Amplifier and Oscillator Design).

Suggested Readings

1. Paul Tobin, "PSpice for Circuit Theory and Electronic Devices," Morgan and Claypool.
2. Muhammad H. Rashin, "Introduction for PSPICE Using OrCAD for Circuits and Electronics," Prentice-Hall.
3. Paul W. Tuinenga, "SPICE: A Guide to Circuit Simulation and Analysis using PSPICE," Pearson.
4. Gordon W. Roberts, Adel S. Sedra, "SPICE," Oxford.
5. Dennis Fitzpatrick, "Analog Design and Simulation using OrCAD Capture and PSPICE," Newnes.

List of Experiments (Based on Simulation)

1. Introduction to SPIC interface.
2. Simulating Basic Circuits: Ohm's Law, Voltage Dividers, RC Circuits
3. Simulation of Diode and Transistor Characteristics
4. AC Sweep Analysis of Amplifiers
5. Transient Analysis of Switching Circuits
6. BJT Model Parameter Extraction and Simulation
7. MOSFET Characterization and Model Fitting
8. Simulation of JFET and MESGET Circuits
9. Subcircuit Creation and Simulation
10. Noise Analysis of Amplifiers
11. Mixed – Signals Circuit Simulation
12. High – Frequency Circuit Design and Simulation

The experiments in this DSE will involve the modeling of different circuits already analyzed by students during 1st Year on CAD tools.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

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List of Discipline Specific Elective (DSE)/ Generic Elective (GE) courses offered for Minors/ Specializations by the Department in Second Year

1. **Minor in ECE (Offered only to CSE and EE)**
   a) DSE - 1/ GE-3: Fundamentals to Analog Electronics
   b) DSE - 2/GE-4: Introduction to Signals and Systems

2. **Minor/ Specialization in Telecommunication Networks (Offered to ECE, CSE, and EE)**
   a) DSE - 1/ GE-3: Introduction to Analog Communication
   b) DSE - 2/ GE-4: Fundamentals of Digital Communication

3. **Minor/ Specialization in VLSI Technology and System Design (Offered to ECE, CSE, and EE)**
   a) DSE - 1/ GE-3: VLSI Technology and Design
   b) DSE - 2/ GE-4: Microelectronics Design

4. **Minor/ Specialization in IoT System Design (Offered to ECE, CSE, and EE)**
   a) DSE - 1/ GE-3: Introduction to IoT
   b) DSE - 2/GE-4: Introduction to IoT System Design

5. **Minor/ Specialization in Computer Vision (Offered to ECE, CSE, and EE)**
   a) DSE - 1/ GE-3: Fundamentals of Image Processing
   b) DSE - 1/ GE-4: Image Filtering and Restoration

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Detailed Syllabus of Generic Elective (GE) courses offered for Minors/ Specializations by the Department in Semester 3

Fundamentals of Analog Electronics (DSE – 1/ GE – 3)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Fundamentals of Analog Electronics	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
- To introduce components such as diodes, BJTs and FETs.
- To know the applications of components.
- To give Understand of various types of amplifier circuits.

Course Outcomes:
After completing the course, the students should be able to:
1. Know the characteristics of various components.
2. Understand the utilization of components.
3. Design and analyse small signal amplifier circuits.

Unit - I
Introduction to Switching Devices (basic construction and IV characteristics): PN Junction Diode, Zener Diode, LED, Varactor diode, Tunnel Diode, UJT-characteristics. Photo diode, SCR, Diac, Triac
Diode Applications: Rectifiers and Filters. Linear wave shaping - High Pass and Low Pass RC circuits. RC network as differentiator and integrator. Non-linear wave shaping: Diode clippers, clipping at two independent levels, Transfer characteristics of clippers, Clamping operation, clamping circuits using diode with different inputs, Clamping circuit theorem.

Unit - II
BJT: Working, Construction, Biasing and Techniques, Input and Output Characteristics of CE, CC, CB configuration, Concept of Thermal Runaway, Base Width Modulation, and Early Voltage, Application as Switch, CE Amplifier (Transformer, RC, and Direct Coupled), Darlington Pair, Introduction to Small Signal Analysis.

Unit - III
MOSFET: MOSFET types (depletion and enhancement mode), construction, operation, characteristics, Introduction to Small Signal Analysis.

Power Amplifiers: Various classes of Power amplifiers: Class A, Class B, Class AB, Class C and Class D, power efficiency and harmonic distortion.

Unit - IV

Oscillators: Oscillator principle, condition for oscillations (barkhausen's criteria), types of oscillators, RC-phase shift and Wein bridge oscillators with BJT and their analysis, Generalized analysis of LC Oscillators, Hartley and Colpitt's oscillators with BJT and their analysis.

Reference Books

1. Electronic Devices and Circuits- J. Millman, C. Halkias, Tata Mc-Graw Hill, Fourth Edition 2015.
2. Electronic Devices and Circuits - Salivahanan, Kumar, Vallavaraj, Tata Mc-Graw Hill, Fourth Edition 2016.
3. Microelectronic Circuits – Sedra and Smith, Oxford Series
4. Introduction to PSpice Using OrCAD for Circuits and Electronics – M. H. Rashida, Pearson.
5. Electronic Devices and Circuit Theory – Robert L. Boylestad, Pearson

List of Experiments (Hardware on Breadboard / Software using NI Multisim)

1. Design clipping circuits for both positive and negative reference voltages
2. Design clamping circuits for both positive and negative reference voltages
3. Obtain the response of high pass and low pass RC circuit for various inputs
4. To study different biasing techniques of BJT.
5. Frequency Response of CE BJT Amplifier.
6. Frequency Response of Common Source FET Amplifier
7. Design and observe the working of RC-phase shift Oscillator.
8. Design and observe the working of Colpitts Oscillator.
9. Design and observe the working of Wein Bridge Oscillator.
10. Design and observe the working of Hartley and Colpitt's Oscillator.
11. Class A, Class B, Class AB Power amplifier

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Introduction to Analog Communication (DSE – 1/ GE – 3)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Introduction to Analog Communication	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
- To impart understanding of the concepts of analog communication systems.
- To impart understanding of various modulation and demodulation techniques of analog communication.
- To impart understanding of transmitters and receivers in analog communication.
- To impart understanding of the causes of noise and noise performance of analog communication.

Course Outcomes:
After completing the course, the students should be able to:
1. To understand the concepts of analog communication systems.
2. To understand various modulation and demodulation techniques of analog communication.
3. To understand transmitters and receivers in analog communication.
4. To understand the causes of noise and noise performance of analog communication.

Unit - I
Introduction to Communication systems, source of information, communication channels, base band pass band signals, representation of signals and systems, analog versus digital communication, applications of communications systems.

Unit - II
Linear modulation: Time and frequency domain expression of AM, DSB, SSB and VSB; generation of linearly modulated signals. Coherent demodulation and envelope detection. Angle modulation: Instantaneous frequency; phase and frequency modulation (PM and FM)

Unit - III
Multiplexing Techniques, radio transmitters and receivers, sampling theory (sample and hold circuits and their working, Nyquist Criteria, Bandwidth Requirements), Pulse Modulation Techniques - including PCM, PPM, PWM, DM, ADM, and its variants.

Unit - IV
Noise in Communication systems: Thermal noise, shot noise and white noise. Noise equivalent bandwidth, noise figure and noise temperature. Comparison of the noise performance of CW modulation schemes.

Suggested Readings

1. Communication System by Simon Haykin (John Wiley and Sons)
2. Communication Systems by Proakis (John Wiley and Sons)
3. Modern Analog and Digital Communication by B. P. Lathi (Oxford)
4. Electronic Communication Systems by Kennedy (TMH)
5. Principles of Communication System by Taub and Schilling (TMH)

<u>List of Experiments</u> (Hardware on Breadboard / Software using NI Multisim)

1. Study of different Sampling Techniques.
2. To study Amplitude Modulation - Modulation and Demodulation.
3. AM - DSB SC - Modulation and Demodulation.
4. Frequency Modulation - Modulation and Demodulation.
5. Sampling Theorem and its implementation.
6. Pulse Amplitude Modulation - Mod. and Demodulation.
7. To study PWM, PPM - Mod. and Demodulation.
8. To study TDM (Time Division Multiplexing).

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

VLSI Technology and Design (DSE – 1/ GE – 3)
(Credit Distribution and Prerequisites of the Course)

Course Title	**Credits**	**Credit Distribution of the Course**			**Prerequisite of the course (if any)**
		Lecture	**Tutorial**	**Practical**	
VLSI Technology and Design	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
To provide an understanding of the manufacturing methods and their underlying scientific principles in the context of technologies used for VLSI chip fabrication.

Course Outcomes:
After completing the course, the students should be able to:
1. Analyze and explain the fundamental principles of VLSI Technology, including semiconductor physics, device characteristics, and fabrication processes.
2. Design and model basic VLSI devices and circuits, demonstrating proficiency in using industry-
3. standard software tools for simulation and analysis.
4. Evaluate the performance and limitations of different VLSI devices and technologies, and make informed decisions in selecting appropriate components for specific applications.
5. Apply their knowledge of VLSI technology to contribute effectively to the design and development of integrated circuits, taking into consideration the latest advancements and challenges in the field.

Unit - I
Review of Semiconductor Fundamentals and Device Physics: Introduction to semiconductor materials and crystal structures, Intrinsic and extrinsic semiconductors, doping, and carrier concentration, PN junctions and diode characteristics (including PIN), Bipolar Junction Transistors (BJTs) and Field-Effect Transistors (FETs) principles, MOSFET operation modes and characteristics.

Unit - II
VLSI Fabrication Processes: Overview of VLSI fabrication process flow; Photolithography and patterning techniques; Oxidation, diffusion, and ion implantation processes; Thin film deposition methods: CVD, PVD; Etching techniques: wet etching, dry etching, plasma etching; Interconnect technologies and back-end processing;

Unit - III
Device Modeling and Simulation: Introduction to device modeling and its significance, SPICE (Simulation Program Emphasis) fundamentals, MOSFET modeling: Level 1, Level 2, and Level 3 models, Capacitance and delay modelling, Process variations and statistical modelling,

Unit - IV
Advanced VLSI Technologies and Trends: Introduction to advanced CMOS technologies (TFET, SOI, FD-SOI, etc.), Low-power design techniques and considerations, Introduction to semiconductor memories: SRAM, DRAM, Flash, Emerging trends in VLSI.

Suggested Readings

1. N. Weste and D. Harris, "CMOS VLSI Design: A Circuits and Systems Perspective," Addison-Wesley, 2011.
2. J. Rabaey, A. Chandrakasan, and B. Nikolic, "Digital Integrated Circuits: A Design Perspective," Pearson, 2016.
3. E. J. Rymaszewski, "Advanced CMOS Process Technology," IEEE Press, 2005
4. S. M. Sze and K. K. Ng, "Physics of Semiconductor Devices," Wiley, 2006.
5. Y. Leblebici and M. Tan, "Fundamentals of Microelectronics," McGraw-Hill, 2013.
6. J. D. Meindl and S. F. Gong, "Conduction and Breakdown in Solid Dielectrics," IEEE Press, 1993.
7. C. Liu and S. M. Kang, "Introduction to Solid State Physics," Wiley, 2015

List of Experiments
(Will be based on open-source/ Proprietary EDA tools such as Silvaco's TCAD or Synopsys Sentaurus)

1. To carry out SPICE modeling/simulation of the PN junction diode.
2. To carry out SPICE modeling/simulation of the BJT.
3. To carry out SPICE modeling/simulation of the nMOS and pMOS transistors.
4. To perform virtual fabrication of PN junction diode and characterize it under different ambient temperatures.
5. To perform virtual fabrication of BJT and characterize it under different ambient temperatures.
6. To perform virtual fabrication of MOSFET and study the impact of ambient temperatures on Input and Output characteristics.
7. To perform virtual fabrication of CMOS technology and study its application towards low power applications.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Introduction to IoT (DSE – 1/ GE – 3)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Introduction to IoT	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
- To make students know the IoT ecosystem.
- To provide an understanding of the technologies and the standards relating to the Internet of Things.
- To develop skills on IoT technical planning.

Course Outcomes:
After completing the course, the students should be able to:
1. To understand the technology and standards relating to IoTs.
2. To understand the critical ecosystem required to mainstream IoTs.
3. To acquire skills on developing their own national and enterprise level technical strategies.

Unit - I
IoT and Web Technology: The Internet of Things Today, Time for Convergence, Towards the IoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Applications, Future Internet Technologies, Infrastructure, Networks and Communication, Processes, Data Management, Security, Privacy and Trust, Device Level Energy Issues, IoT Related Standardization.

Unit - II
M2M to IoT – A Basic Perspective– Introduction, M2M Value Chains, IoT Value Chains, an emerging industrial structure for IoT, M2M to IoT-An Architectural Overview– Building an architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations.

Unit - III
IoT Architecture -State of the Art – Introduction, State of the art, Architecture Reference Model Introduction, Reference Model and architecture, IoT reference Model, IoT Reference Architecture Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views.

Unit - IV
IoT Applications for Value Creations Introduction, IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Four Aspects in your Business to Master IoT, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT for Oil and Gas Industry, Opinions on IoT Application and Value for Industry, Home Management, eHealth.

Internet of Things Privacy, Security and Governance Introduction, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, Data Aggregation for the IoT in Smart Cities.

Suggested Readings

1. Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, "Internet of Things," John Wiley and Sons.
2. Cuno Pfister, "Getting Started with the Internet of Things", Shroff Publisher/Maker Media.
3. Francis da Costa, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, A press Publications.
4. Massimo Banzi, Michael Shiloh Make: Getting Started with the Arduino, Shroff Publisher/Maker Media Publishers.
5. Nitesh Dhanjani, Abusing the Internet of Things, Shroff Publisher/O'Reilly Publisher.

List of Experiments (Hardware – Raspberry Pi based/ Software based)

1. LED Control using R Pi.
2. Potentiometer and IR sensor interfacing with R Pi.
3. Controlling actuators using R Pi.
4. DHT11 sensor data to cloud.
5. IoT based air pollution control system.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Fundamentals of Image Processing (DSE – 1/ GE – 3)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Fundamentals of Image Processing	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
- To study the image fundamentals and mathematical transforms necessary for image processing.
- To study the image enhancement techniques
- To study image restoration procedures.
- To study the image compression procedures

Course Outcomes:
After completing the course, the students should be able to:
1. Understand the basic principles of digital image processing and explain the core components of an image processing system.
2. Apply various image enhancement techniques to improve image quality and interpret the effects of different enhancement methods.
3. Implement image transformation and restoration techniques, and analyze their applications in noise reduction and image reconstruction.
4. Describe the principles of image compression, apply different compression algorithms, and evaluate their trade-offs between compression ratio and image quality.

Unit - I
Introduction to Image Processing: Introduction to digital image processing, image representation and models, human visual perception, image acquisition and sampling, color models and applications.

Unit - II
Image Enhancement: Histogram equalization, contrast stretching, spatial domain enhancement techniques (smoothing, sharpening), frequency domain enhancement (Fourier transform, filtering), adaptive and histogram specification.

Unit - III
Image Transformation and Restoration: Geometric transformations (scaling, rotation, translation), image interpolation methods, restoration models (degradation, noise), noise models (additive, multiplicative), image denoising techniques (spatial filters, median filters), image deblurring techniques.

Unit - IV
Image Compression: Lossless and lossy compression, entropy coding, Huffman coding, Run-Length Encoding (RLE), transform coding (Discrete Cosine Transform - DCT), JPEG image compression, evaluation metrics for compression.

Suggested Readings

1. R. C. Gonzalez and R. E. Woods, “Digital Image Processing”, Prentice Hall, 3rd Ed.
2. A. K. Jain, Fundamentals of Digital Image Processing, Prentice Hall.
3. S. Sridhar, Digital Image Processing, Oxford University Press.
4. R. C. Gonzalas, “Digital Image Processing using MATLAB,” McGraw Hill.

List of Experiments/ Practical (Based on MATLAB)

1. WAP to separate the 3 channels of an RGB Image.
2. WAP to demonstrate gamma correction of a Grayscale Image and observe the changes in the histogram plot.
3. WAP to demonstrate histogram equalization.
4. WAP to demonstrate image restoration of a blurred image.
5. WAP to demonstrate image segmentation based on edge discontinuity.
6. WAP to demonstrate image segmentation based on thresholding concept.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Department of Electronics and Communication Engineering
Faculty of Technology
University of Delhi

Detailed Syllabus of Generic Elective (GE) courses offered for Minors/ Specializations by the Department in Semester 4

Introduction to Signals and Systems (DSE – 2/ GE – 4)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Introduction to Signals and Systems	4	3	0	1	NIL

Course Hours: L – 03, T – 00, P - 02

Course Objectives:

- To describe various signals and systems mathematically and understand how to perform mathematical operations on them.
- Also familiar with commonly used signals such as the unit step, ramp, and impulse function, sinusoidal signals, complex exponentials and their operations.
- Analysis using Fourier transform for a given signal.

Course Outcomes:
After completing the course, the students should be able to:

1. Understand and analyse the mathematical modelling of various signals and systems.
2. Analyse continuous and discrete time linear time invariant systems
3. Evaluate and analyse various signals in terms of Fourier and Laplace transform.
4. Evaluate and analyse the reconstruction of signals.

Unit - I
Introduction: Basic concepts and definitions of continuous and discrete time Signals and their classification, continuous and discrete time system and their properties, elementary Signals. Linear time invariant systems response for continuous time systems and discrete time systems. Properties of continuous and discrete LTI systems. System representation through differential equations and difference equations.

Unit - II
Introduction to Fourier Transform Analysis: continuous and discrete time Fourier series and its properties, Fourier Transform for continuous and discrete time signals/system. Magnitude and phase spectra of continuous and discrete time signal, response of LTI system using Fourier transform.

Unit - III
The Laplace Transform. The Region of Convergence for Laplace Transforms. The Inverse Laplace Transform. Geometric Evaluation of the Fourier Transform from the Pole-Zero Plot. Properties of the Laplace Transform. Some Laplace Transform Pairs. Analysis and Characterization of LTI Systems Using the Laplace Transform.

Unit - IV
Z-Transform: Basic principles of z-transform, z-transform definition, Relationship between z-transform and Fourier transform, Region of Convergence, Properties of ROC, Properties of z-transform, Poles and Zeros, Inverse z-transform using Contour integration, Residue Theorem, Power Series expansion and Partial fraction expansion.

Suggested Readings

1. Signals and Systems by Alan V. Oppenheim (Pearson Education)
2. Signals and Systems by Simon Haykin (John Wiley and Sons)
3. Linear Systems and Signals by B. P. Lathi (Oxford Publication)
4. Fundamentals of Signal and Systems using the Web and MATLAB by Kamen (Pearson)
5. Schaum's Outline of Signals and Systems by Hwei P. Hsu (TMH)

List of Experiments (Software using MATLAB)

1. Generation of Continuous Time and Discrete Time signals.
2. Implementation of Fourier Transform and Inverse Fourier Transform.
3. Implementation of Laplace Transform and Inverse Laplace Transform.
4. Implementation of Z – Transform and Inverse Z - Transform.
5. Implementation of Digital Filter (IIR and FIR Filters)

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Fundamentals of Digital Communication (DSE – 2/ GE – 4)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Fundamentals of Digital Communication	4	3	0	1	Introduction to Analog Communication

Course Hours: L – 03, T – 00, P - 02

Course Objectives:

- To understand importance of information theory in digital communication and various PCM Modulation
- To understand the variance basic concepts of digital communication.
- To understand the various digital Modulation-demodulation techniques.
- To understand various coding in digital communications.

Course Outcomes:
After completing the course, the students should be able to:

1. To understand the channel information carrying capacity and conversion of analog to digital signals.
2. To understand the effect of additive white Gaussian Noise on digital communication modulation techniques.
3. To analyse the effect of inter symbol interference as the source of channel impairment and the effect of multipath phenomenon.
4. To use and design communication systems for reliable communication.

Unit - I
Analog Pulse Modulation: Generation and Demodulation of Pulse Amplitude Modulation, Pulse Width Modulation, PCM and DPCM, PAM/TDM System, Spectra of Pulse Modulated Signals, SNR Calculations for Pulse Modulation Systems.

Unit - II
Digital modulation schemes: Coherent Binary Schemes: ASK, FSK, PSK. Coherent M-ary Schemes, Non-Coherent Schemes, Calculation of Average Probability of Error for Different Modulation Schemes, Power Spectra of Digitally Modulated Signals.
A discussion on various Modulation Schemes used in various standards such as GSM, IS-95, IS-56, CDMA.

Unit - III
Information Theory: Discrete messages, concept of amount of information and its properties. Average information, Entropy and its properties. Information rate, Mutual information and its properties. Source Coding: Introductions, Advantages, Shannon's theorem, Shanon-Fano coding, Huffman coding, efficiency calculations.

Unit - IV
Linear Block Codes: Introduction, Matrix description of Linear Block codes, Error detection and error correction capabilities of linear block codes, Hamming codes, Binary cyclic codes, Algebraic structure, encoding, syndrome calculation, BCH Codes.
Detection and Estimation: Review of Gaussian Random Process, Detection of Known Signals in Noise, Optimum Threshold Detection.

Suggested Readings

1. Digital Communication Systems by Simon Haykin; John Wiley and Sons.
2. Modern Digital and Analog Communication, 3rd Edition by B.P. Lathi (Oxford University Press)
3. Digital Communication by Sklar (Pearson)
4. Digital Communications by John G. Proakis (TMH)
5. Principles of Communication Systems by H. Taub and Schilling (TMH)

List of Experiments (Hardware on Breadboard / Software using NI Multisim/ MATLAB)

1. Study of PAM/PPM/PWM and Demodulation.
2. Study of an ASK and Demodulation.
3. Study of a PSK and Demodulation.
4. Study of FSK and Demodulation.
5. Study of Pulse Code Modulation
6. Study of Delta Modulation
7. Study of Adaptive Delta Modulation
8. Study of Companding
9. Source Encoder and Decoder
10. Linear Block Code-Encoder and Decoder
11. Binary Cyclic Code– Encoder and Decoder
12. Convolution Code– Encoder and Decoder

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Microelectronics Design (DSE – 2/ GE – 4)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Microelectronics Design	4	3	0	1	VLSI Technology and Design

Course Hours: L – 03, T – 00, P - 02

Course Objectives:

- To understand device structure and properties of NMOMS, PMOS, and CMOS.
- To understand static and switching characteristics of CMOS Inverter.
- To design the CMOS based combinational and sequential circuits.
- To understand the concept of hierarchy, regularity, modularity, and locality.

Course Outcomes:
After completing the course, the students should be able to:

1. Characterize IC Technology.
2. Characterize Switching characteristics and Inter Connect Effects.
3. Design the CMOS based combinational and sequential circuits.
4. Perform gate level minimization and design various logic Gates.

Unit - I
Introduction: Introduction to IC Technology – MOS, PMOS, NMOS, CMOS and BiCMOS. Technologies: oxidation, lithography, diffusion, ion implantation, metallization, encapsulation, probe testing, integrated resistors and capacitors. VLSI design flow, MOS transistor theory- MOS structure, enhancement and depletion transistor, threshold voltage, MOS device design equations, CMOS inverter- DC characteristics, static load MOS inverter, pull up/ pull down ratio, static and dynamic power dissipation, CMOS and NMOS process technology – explanation of different stages in fabrication, latch up, BiCMOS circuits and their characteristics.

Unit - II
Switching characteristics and inter connection effects: Rise time, fall time delays inverter design with delay constants, parasitic effect, super buffer. Clocked CMOS logic, pass transistor logic, domino, zipper CMOS, clocking strategies, clocked system, latches and registers, system timing set-up and hold timing, signal phase memory structure, 2 phase clocking, two phase memory structure.

Unit - III
Two phase logic structure, four phase memory and logic structure, design hierarchy, concept of regularity, modularity and locality, VLSI design style, design quality, computer aided design technology, design capture and verification tools. VLSI CIRCUIT DESIGN PROCESSES: MOS layers, stick diagrams, design rules and layout, CMOS design rules for wires, contacts, and transistors layout diagrams for NMOS and CMOS inverters and Gates, scaling of MOS circuits, limitations of scaling.

Unit - IV

GATE LEVEL DESIGN: basic circuit concepts, sheet resistance Rs and its concept to MOS, area capacitance units, delays, driving large capacitive loads, wiring capacitances, Fan in and fan out, typical NAND, NOR, delays, transistor sizing XOR, and XNOR gates, CMOS logic structures, CMOS complimentary logic, Pseudo NMOS logic. CMOS testing: CMOS testing, need for testing, test principles, design strategies for test, chip level test techniques, system level test techniques, layout design for improved testability.

Suggested Readings

1. Essentials of VLSI circuits and systems- Kamran Eshraghian, Dougles A. Picknell, and Sholeh Eshraghian, PHI, 2005
2. Principles of CMOS VLSI Design: A Systems Perspective –Neil H.E. West and Kamran Eshraghian, Pearson education, 1999.
3. CMOS VLSI Design: A Circuits and Systems Perspective, Neil H. E. Weste and David Money Harris, Addison-Wesley (Pearson), 2011
4. VLSI Design, Debaprasad Das, Oxford University Press, 2015

List of Experiments

1. Input and Output characteristics of NMOS transistor.
2. Input and Output characteristics of PMOS transistor.
3. Input and Output characteristics of CMOS transistor.
4. Input and Output characteristics of BiCMOS transistor.
5. To understand the static and switching characteristics CMOS inverter. To measure propagation delay of CMOS circuit.
6. Design of Transmission Gate using CMOS
7. Design of NAND and NOR Gate using CMOS
8. Design of XOR and XNOR Gate using CMOS
9. Ring Oscillator using CMOS.
10. Observe pseudo NMOS logic.
11. Compute Fan In and Fan Out metrics.
12. To prepare layout for given logic function and verify it with simulations.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Introduction to IoT System Design (DSE – 2/ GE – 4)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Introduction to IoT System Design	4	3	0	1	Introduction to IoT

Course Hours: L – 03, T – 00, P - 02

Course Objectives:

- The focus of this introductory course would be "the smart sensor node" with emphasis on design, requirement, data interfacing and capabilities.
- Outline toe various IoT communication models and terminologies with networking and protocol considerations.

Course Outcomes:

After completing the course, the students should be able to:

1. Understand the working of different IoT communication models.
2. Understand the interfacing and communication of different sensors and actuators.
3. Innovate solutions for real – life problems through IoT.
4. Make right choice of hardware, software and protocols for the desired application.

Unit - I

Introduction to IOT (People Connecting to Things, Things Connecting to Things, Definition of IOT, History of IOT), IOT Components (Sensors and Actuators, Things, Communications Networks, The Internet, Protocol Stack), IOT Communication Models, IOT Applications, IOT Companies, Baseline Technologies (Machine to Machine(M2M)Communication, Web of Things (WOT)), Address Crunch in IOT, IOT Terminologies (IOT Node, LAN, MAN and WAN, IOT Gateway and Proxy), IOT Network Configuration (Gateway Prefix Allotment, Impact of Mobility on Addressing, Concept of Tunneling Multi homing), IPv4 Versus IPv6.

Unit - II

Introduction to IOT Networking, Networking Standards and Technologies (Network Access and Physical Layer, Internet Layer, Transport Layer, The application layer), IOT Networking Protocols, Network Access and Physical layer IoT Network Technologies ((LPWAN (Low Power Wide Area Network), Cellular, Bluetooth Low Energy (BLE), RFID, NFC, Zigbee, Wifi, Ethernet), Internet layer IoT network technologies (IPv6, 6LoWPAN, and RPL), Application layer IoT network technologies (HTTP, HTTPS, MQTT, AMQP, and XMPP), IoT networking considerations and challenges, IoT Platforms Capabilities.

Unit - III

Introduction to Arduino (Different Arduino boards, Arduino Uno board description and its pin configuration, Arduino IDE and program uploading, different functions related to GPIOs and special functions (PWM and Serial communication), Interrupts, Introduction to NodeMcu (board description and pin configuration), Integration of NodeMcu in Arduino IDE, Interfacing with Arduino/NodeMcu using processing language (LED, Switch, Seven Segment, LCD, DC Motor, Relay, IR, LDR and DHT11 sensor), use of simulator and compiler, Configuring Node Mcu as Wi fi Module (ESP8266).

Unit - IV

Basics of HTML programming (elements, attributes, paragraph, image etc), CSS, Tables and Forms, Creating local server and webserver using Node Mcu, Creating a Web page to control actuator Wi fi, Introduction to Thing speak Cloud Platform (creating account and configure channel for live data feed, Concept of Write and Read APIs), Case Studies: Controlling an actuator connected to Node Mcu using remote web interface via cloud, Visualization of sensor data on the cloud and integrate them onto the webpage, Introduction to IFTTT and Ada fruit IO (creating account and configuration), Controlling home appliances using Google Assistant AI application via IFTTT and Adafruit I/O (MQTT protocol).

Suggested Readings

1. Internet of Things: A Hands-on Approach by Arshdeep Bahga and Vijay Madisetti (University Press)
2. The Internet of Things: Enabling Technologies, Platforms, and Use Cases by Pethuru Raj and Anupama C. Raman (TandF – CRC Press)
3. Shriram K Vasudevan, Abhishek S Nagarajan, RMD Sundaram, "Internet of Things," John Wiley and Sons.
4. Cuno Pfister, "Getting Started with the Internet of Things", Shroff Publisher/Maker Media.

<u>List of Experiments</u> (Hardware based – Arduino Uno)

1. Interfacing of Arduino Uno with LED.
2. Interfacing of Arduino Uno with DC Motor.
3. Interfacing and Application of various sensors using Arduino Uno.
4. Configuring and Interfacing of Wi-Fi module with Arduino Uno.
5. Interfacing of Bluetooth Module with Arduino Uno and Application.
6. Interfacing of ZigBee module with Arduino Uno and Applications.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)

Image Filtering and Restoration (DSE – 2/ GE – 4)
(Credit Distribution and Prerequisites of the Course)

Course Title	Credits	Credit Distribution of the Course			Prerequisite of the course (if any)
		Lecture	Tutorial	Practical	
Image Filtering and Restoration	4	3	0	1	Fundamentals of Image Processing

Course Hours: L – 03, T – 00, P - 02

Course Objectives:
- To study image enhancement techniques.
- To study image restoration procedures.
- To study the various transformation techniques used for filtering and restoration.

Course Outcomes:
After completing the course, the students should be able to:
1. Understand the basic concepts of image filtering and restoration techniques.
2. Analyze different types of noise and artifacts present in images.
3. Apply various image filtering techniques to enhance image quality.
4. Implement image restoration algorithms to recover degraded images.

Unit - I
Fundamentals of Image Filtering and Restoration: Introduction to image processing, image enhancement vs. image restoration, image degradation processes, noise models, point processing techniques, spatial domain vs. frequency domain methods.

Unit - II
Image Filtering Techniques: Convolution and correlation, linear and nonlinear filters, mean and order statistics filters, Gaussian and adaptive filters, edge enhancement filters, morphological filters, filter design and analysis.

Unit - III
Noise Reduction and Restoration: Noise reduction methods, types of noise (additive, multiplicative, impulse), spatial domain noise reduction filters (median, adaptive median, Wiener), frequency domain noise reduction (FFT-based filtering), restoration process overview, inverse filtering, least squares filtering, constrained least squares filtering.

Unit - IV
Advanced Restoration Techniques: Blind deconvolution, Wiener deconvolution, regularization methods (Tikhonov, total variation), image denoising algorithms (BM3D, wavelet denoising), image inpainting, super resolution techniques, case studies in image restoration.

Suggested Readings

1. R. C. Gonzalez and R. E. Woods, "Digital Image Processing", Prentice Hall, 3rd Ed.
2. A. K. Jain, Fundamentals of Digital Image Processing, Prentice Hall.
3. S. Sridhar, Digital Image Processing, Oxford University Press.
4. R. C. Gonzalas, "Digital Image Processing using MATLAB," McGraw Hill.
5. W. K. Pratt, "Digital Image Processing," Wiley

List of Experiments/ Practical (Based on MATLAB)

1. Study the histogram plot of different noise sources added to a standard image.
2. DFT analysis of Images.
3. Intensity transformation of Images.
4. Histogram Processing and Thresholding techniques.
5. WAP to implement spatial filtering (image enhancement).
6. WAP to implement filtering in frequency domain (image enhancement).
7. WAP to restore a noisy image.

(Note: Course instructor may add/delete/update new experiments in addition to the above suggested practical exercises.)