Course Curriculum

(Course Structure and Syllabi)

for

Bachelor of Technology

in

Electrical Engineering

(Second Year Onwards)

Department of Electrical Engineering

National Institute of Technology

Hamirpur (H.P) – 177 005 (India)

Curriculum for B Tech Programme

Course No.	Semester 3	Credits	Course Type
BS/Engg	Basic Sciences	3	Discipline core
	Engineering Courses	14	Discipline core
	Engineering Course (Lab)	2	Discipline core
Discipline Workshop	Basic Engineering Skills	1	Discipline core
	Total		**20**

Course No.	Semester 4	Credits	Course Type
	Engineering Course	13	Discipline core
	Engineering Course	3	Discipline Elective
	Engineering Course (Lab)	3	Discipline core
	LA/CA	1	Institute Elective
	Total	**20**	

Curriculum for B Tech Programme

Second Year													
3rd Semester							4th Semester						
SN	Code	Subject	L	T	P	C	SN	Code	Subject	L	T	P	C
1	EE-211	Linear System Analysis and Transforms	3			3	1	EE-221	Transformers and DC Machines	3			3
2	EE-212	Network Analysis & Synthesis	3	1		4	2	EE-222	Elements of Power System	3	1		4
3	EE-213	Applied Electromagnetic Field Theory	3			3	3	EE-223	Microprocessors & Microcontrollers	3			3
4	EE-214	Measurements & Instrumentation	3			3	4	EE-224	Power Electronics	3			3
5	EE-215	Analog & Digital Electronics	3	1		4	5	EE-225	Electrical Machines Lab-I			2	1
6	EE-216	Measurements & Instrumentation Lab			2	1	6	EE-226	Microprocessors & Microcontroller Lab			2	1
7	EE-217	Analog & Digital Electronics Lab			2	1	7	EE-227	Power Electronics Lab			2	1
8	EE-218	Workshop Practice for Electrical Engineering			2	1	8	EE-241/242/243/244	Discipline Elective (I)	3			3
							9	SA-201 to SA-209	LA/CA (NSS/NCC/Prayas etc)				1
		Total =				20			Total =				20

Curriculum for B Tech Programme

Discipline Elective (I)

1. (EE-241) Neural Networks and Fuzzy Logic
2. (EE-242) Data Structures & Algorithms in Python
3. (EE-243) Internet of Things
4. (EE-244) Optimization Techniques

Curriculum for B Tech Programme

Course No.	Semester 5	Credits	Course Type
	Open Elective	3	Institute Electives
	Engineering Course	**12/10**	Discipline core
	Engineering Course	3	Discipline Elective
	Engineering Course (Lab)	2	Discipline core
	HSS Course (**Non Circuital branches**)	**0/2**	Institute Core
	Total	**20**	
Course No.	**Semester 6**	**Credits**	**Course Type**
	Engineering Course	**10/8**	Discipline Core
	Engineering Course	6	Discipline Elective
	Engineering Course	2	Stream Core
	Engineering Course (Lab)	2	Discipline Core
	HSS Course **(Circuital branches)**	**0/2**	Institute Core
	Total	**20**	

Curriculum for B Tech Programme

Third Year													
5th Semester							6th Semester						
S.No	**Code**	**Subject**	**L**	**T**	**P**	**C**	**S.No**	**Code**	**Subject**	**L**	**T**	**P**	**C**
1	EE-311	Induction & Synchronous Machines	3			3	1	EE-321	Transducers & Signal Conditioning	3			3
2	EE-312	Power System Protection	3			3	2	EE-322	Digital Signal Processing	3	1		4
3	EE-313	Methods of Signal & System Analysis	3			3	3	EE-323	Power System Analysis	3			3
4	EE-314	Linear Control Systems	3			3	4	EE-324	Transducers & Signal Conditioning Lab			2	1
5	EE-315	Induction & Synchronous Machines Lab			2	1	5	EE-325	Power System Simulation Lab			2	1
6	EE-316	Power System Protection Lab			2	1	6	EE-341/342/343/344/345	Discipline Elective (III)	2			2
7	EE-317	Control Engineering Lab			2	1	7	EE-361/362/363/364	Discipline Elective (IV)	2			2
8	EE-351/352/353/354	Discipline Elective (II)	2			2	8	EE-381/382/383	Stream Core -I	2			2
9	EE-301/302/303/304/305/306/307	Open Elective	3			3	9	HS-321	HSS course	2			2
		Total =				**20**			**Total =**				20

Curriculum for B Tech Programme

Discipline Elective (II)

1. (EE-351) Utilization of Electrical Energy & Illumination
2. (EE-352) Non-Conventional Energy
3. (EE-353) Advance Topics in Electrical Insulations
4. (EE-354) Energy Auditing and Management

Discipline Elective (IV)

1. (EE-361) Embedded Systems
2. (EE-362) Biomedical Instrumentation
3. (EE-363) Probability Random Variables and Stochastic Processes
4. (EE-364) Reliability Engineering

Open Elective

1. (EE-301) Fundamentals of Control System
2. (EE-302) Neural Networks and Fuzzy Logic Systems
3. (EE-303) Electrical Machines & Drives
4. (EE-304) Sensors & Transducers
5. (EE-305) Renewable Energy Sources

Stream Core-I

1. (EE-381) Smart Grid Technologies
2. (EE-382) Industrial Electronics
3. (EE-383) Digital Control Systems

Discipline Elective (III)

1. (EE-341) Hydropower System Design
2. (EE-342) Deregulation of Power System
3. (EE-343) Flexible AC Transmission Systems
4. (EE-344) Electric Drives & Transportation systems
5. (EE-345) Electrical Machine Design

Curriculum for B Tech Programme

Course No.	Semester 7	Credits	Course Type
	Engineering Course	9	Discipline Core
	Engineering Course	3	Discipline Elective
	Engineering Course	4	Stream Core
	Engineering Course (Lab)	2	Discipline Core
Vocational Training	Engineering Course	2	Discipline Core
	Total	**20**	

Course No.	Semester 8	Credits	Course Type
	UG Project*	12/12	Discipline elective
	Free Elective/Engineering Course/Open Elective Course (Courses available in other departments in the even semester)	**6**	Free Electives/Stream Elective (offered by Department/Institute Elective (Open Elective)
General Proficiency	Holistic Assessment	2	Institute Core
	Total	**20**	

* (Students **opting for internship** will **complete the UG project** and the remaining credit requirements will be by fulfilled by opting **Free Elective Courses)**

Curriculum for B Tech Programme

Fourth Year													
7th Semester							8th Semester						
SN	Code	Subject	L	T	P	C	SN	Code	Subject	L	T	P	C
1	EE-411	Communication Systems	3			3	1	EE-461/462/463/464/465/466/467	Stream Electives-I	3			3
2	EE-412	High Voltage Engineering	3			3	2	EE-481/482/483/484/485/486/487	Stream Electives-II	3			3
3	EE-413	Modern Control Systems	3			3	3	EE-498	Holistic Assessment				2
4	EE-414	Simulation Lab			2	1	4	EE-499	UG Project				12
5	EE-415	High Voltage Engineering Lab			2	1							
6	EE-431/432/433/434/435	Discipline Elective (V)	3			3							
7	EE-451/452/453	Stream Core-II	2			2							
8	EE-471/472/473	Stream Core-III	2			2							
9	EE-419	Vocational Training*				2							
		Total =				20			Total =				20

Curriculum for B Tech Programme

Discipline Elective (V)

1. (EE-431) Transformer Engineering
2. (EE-432) Distributed Generation & Microgrid
3. (EE-433) Process Modelling and Control
4. (EE-434) Image Processing
5. (EE-435) Power Quality and Harmonics

Stream Core-II

1. (EE-451) Power System Dispatch and Control
2. (EE-452) Optimal Control Theory
3. (EE-453) Hybrid Electric Vehicles

Stream Core-III

1. (EE-471) Electrical Safety & Standards
2. (EE-472) Modelling & Analysis of Electrical Machines
3. (EE-473) Robust Control System

Stream Elective-I

1. (EE-461) Time frequency Analysis and Wavelet Transforms
2. (EE-462) Distributed System and Grid Integration
3. (EE-463) Control System Design
4. (EE-464) Switched Mode Power Supply
5. (EE-465) Special Electrical Machines
6. (EE-466) Over Voltages and Transients
7. (EE-467) Electrical Distribution System Analysis

Stream Elective-II

1. (EE-481) Computer Control of Industrial Processes
2. (EE-482) Bio Signal Processing
3. (EE-483) Vehicular Power System
4. (EE-484) Intelligent Robotic Control
5. (EE-485) Soft computing
6. (EE-486) System Identification & Parameter Estimation
7. (EE-487) High Voltage DC Transmission

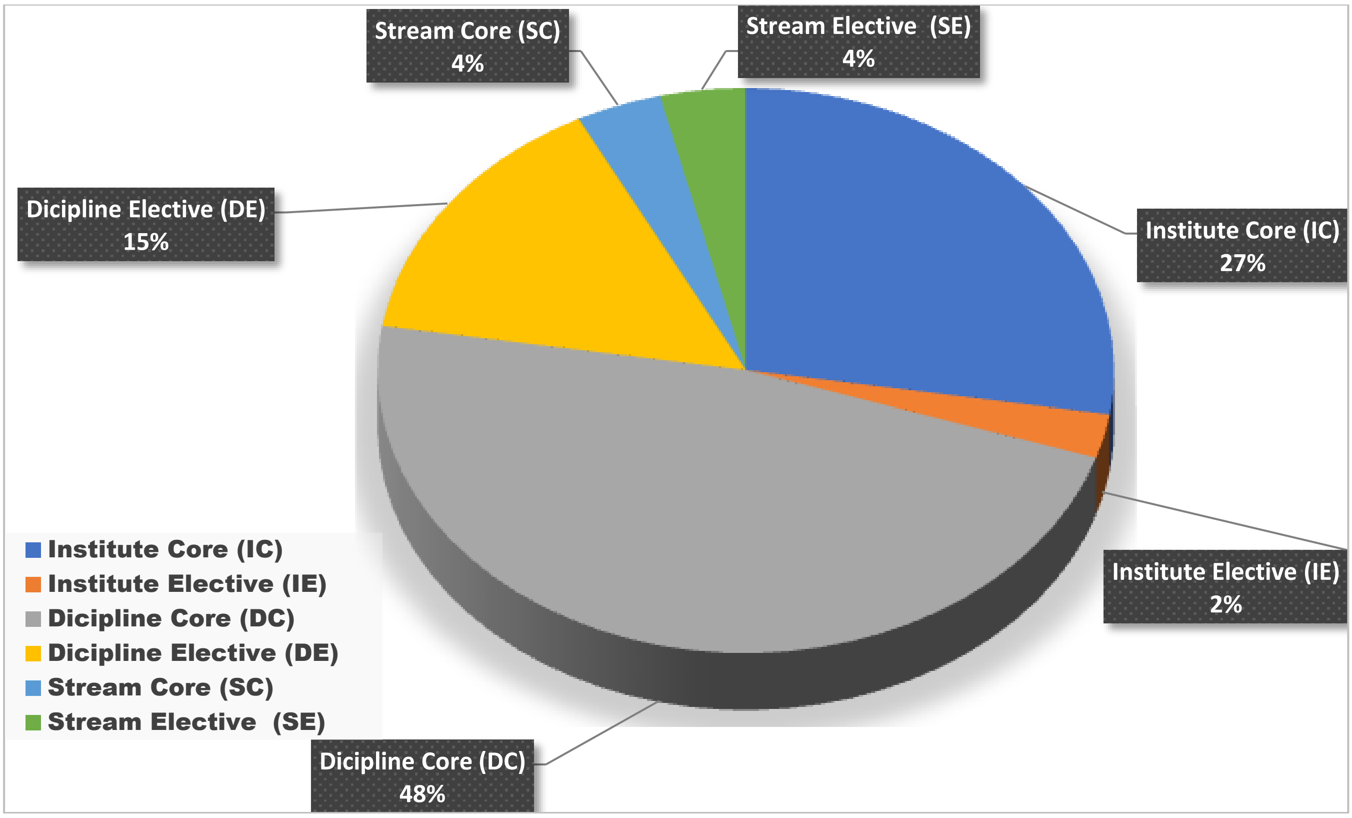
Types of Courses and credits in each Semester

	Semester								
Types of Courses	1st	2nd	3rd	4th	5th	6th	7th	8th	Total
IC	20	20	0	0	0/2	0/2	0	2	44
IE	0	0	0	1	3	0	0	6*	4-10*
DC	0	0	20	16	(15) 14/12	(12) 12/10	13	0	76
DE	0	0	0	3	2	4	3	12	24
SC	0	0	0	0	0	2	4	0	6
SE	0	0	0	0	0	0	0	6*	0-6*
Total	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**160**
Total									**160**

* Students are free to choose any combination out of Free Electives, IE and SE for 6 credits

Course Name: **Linear System Analysis and Transforms**	
Course Code: **EE-211**	
Course Type: **Discipline Core**	

Share of Credits based on the Requirement of the Programme



Contact Hours/Week: 3L		Course Credits: 03

Course Objectives

- To develop an understanding of signals, systems, and their properties.
- To describe the methods for computing the response of LTI systems.
- To develop an ability to carry out frequency analysis of continuous and discrete- time signals.
- To introduce the concept of linear filtering and explain the importance of frequency domain analysis.

Unit Number	Course Content	Contact Hours
UNIT-01	**From Euclid to Hilbert:** Vector Spaces-Definition and Properties, Inner Product, Norm, Lengths and Distances Angles, Standard Spaces, Hilbert Spaces, Convergence, Completeness, Linear Operators, Approximations, Projections, and Decompositions, Projection Theorem, Projection Operators, Direct Sums and Subspace Decompositions, LS approximations, Systems of Linear Equations, Matrices Solving Systems of Linear Equations, Linear Independence, Rank Linear Mappings Affine Spaces, Minimum Mean-Squared Error Estimation, Bases and Frames, Bases and Riesz Bases, Orthogonality, Orthonormal Bases, Biorthogonal Pairs of Bases, Frames, Matrix Representations of Vectors and Linear Operators, Orthogonal Complement Inner Product of Functions Orthogonal Projections Rotations Matrix Decompositions Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition Eigen decomposition and Diagonalization Singular Value Decomposition Matrix Approximation, Special matrices.	**9**
UNIT-02	**Signals and Systems:** Continuous Time and Discrete Time Signals, Periodic Signals, Energy and Power Signal, Transformer of Independent Variables, Even and Odd Signals, Exponential and Sinusoidal Signal, Unit Impulse and Unit Step Functions, Interconnections of Systems, Systems with and Without Memory, Causality, Stability, Linearity and Time Invariance.	**4**
UNIT-03	**Time Domain Analysis of Continuous and Discrete Time Systems:** Linear Time Invariant systems, Convolution Continuous Time Unit Impulse Response and Convolution Integral Representation of LTI Systems, Properties of LTI Systems, Stability, Causal LTI System Described by Difference Equation, Singularity Functions.	**4**
UNIT-04	**Continuous-Time Signal Analysis - Fourier Series & Fourier Transform:** Fourier series representation for continuous time periodic signals, convergence, and properties of continuous time Fourier series, convergence of Fourier transform, Fourier Transform for periodic, properties of continuous time Fourier transform, convolution and multiplication properties systems described by linear constant coefficient different equations.	**8**
UNIT-05	**Sampling:** Sampling theorem, sampling with zero order hold reconstruction of a signal from its samples, aliasing, sampling of discrete time signals, decimation, and interpolation.	**3**
UNIT-06	**Continuous and Discrete-Time System Analysis:** Laplace Transform and its properties, solution of Differential and Integral-Differential	**8**

	Equations, Block Diagram, System Realization, Bilateral Laplace Transform, Z-Transform, inverse Z-transform, Properties of Z-transform, Solution of Difference Equations.	

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Demonstrate and explain the properties of signals and systems.

CO2: Find out the response of a LTI system for an arbitrary input.

CO3: Evaluate Z-transform and Laplace transform.

CO4: Evaluate Fourier series/Transform for a given continuous-time signal.

Textbooks

1. Signals and Systems by A.V. Oppenheim, A. S. Willsky and Hamid Nawab, PHI Publication
2. Digital Signal Processing by J. G. Proakis and D. G. Manolakis, PHI Publication.
3. Digital Signal Processing: A computer-based Approach by Sanjit K Mitra, Tata McGraw Hill.

Reference books

1. Signals and Systems by Simon Haykin and Barry Van Veen, Wiley Publication.
2. Signal Processing and Linear Systems by B.P. Lathi, Oxford University Press.

Course Name: **Network Analysis and Synthesis**
Course Code: **EE-212**
Course Type: **Discipline Core**

Contact Hours/Week: 3L+1T **Course Credits: 04**

Course Objectives

- To impart knowledge about transient response of R-L-C for DC and sinusoidal excitation.
- To learn the network analysis using graph theory
- To enable the students to understand the significance and practical aspects of network functions and two port networks.
- To introduce the fundamental concepts of Network realizability and synthesis of filters

Unit Number	Course Content	Contact Hours
UNIT-01	**Transient analysis of Electrical and Magnetic Circuits:** Review of Methods of Circuits analysis, Laplace transform, Transient Analysis of Networks: Transient response of R-L-C for DC and sinusoidal excitation, Initial condition, Solution using differential equation approach, Self-inductance, Coefficient of coupling, dot convention analysis of coupled circuits, analysis of single tuned and double tuned circuits.	**6**
UNIT-02	**Network Topology:** Definition, Graph, Tree, Basic cut-set and tie-set matrices for planer networks-loop and nodal method of analysis of networks with independent and dependent Voltage And current source, Duality And dual networks.	**5**
UNIT-03	**Network Functions:** Introduction, driving point and transfer functions, poles and zeros and their significance, network functions for one port and two port networks, time domain behaviour from the pole-zero plot.	**5**
UNIT-04	**Two-Port Network:** Introduction, different parameters and relationship between different parameters, inter-connections of two port networks, open circuit and short-circuit impedances and ABCD constants, image impedance, image parameters.	**6**
UNIT-05	**Elements of Network Synthesis:** Network realizability, Hurwitz Polynomials, Positive real functions, Properties of RC, RL and LC networks, Foster and Cauer forms of realization.	**6**
UNIT-06	**Filters Synthesis:** Classification of filters, characteristics impedance and propagation constant of pure reactive network, Ladder network, T section, π section, terminating half section, Low pass, High pass, Band pass & Band reject filter design concepts, Design of constant-K, m derived filters, Composite filters, Butterworth and Chebyshev approximations, Normalized specifications, Frequency transformations, Frequency and impedance denormalization, Types of frequency selective filters, Linear phase filters, Overview of Op-Amp, active filter concept.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the response of DC and AC excitation to different network elements and their combination.
CO2: Apply variety of two-port parameters for easier analysis of circuits.
CO3: Synthesize and realize Networks using Foster and Causer forms.
CO4: Design Active and passive frequency selective filters.

Textbooks

1. Fundamental of Electric Circuits by Charles K Alexander and Matthew N. O. Sadiku, TMH Publication.
2. Circuit Analysis with Computer Applications to Problem Solving by Someshwar C. Gupta, Jon W. Bayless, Behrouz Peikar, Wiley- Eastern Ltd., 1991.
3. Network Analysis and Synthesis by L. Weinberg, McGraw Hill Book Company Inc., 1962.
4. Network Theory and Filter Design by Vasudev K. Aartre, Wiley- Eastern Ltd., Second Edition, 1993.

Reference Books

1. Network Analysis and Synthesis by Franklin F. Kuo, John Wiley.
2. Network Analysis by Van Valkenburg, Prentice Hall of India Pvt. Ltd., New Delhi, 1994.
3. Active and Passive Analog Filter Design by Lawrence P. Huelsman, McGraw Hill, 1993.

Course Name:**Applied Electromagnetic Field Theory** Course Code: **EE-213** Course Type: **Discipline Core**		
Contact Hours/Week: 3L		**Course Credits: 03**
Course Objectives • To acquire the basic knowledge of Electromagnetic field theory, that allows the student to have a solid theoretical foundation for learning operation of various electrical systems. • To formulate and solve the electromagnetic fields and waves propagation-based problems. • To provide the students with a solid foundation fundamental required to solve engineering problems.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction:** Review of vector analysis: scalar and vector products, gradient, divergent and curl of a vector and their physical explanation; Transformation amongst rectangular, cylindrical, and spherical coordinate systems.	**6**
UNIT-02	**Electrostatics and Magnetostatics:** Coulomb's law; Electric field intensity from point charges and continuous distribution of charges; Gauss's law; Electric displacement and displacement density potential function, potential field of a point charge; Laplace's, and Poison's equations. Magnetic field intensity and magneto motive force; Ampere's circuit law; Biot-Savart law; Energy stored; Vector potential; Magnetic dipole.	**8**
UNIT-03	**Time Dependent Fields:** Ampere's circuit law in differential vector form; Continuity of currents; Conduction and displacement currents. Maxwell's equations and their interpretations, boundary conditions. Wave equations: sinusoidal time varying fields, uniform plane wave in dielectric and conductor media, skin effect and depth of penetration, reflection, and refraction of plane waves at boundaries for normal and oblique incidence surface impedance.	**8**
UNIT-04	**Energy Flow and Poynting Vector:** Poynting's theorem and interpretation of E x H; Simple application; Complex Poynting vector.	**2**
UNIT-05	**Transmission Lines and Guided Waves:** Transmission lines theory from the circuit concept, properties; Transmission line parameters and equations; Infinite line; Reflections in transmission lines; Voltage, current and impedance relations-open and short circuit lines; Experimental determination of line constants; Standing wave ratio; Impedance matching, quarter and half wave lines, single stub, and double stub matching; Smith chart. Waves between parallel planes: Transverse Electric waves, Transverse magnetic waves, and their characteristics; Transverse Electromagnetic waves; Velocity of propagation; Attenuation in parallel plane guides; Wave impedance**.**	**10**
UNIT-06	**FEM Applications:** Introduction of FEM; Applications of FEM in magnetic fields, electric fields, and electromagnetic waves.	**2**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Apply vector calculus to static and dynamic electromagnetic fields in different engineering situations. CO2: Describe Maxwell' equation in different forms and apply them to diverse engineering problems. CO3: Apply principles of wave propagation in different media, interfaces and in engineering systems. CO4: Assess the nature of electromagnetic wave propagation in guided medium which are used in transmission of wave.		

Textbooks

1. Electromagnetic waves and Radiating systems by E. Jordan, Prentice-Hall.
2. Principle and applications of Electromagnetic fields by R. Plonsey and R.E. Collin, McGraw-Hill Book Co, New York.

Reference Books

1. Applied Electromagnetics by M.A. Planus, Mc Graw-Hill Book Co.
2. Elements of Electromagnetic by Mathew N.O. Sadiku, Oxford University Press.

Course Name: **Measurements and Instrumentation** Course Code: **EE-214** Course Type: **Discipline Core**		
Contact Hours/Week: **3L**		Course Credits: **03**

Course Objectives

- To learn the different errors, their sources from where they arise in measurement of a quantity and their analysis.
- To explain the basic principle, working and construction of various instruments used for measuring the electrical and magnetic quantities.
- To understand various methods for the measurement of different range of resistances.
- Learning about various AC bridge methods for the measurement of different range of inductances of a coil and capacitance of a capacitor.
- To know the basic principle, working and construction of various instruments used for measuring the power factor and frequency in both single phase and three phase electrical systems.
- Understanding the basic principle of working of potentiometers, procedures for measurement of electrical quantities using potentiometer and calibration of instruments.
- To learn use of instrument transformers for the measurements of high voltage and current in an electrical circuit and to understand various errors which appears in using instrument transformers.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Measurement System:** Introduction, Static error, Limiting errors, Relative limiting errors and their combinations, Types of errors: Gross Errors, Systematic Errors, Random Errors; Error analysis, Static and dynamic characteristics of measurement system.	**6**
UNIT-02	**Electrical Measuring Instruments:** Introduction, D'Arsonval galvanometer, moving iron and moving coil instruments, Electrodynamometer, Electrostatic Instruments, wattmeter, Energy Meter, Smart Metering Systems. Single phase and three phase electrodynamometer type power factor meters. Electrical resonance type, Ratio meter type frequency meter.	**10**
UNIT-03	**Measurement of Resistance:** Methods for measurement of low, medium, and high resistance, localization of cable faults by Murray and Varley loop test.	**5**
UNIT-04	**Measurement of Inductance and Capacitance:** Measurement of inductance and capacitance by A.C. bridge methods, Q-factor and dissipation factor, Sources of errors in bridge circuits, shielding of bridge elements, Wagner earthing device.	**7**
UNIT-05	**D.C. Potentiometers:** Basic D.C. potentiometer circuit, Modern form of D.C. potentiometer, measurement of voltage, current, resistance and calibration of voltmeter and ammeter using D.C. potentiometer, volt ratio box.	**4**
UNIT-06	**Instrument Transformers:** Introduction, use of instrument transformers, ratio and phase angle errors, reduction of errors.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic principle, working and construction of various instruments used for measuring the electrical and magnetic quantities.

CO2: Comprehend the merits of various bridge methods used for the measurement of resistance, inductance and capacitance.

CO3: Understand basic principle of working of potentiometers, its use for measurement of electrical quantities and calibration of instruments.

CO4: Realize the requirement of Instrument transformers in high voltage and current measurements.

Textbooks

1. A Course in Electrical and Electronic Measurements and Instrumentation by A.K. Sawhney and P. Sawhney, Dhanpat Rai & Sons.
2. Electronic Instrumentation and Measurement Techniques by W.D. Cooper and A.D. Helfrick, Prentice-Hall India.

Reference Books

1. Electrical Measurement and Measuring Instruments by E.W. Golding and F.C. Widdis, Wheeler Publishing.

Course Name: **Analog and Digital Electronics** Course Code: **EE-215** Course Type: **Discipline Core**		
Contact hours/week: **3L+1T**		Course Credits**: 04**
Course Objectives • Understand the characteristics and biasing of transistors, JFET and MOSFET. • Comprehend the characteristics and parameters of operational amplifier. • To impart knowledge about the concept of digital design, number system and codes. • To introduce the fundamental concepts related to the design of combinational logic circuits. • To enable the students to understand the design of Sequential Circuits.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Review of BJT, JFET, MOSFET:** Basics of BJT, General cascaded system, RC coupled amplifier and its frequency response, merits and demerits, cascade amplifier, Darlington compound configuration, multistage frequency effect. High frequency model for CE configuration, approximate CE high frequency model with resistive load, CE short circuit current gain, HF current gain with resistive load. JFET Structure and I-V characteristics. MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits, common-source, common-gate and common-drain amplifiers; small signal equivalent circuits - gain, input and output impedances, trans-conductance, high frequency equivalent circuit.	**10**
UNIT-02	**Feedback Amplifier and Large Signal Amplifier:** Feedback concept, characteristics of negative and positive feedback, Effect of negative and positive feedback on input impedance, output impedance, gain, and noise and frequency response, Problem Solving. Analysis and design of class A, B, AB amplifiers, push pull amplifiers, transformer less output stages, distortion calculations.	**6**
UNIT-03	**Oscillator and Operational Amplifier:** Oscillators- RC & LC oscillators and crystal oscillators. Operational amplifier characteristics, slew rate, bandwidth, offset voltage, basic current, application, inverting, non-inverting amplifier, summer, average, differentiator, integrator, differential amplifier, instrumentation amplifier, log and antilog amplifier.	**7**
UNIT-04	**Number Systems and Logic Families:** Analog to Digital and Digital to Analog Converter Circuit, Number systems and their inter-conversion, Binary Arithmetic (Addition, Subtraction, Multiplication and Division), Diminished radix and radix compliments, BCD codes, 8421 code, Excess-3 code, gray code. Boolean Algebra, Basic Theorems and Properties of Boolean Algebra, Minimization of Logic functions, Karnaugh -Map method, Sum of products and products of sums Simplification, NAND and NOR implementation, Determination of prime implicants. Digital Logic Gates. Various Logic Families like TTL, RTL, DTL and ECL, working and their characteristics, MOS, and CMOS devices.	**8**
UNIT-05	**MSI and PLD Components:** Binary adder and subtractor, Multiplexers, Decoders and Encoders, Multiplexers and Demultiplexers, Implementation of Combinatorial Logic using these devices.	**5**

Course Outcomes Upon successful completion of the course, the students will be able to CO1: Understand the characteristics and biasing of transistors. CO2: Comprehend the characteristics and parameters of operational amplifier. CO3: Apply principles of minimization techniques to simplify digital functions. CO4: Design and analyze the combination electronic circuit based on digital logic. CO5: Design and analyze the sequential electronic circuit based on digital logic.
Textbooks 1. Electronic Devices and Circuit theory by R. Boylestad and L. Nashelsky, Pearson. 2. Electronic Devices and Circuits by Millman Halkias; McGraw- Hill. 3. Digital Design by M. Morris Mano, Prentice Hall of India. 4. Modern Digital Electronics by R.P Jain Tata Mc-GrawHill **References Books** 1. Electronic Circuits by A Sedra and K. Smith, Oxford University Press. 2. Electronic Fundamental Applications by Integrated and Discrete Systems: J. D. Ryder, Printice Hall. 3. Digital Principle and Applications by Malvino and Leach, Tata Mc-Graw Hill. 4. Fundamentals of Digital Electronics by Anand Kumar, Prentice Hall India

Course Name: **Measurements & Instrumentation Lab** Course Code: **EE-216**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- Provide hands-on experience to the students so that they can put theoretical concepts into practice.
- Solve and measure the basic parameters like resistance, capacitance and inductance using suitable methods.
- To impart knowledge about calibrating the voltmeter and ammeter.
- To impart knowledge about the experimental determination of quality factor with LCR bridge circuit.

List of Experiments

1. To measure unknown resistance using Wheat stone bridge method.
2. To measure insulation resistance of a given wire using megger.
3. To measure unknown capacitance using low voltage Schering bridge.
4. Measurement of unknown inductance and resistance using Maxwell's inductance bridge.
5. To calibrate an energy meter using Phantom loading method.
   (i) To calibrate the voltmeter using a direct reading potentiometer.
   (ii) Measurement of current and resistance using potentiometer method.
6. Measurement of low resistance using Kelvin double bridge method.
7. To determine the value of unknown high resistance using loss of charge method.
8. To measure power and power factor for an inductive circuit using: (i) three voltmeter method (ii) three ammeter method.
9. To calibrate an ammeter using a direct reading potentiometer.
10. Measurement of inductance, capacitance, resistance, and quality factor (Q) with LCR bridge circuit.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the fundamentals of measuring methods in computing basic R, L and C parameters.

CO2: To be able to calibrate various instruments like ammeter and voltmeter.

CO3: Be able to determine inductance, capacitance, and Q factor.

Course Name: **Analog and Digital Electronics Lab** Course Code: **EE-217**
Contact hours/week: **2P** Course Credits**: 01**
Course Objectives • To analyse the performance of various oscillators. • To understand the concept of feedback amplifier. • To analyse the effect of operational amplifier • Familiarization with digital integrated circuits and equipment • Implementation and design of combinational logic circuits using different gates. • To understand concepts of sequential circuits and to analyse and design sequential circuits.
List of Experiments 1. To study the working of Hartley Oscillator and measure the frequency of oscillations. 2. To study the working of Colpit's Oscillator and measure the frequency of oscillations. 3. To study the functioning of Crystal Oscillator and measure the frequency of oscillations. 4. To study the frequency response of two-stage RC coupled amplifier and find the voltage gain. 5. To identify the type of feedback used in an amplifier and determine the voltage gain. 6. Operational Amplifier as an Inverting amplifier Aim: To plot frequency response of Inverting amplifier & find unity gain BW product. 7. Operational Amplifier applications Aim: To design and implement i) Integrator and ii) Differentiator. 8. To study about the logic gates and verify their truth table. 9. Realization of AND and OR gates using 10. Diodes and resistors. 11. Universal gates. 12. Design and implement half adder and full adder circuits and verifies the truth table using logic gates. 13. Design and implement half sub-tractor and full sub-tractor circuits and verifies the truth table using logic gates. 14. Realization of SR, JK, D and T flip flop using gates.
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Understand the digital signals, applications of ICs and logic circuits. CO2: Develop skills for designing combinational logic circuits and their practical implementation on breadboard. CO3: Analyze, design, and implement sequential logic circuits.

Course Name: **Workshop Practice for Electrical Engineering**
Course Code: **EE-218**

Contact Hours/Week: 2P **Course Credits: 01**

Course Objectives

- To introduce electrical tools & components
- The main objective is to make the students able to understand, design and prepare electrical circuits using basic concepts.

List of Experiments

1. Introduction to electrical tools, components, and electric materials.
2. To study various electrical symbols and notices used in electrical factory and workshop.
3. Design and drawing of electrical panel boards/switch boards.
4. To study various electrical home appliances like electric room heater, electric iron, juicer mixer grinder, table fan etc.
5. To calibrate energy meter with a standard wattmeter by direct loading method.
6. To measure earth resistance using three terminal method.
7. To measure earth resistance using megger and to determine OC and SC faults.
8. To study operation of star-delta starter and direct online (DOL) starter for starting 3-phase induction motor.
9. To study the fluorescent tube connection including choke and starter.
10. To study two way and intermediate switches and design staircase lighting in long corridor lighting.
11. Study of different types of house wiring schemes and important electricity rule.

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Identify various electrical symbols and notices used in electrical factory and workshop.
CO2: Use of different electrical measuring Instruments and different safety standards.
CO3: Know about different types of house wiring schemes and important electricity rule.

Course Name: **Fundamentals of Electrical Machines**
Course Code: **EE-221**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** **Course Credits: 03**

Course Objectives

- To have knowledge about operation, testing, efficiency and various configurations of single phase and three phase transformers.
- To understand the concepts of rotating electrical machines and principle of energy conversion.
- To impart knowledge about operation, various characteristics, starting and control of DC machines.

Unit Number	Course Contents	Contact Hours
UNIT-01	**Transformers:** Construction, Theory, and operation, E.M.F. equation, phasor diagram, rating of transformers, equivalent circuit, open and short circuit tests, back-to-back test, voltage regulation and efficiency, auto-transformers, three winding transformer, parallel operation of single phase and three phase transformers, three phase transformer connections, phasor groups, three phase to two phase and six phase conversion Harmonics and excitation phenomenon, inrush current phenomenon.	**11**
UNIT-02	**Basic Concepts of Electrical Machines**: Constructional details of various rotating machines, Introduction to Lap and wave windings, EMF generation, Effect of chording and distribution of winding on EMF, Harmonics in generated emf, MMF produced by distributed winding.	**8**
UNIT-03	**Energy Conversion:** Principle of electromechanical energy conversion, energy stored in a magnetic field system, singly and doubly excited systems.	**7**
UNIT-04	**DC Machines:** Action of commutator, E.M.F. generated in armature, Torque in DC machines, Methods of excitation, armature reaction and flux density waveform of DC Machines, Commutation process, inter poles and compensating windings, Basic performance equations of DC machine, Magnetization and operating characteristics of DC generators and DC motors, DC motor starting and speed control, Ward Leonard system, losses and efficiency, applications of DC motors.	**10**

Course Outcomes:

Upon successful completion of the course, the students will be able to understand:

CO1: Operation of transformers and carry out performance tests.

CO2: Working Principles of DC Machines, and learn Electromechanical Systems requisites, Generating & Motoring aspects.

CO3: Function of Commutator, Magnetization aspects and Speed Control of DC Machines.

CO4: Various Aspects of Performance of DC machines.

Textbooks

1. Electrical Machinery by P.S. Bhimbra, Khanna Publishers, Delhi.
2. Electrical Machinery Fundamentals by S.J. Chapman, McGraw Hill, New York.

Reference books

Course Name: **Elements of Power System**
Course Code: **EE-222**
Course Type: **Discipline Core**

1. Electric Machinery by Fitzgerald Mc Graw Hill.
2. Electrical Machines by Ashfaq Hussian, Dhanpat Rai Company.

Contact Hours/Week: 3L+1L **Course Credits: 04**

Course Objectives

- Identify major components of power transmission and distribution systems.
- Describe the principle of operation of transmission and distribution equipment.
- Know and appreciate the key factors in equipment specification and network design.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction to Power System, Load Characteristics and Economic Aspects. Basic structure of power system, sources of electric energy: conventional and non-conventional; cogeneration, combined heat and power, captive power plants, distributed generation. Commonly used terms and factors, curves useful in system operation and planning, economics of power factor improvement, interconnection of power stations and tariffs.	**6**
UNIT-02	**Transmission Line Parameters:** Types of conductors, Ampere's law, inductance of a conductor, inductance of a single-phase line, inductance of a three-phase line, inductance of three-phase double circuit line, bundled conductors, skin effect, proximity effect, Guy's theorem, Capacitance of single-phase line, capacitance of a three-phase line, capacitance of double circuit three phase line, effect of earth on capacitance.	**8**
UNIT-03	**Transmission Line Performance:** Classification of lines, models, circuit constants of transmission lines: short, medium, and long lines; Ferranti effect, power flow through a line, sending and receiving end power circle diagram, reactive power generation/absorption of line, compensation, and voltage control.	**8**
UNIT-04	**Insulators for Overhead Transmission lines and Mechanical Design of Transmission line:** Types of insulators, ratings, voltage distribution across suspension insulators, string efficiency, methods to improve string efficiency. Calculation of sag and tension, equivalent span length and sag, effect of ice and wind loading, stringing chart, sag template, conductor vibrations and vibration dampers.	**6**
UNIT-05	**Corona and Radio Interference:** Critical voltages, corona loss, advantages and disadvantages of corona, factors affecting corona loss, effect of corona online design, radio interference.	**4**
UNIT-06	**Distribution System and Insulated Cables:** Effect of voltage on transmission efficiency, Kelvin's law, radial and ring main distributors, interconnectors, methods of feeding distributors, ac distribution, three-phase four-wire distribution system, stepped and tapered mains. Cable conductors, insulating materials, insulation resistance, electrostatic stress in cables, grading of cables, capacitance of a three-core cable, dielectric loss, dielectric power factor, classification of cables, cable performance.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Comprehend various elements of power system, its changing landscape, and different sources of energy.

CO2: Able to produce concepts regarding basics of Electrical Engineering such as KW, KVAR, KVA.

CO3: Able to understand the importance of power factor, capacitor bank and metering system in industrial and residential areas.

CO4: Able to analyze the Performance of Transmission Lines, Efficiency in Transmission Lines.

Textbooks

1. Electric Power Systems by C. L. Wadhwa, New Age International, New Delhi.
2. Electric Power Generation Transmission and Distribution by S. N. Singh, Prentice-Hall of India, Private Limited, New Delhi.
3. Elements of Power System Analysis by W. B. Steveson, McGraw Hill.

Reference Books

1. Power System Engineering by D. P. Kothari and I. J. Nagrath, Tata McGraw Hill, New Delhi.

Course Name: **Microprocessors and Microcontrollers** Course Code: **EE-223** Course Type: **Discipline Core**		
Contact Hours/Week: 3L		**Course Credits: 03**
Course Objectives • To emphasize hardware functionality of Intel 8051 Microcontroller and ARM Processor. • To familiarize and develop programs for Intel 8051 Microcontroller and ARM Processor. • To create an essential knowledge of the I/O ports and various types of interruptions. • To demonstrate the procedure to interface microcontroller and processor to various devices.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction:** Evolution of Microprocessors, Microcontrollers and Computers, Microprocessor based system design-need and steps-Advantages and limitations, Intel 8085, Intel 8086, and Intel 80 x 86 Family of Processors: Intel 80186, Intel 80286, Intel 80386, Intel 80486, Pentium microprocessor, Numeric Data Processor 8087, classification of Memory devices, Mapping and its interfacing.	**10**
UNIT-02	**High Performance RISC Architecture-ARM Processors**: Comparison between RISC and CISC; Overview of 32-bit ARM architecture; ARM memory organization; Different modes of ARM Processor; Instruction set of ARM Processor; Basic ARM ALP (32 bit addition, subtraction, multiplication, binary sorting), ARM memory interface; Program status register; 3-stage pipeline.	**8**
UNIT-03	**Intel 8051 Micro Controllers:** Introduction, functional block diagram of Intel 8051/8031 microcontroller, Memory organization in Intel 8051/8031 microcontroller, Memory and I/O interfacing in Intel 8051/8031 based system, Examples of memory and I/O interface in 8031/8051 based system, addressing modes, Instruction set of Intel 8051/8031, Assembly language programming.	**5**
UNIT-04	**Assembler Directives**: Peripheral devices and interfacing, parallel data transfer schemes, Serial data communication in 8051 microcontroller, DAC interface, ADC interface, Application examples of Intel 8051 microcontroller, Intel 8096 microcontroller, architecture and SFRs of 8096, Trends and developments in microcontrollers.	**5**
UNIT-05	**Peripherals and Interfacing**: Display interface; Timer module; PWM module; Analog-to-Digital conversion; Digital-to-Analog conversion; programming of peripherals.	**4**
UNIT-06	**Introduction to Single board Computers (SBC):** The Arduino, a microcontroller unit (MCU), ESP 32, Node MCU, the Raspberry Pi 4 module (SBC) etc.	**4**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Acquire knowledge on Microcontrollers, Processors and interfacing devices. CO2: Comprehend and develop structured assembly programs using Microcontroller 8051. CO3: Analyze the different ARM instructions to solve real time problems and interface various peripherals. CO4: Understand the impact of 8051 and ARM Processor in Engineering applications		

Textbooks

1. The 8051 Microcontroller and Embedded Systems: Using Assembly and C, by Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, 2018, 2nd Edition, Pearson Education.
2. Modern Assembly Language Programming with the ARM Processor by Pyeatt, Larry D, 2016, 1st Edition, Newnes, Elsevier.
3. Microprocessors & Microcontrollers by A. Nagoor Kani, 1st Edition, RBA Publications.

Reference Books

1. Microcomputer systems the 8086/8088 family by Yu-cheng Liu and Glenn A. Gibson, PHI.
2. ARM assembly language: fundamentals and techniques, by Hohl, William, 2016, 2nd Edition, CRC Press.
3. The 8051 Microcontroller: Architecture, Programming and Applications, by Kenneth JA, Penram International.
4. Microcontrollers: Theory and Applications by AV Deshmukh, Tata McGraw-Hill.

Course Name: **Power Electronics** Course Code: **EE-224** Course Type: **Discipline Core**		
Contact Hours/Week: 3L		**Course Credits: 03**
Course Objectives • To learn the construction, working, characteristics and protection of power electronic switches and its power ratings • To provide the knowledge of the different types of power electronic converters and to learn the types of output waveforms. • To enable the students to understand various factors while designing power electronic systems.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction to Solid-State Devices:** Concept of Power Electronics, brief introduction of different types of power electronics devices, converter systems, areas of application, device construction and characteristics of power diode, power BJT, power MOSFET, power IGBT, SCR, two transistor analogy of thyristor, thyristor dv/dt and di/dt protection, series and parallel operation of thyristor, GTO, basics of firing/triggering circuit.	**8**
UNIT-02	**Phase Controlled Rectifier:** Principles and operation of phase-controlled rectifiers (single/three phase), performance parameters, evaluation of single-phase half controlled/fully controlled converter with R, RL, and RLE load, operation of three-phase fully controlled converter with different types of loads, effect of source impedance, dual converters (single/three phase).	**8**
UNIT-03	**Choppers:** Basic principles of DC-DC switched mode Converters, Classification and quadrant operation, step-up and step-down choppers, output control methods of thyristor choppers, voltage, current and load commutation, Analysis of buck, boost, SEPIC, and buck-boost converters.	**6**
UNIT-04	**Inverters:** Introduction of inverter operation, classification of inverters and its applications, performance parameters, analyze the performance of single-phase half bridge and full-bridge voltage source inverters with R, RL and RLE load, three-phase voltage source inverters-180 degree and 120 degrees mode of operation, voltage control of single-phase inverters-single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation.	**6**
UNIT-05	**AC Voltage Controllers and Cycloconverters:** Single-phase and 3-phase AC voltage controllers, phase control and integral bicycle control, evaluation of single-phase voltage controllers for R and R-L load, single phase cycloconverters (step-up and step-down), effects of harmonics and electromagnetic interference.	**6**
UNIT-06	**Applications of Converters:** Voltage Source Inverter (VSI) fed motor drive systems, VSI applications in distribution and transmission systems, DC-DC converters in battery charging systems	**4**

Course Outcomes
Upon successful completion of the course, the students will be able to
CO1: Select power switching devices for suitable power conversion.
CO2: Analyze the performance of different types of phase-controlled rectifiers.
CO3: Examine DC-DC converter for a given performance and application.
CO4: Analyze the operation of Inverters, ac voltage controllers and cycloconverters.

Textbooks

1. Power Electronics by P.S. Bhimbra, Khanna Publishers, Delhi.
2. Power Electronics, by M.D. Singh, Khan Chandani, TMH publications,
3. Power Electronics-Circuits, Devices and Applications by M.H. Rashid, Pearson Education.
4. Fundamentals of Power Electronics, by Robert W. Ericks, D. Maksimovicvic, Springer Science Business Media

Reference Books

1. Modern Power Electronics by B.K. Bose, IEEE Press, New York
2. Thyristorised Power Controllers by Dubey, Doradla, Joshiand Sinha, New age International Pub., New Delhi.

Course Name: **Electrical Machines Lab-I**
Course Code: **EE-225**

Contact Hours/Week: **2P** **Course Credits**: **01**

Course Objectives

- To provide basic information about electrical machine parts and their tests.
- To impart knowledge and understanding about D.C. machines and transformers.
- To acquire basic understanding about working of dc machines and about its generator and motors mode.

List of Experiments

1. To conduct open circuit and short circuit test on a single-phase transformer.
2. To conduct a polarity test on a single-phase transformer.
3. To study the constructional details and working of a transformer.
4. To perform back-to-back test on a single-phase transformer.
5. To perform parallel operation on single phase transformers for the load sharing between them.
6. To perform load test on a single-phase transformer.
7. To study the speed control of a D.C shunt motor by field control method.
8. To study the speed control of a D.C shunt motor by armature control method.
9. To study external load characteristic of D.C shunt generator.
10. To conduct an experiment on a separately excited DC generator and draw the magnetization characteristic and then determine the critical field resistance.

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Explain the practical operation of transformers.

CO2: Carryout various tests on a two winding transformer & be able to measure loading data.

CO3: Calculate performance estimation of DC machines.

CO4: Explain the theory of electromechanical energy conversion.

CO5: Carryout calculations regarding performance of DC machines.

Course Name: **Microprocessors & Microcontroller Lab**

Course Code: **EE-226**

Contact Hours/Week: 2P **Course Credits: 01**

Course Objectives

- To provide ability for drawing flowcharts and writing Assembly Language Programs for a given problem.
- Familiarize and develop programs for Intel 8085, 8086, 8051 and ARM processor.
- To enable the students to debug the Assembly Language Programs.
- Implement various interfacing techniques with controller and processor.

List of Experiments

1. To familiarize yourself with 8085,8086 and 8051 microprocessor trainer kits.
2. To understand and write an assembly language program (ALP) for interfacing of stepper motor with microprocessor/microcontroller.
3. To interface relay and opto-isolator with microprocessor/microcontroller.
4. To study the characteristics of 8253 in different modes using counter 0.
5. To conduct the following experiments on an ARM CORTEX M3 evaluation board to learn ALP and using evaluation version of Embedded 'C' & Keil Uvision-4tool/compiler:
    a) To write an ALP using 8086 for arranging an array in descending/ascending order.
    b) To write an ALP to add two 8- bit numbers in 8051 microcontroller/ARM Processor.
    c) To write an ALP to subtract two 8 –bit numbers in 8051 microcontroller/ ARM Processor.
    d) To write an ALP for decimal addition of two numbers in 8051 microcontroller/ ARM Processor.
    e) To solve simple arithmetic expressions using 8051 instructions
    f) To write an ALP to determine the sum of elements in an array using 8051 microcontrollers.
6. (a)To study the digital input/output interface module.
   (b) To study the dual channel digital to analogue interfacing card.
   (c) To study the dual channel analogue to digital interfacing card.
7. To study and interface LED matrix card with the microprocessor/microcontroller.
8. To interface ADC and DAC with 8085 Microprocessor and generation of waveforms using DAC. Interfacing display devices with controllers.
9. (a) Introduction to ARM Processor instructions and perform arithmetic and logical tasks
   (b) Programming ARM Processor using subroutines
   (c) Generation of delay using timers of ARM Processor.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify various electronic components on Intel 8085, 8086, 8051 microprocessor/microcontroller kit.

CO2: Understand and apply the fundamentals of assembly level programming of Intel 8085, 8086, 8051 and ARM processor to solve problems.

CO3: Work with microprocessor interfacing modules including serial ports, digital-to-analog and analog-to-digital converters etc.

CO4: Analyze abstract problems and apply a combination of hardware and software using Microprocessor/Microcontroller to address the Problems.

Textbooks

1. The 8051 Microcontroller and Embedded Systems: Using Assembly and C, by Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. McKinlay, 2018, 2nd Edition, Pearson Education.
2. Arm Cortex-M Assembly Programming for Embedded Programmers: Using Keil, by Muhammad Ali Mazidi, Sarmad Naimi, Sepehr Naimi, 2020, 1st Edition, Pearson Education.
3. Modern Assembly Language Programming with the ARM Processor by Pyeatt, Larry D, 2016, 1st Edition, Newnes, Elsevier.

References Books

1. Microprocessors & Microcontrollers by Kani, A. Nagoor, 1st Edition, RBA Publications.
2. The 8051 Microcontroller: Architecture, Programming and Applications by Kenneth J.A, Penram International.
3. Programming and customizing the 8051 Microcontroller by Predko Myke, 3rd edition McGraw Hill.

Course Name: **Power Electronics Lab** Course Code: **EE-227**
Contact Hours/Week: 2P **Course Credits: 01**
Course Objectives • To learn the operation and characteristics of different power semiconductors switches. • To understand and analyze the operation of controlled rectifier, chopper, and cyclo-converter.
List of Experiments 1. To determine the V-I characteristics of silicon-controlled rectifiers (SCR). 2. To study the output and transfer characteristics of MOSFET. 3. To study output and transfer characteristics of IGBT. 4. To determine the V-I characteristics of DIAC and TRIAC. 5. Experimental study of a buck-boost dc-dc converter for R load. 6. Development of single-phase voltage source inverter (VSI) under bipolar and unipolar PWM techniques using MATLAB 7. To study the operation of digital storage oscilloscopes using a differential probe. 8. To study the operation of voltage-commutated chopper and plot output waveform. 9. To study the operation of single-phase full wave rectifier half-wave rectifier with RLE with freewheeling diode. 10. To study the operation of single-phase step down cyclo-converter
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Explain the basic operation of various power semiconductor devices and their applications. CO2: Analyze power electronic circuits. CO3: Apply power electronics circuits for different loads.

Course Name: **Neural Networks and Fuzzy Logic**
Course Code: **EE-241**
Course Type: **Discipline Elective (I)**

Contact Hours/Week: 3L **Course Credits: 03**

Course Objectives

- To acquire the basic knowledge of neural networks and fuzzy logic for future applications.
- To impart knowledge about the application of artificial intelligence techniques in engineering.
- To identify, formulate and solve neural networks and fuzzy logic-based problems.
- To provide the students with a strong foundation of subject to pursue higher studies and research.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Biological foundation, mathematical model of biological neuron, types of activation function, feed-forward and feedback ANN models.	**5**
UNIT-02	**Learning Paradigms:** Supervised and unsupervised learning, learning rules, single layer and multilayer perceptron model, error back propagation learning algorithm, pattern classification, clustering, Kohonen self-organizing feature map, radial basis function network.	**8**
UNIT-03	**Feedback Networks and ANN Applications:** Hopfield network, Associative memory and BAM, applications of ANN models to engineering problems.	**8**
UNIT-04	**Fuzzy Sets and Theory:** Crisp sets, fuzzy sets, fuzzy set operations, properties, membership functions, measures of fuzziness, fuzzification and defuzzification methods, fuzzy relations, operation on fuzzy relations, fuzzy numbers and arithmetic, fuzzy implications, approximate reasoning, systems based on fuzzy rules, fuzzy inference.	**8**
UNIT-05	**Fuzzy Control Systems:** Introduction, fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems.	**3**
UNIT-06	**Hybrid Intelligent Systems:** Genetic algorithms, neuro-fuzzy systems, adaptive neuro-fuzzy inference system, evolutionary neural networks, fuzzy evolutionary systems.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe the working of different intelligent systems.

CO2: Able to apply these techniques in different fields, which involve perception, reasoning and learning.

CO3: Analyze and design a real-world problem for implementation and understand the dynamic behavior of a system.

CO4: Assess the results obtained by ANN and fuzzy systems.

Textbooks

1. Introduction to Artificial Neural Systems by Jacek M Zurada, West Publisher.
2. Neural Computing: Theory and Practice by Philip D. Wasserman, Van Nostrand Reinhold.
3. Neural Networks -Algorithms, Applications, and Programming Techniques by Freeman, J. A. and D. M. Skapura, Pearson Education.

Reference Books

1. Essentials of Fuzzy Modeling and Control by Ronald R. Yager and Dimitar P. Filev, John Wiley & Sons Inc.
2. Neural Networks, Fuzzy logic and Genetic Algorithm: Synthesis and Applications by S. Rajasekaran and G. A. Vijayalakshmi Pai, PHI New Delhi.

Course Name: **Data Structures and Algorithms in Python**
Course Code: **EE-242**
Course Type: **Discipline Elective (I)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- Identify data structures suitable to solve problems.
- Develop and analyze algorithms for stacks and queues.
- Design and implement algorithms for binary trees and graphs.
- Implement sorting and searching algorithms.

Unit Number	Course Content	Contact Hours
UNIT-01	**Object-Oriented Programming:** class, object, constructors, types of variables, types of methods. Inheritance: single, multiple, multi-level, hierarchical, hybrid, Polymorphism: with functions and objects, with class methods, with inheritance, Abstraction: abstract classes.	**5**
UNIT-02	**Data Structures:** Definition, Linear Data Structures, Non-Linear Data Structures	**3**
UNIT-03	**Python Specific Data Structures**: List, Tuples, Set, Dictionaries, Comprehensions and its Types, Strings, slicing.	**4**
UNIT-04	**Sorting and Selection:** Overview of Arrays, Types of Arrays, Operations on Arrays, Arrays vs List. Binary Search Trees, Balanced Search Trees, AVL Trees, Splay Trees, (2,4) Trees, Red-Black Trees. Merge-Sort, Quick-Sort, Radix Sort, Selection	**8**
UNIT-05	**Lists, Stacks, and Queues:** Implementation of Singly Linked Lists, Doubly Linked Lists, Circular Linked Lists. Overview of Stack, Implementation of Stack (List & Linked list), Applications of Stack. Overview of Queue, Implementation of Queue (List & Linked list), Applications of Queues, Priority Queues.	**8**
UNIT-06	**Graph Algorithms**: Graphs- The Graph ADT, Data Structures for Graphs, Graph Traversals, Depth-First Search, DFS Implementation and Extensions, Breadth-First Search, Transitive Closure, Directed Acyclic Graphs, Shortest Paths, Weighted Graphs, Dijkstra's Algorithm, Minimum Spanning Trees.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Interpret the concepts of Object-Oriented Programming as used in Python.

CO2: Use of linear and non-linear data structures as the foundational base for computer solutions to problems.

CO3: Implement binary trees, binary tree traversals, and binary search trees.

CO4: Implement various types of sorting algorithms.

Textbooks

1. An Introduction to Data Structures with applications by J.P. Tremblay and P.G. Sorenson, Tata McGraw Hill
2. Data Structures and Algorithms in Python by M. T. Goodrich, R. Tamassia, and M. H. Goldwasser, Wiley

Reference Books

1. Data Structures and Algorithms Using Python by Rance D. Necaise, Wiley
2. Data Structures and Algorithms Using Python and C++ by David M. Reed and John Zelle

Course Name: **Internet of Things**
Course Code: **EE-243**
Course Type: **Discipline Elective (I)**

Contact Hours/Week: 3L **Course Credits: 03**

Course Objectives

- To impart knowledge about the Internet of Things and introduce the infrastructure required for IoT.
- To introduce the fundamental concepts relevant to design issues related to Internet of Things.
- To study Internet of Things technologies and its role in real time applications.
- To familiarize the accessories and communication techniques for IoT.
- To provide insight about the embedded processor and sensors required for IoT.
- To familiarize the different platforms and Attributes for IoT.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Internet of Things**: Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications.	**4**
UNIT-02	**IOT Architecture**: IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture, IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.	**8**
UNIT-03	**Protocols and Wireless Technologies for IOT**: PROTOCOLS: NFC, SCADA and RFID, Zigbee MIPI, M-PHY, Uni Pro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell.	**5**
UNIT-04	**Wireless Technologies for IoT:** Wi-Fi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary Systems-Recent trends.	**6**
UNIT-05	**IOT Processors**: Services/Attributes: Big-Data Analytics for IOT, Dependability, Interoperability, Security, and Maintainability. Embedded processors for IOT: Introduction to Python programming -Building IOT with RASPERRY PI and Arduino.	**8**
UNIT-06	**Case Studies:** Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense etc.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Analyze the concepts of IoT and its present developments.
CO2: Compare and contrast different platforms and infrastructures available for IoT
CO3: Explain different protocols and communication technologies used in IoT and to understand the principles and various research issues related to Internet of Things
CO4: Implement IoT solutions for smart applications.

Textbooks

1. A Hands-on Approach: Internet of Things by Arshdeep Bahga and Vijai Madisetti: Universities Press 2015.
2. The Internet of Things by Oliver Hersent, David Boswarthick and Omar Elloumi Wiley,2016.
3. Designing the Internet of Things by Adrian McEwen and Hakim Cassimally, John Wiley and

sons, 2014.

Reference Books

1. Internet of Things: A Hands on-Approach by Vijay Madisetti, Arshdeep Bahga, 2014.
2. Internet of Things Principles and Paradigms by Rajkumar Buyya and Amir Vahid Dastjerdi, Elsevier.
3. Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence by Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand and David Boyle, Academic Press.
4. Sensors, Actuators, and their Interfaces: A multidisciplinary introduction by N. Ida, Scitech Publishers.

Course Name: **Optimization Techniques**
Course Code: **EE-244**
Course Type: **Discipline Elective (I)**

Contact Hours/Week: 3L **Course Credits: 03**

Course Objectives

- To impart knowledge about the principles of optimization techniques.
- To introduce the fundamental concepts relevant to classical optimization methods, linear programming, nonlinear programming, and dynamic programming.
- To enable the students to understand the factors that causes the different optimization methods to provide different solutions for the same mathematical problem.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Historical Development; Engineering applications of Optimization; Art of Modeling; Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems.	**3**
UNIT-02	**Classification of Optimization Problems**: Based on nature of constraints, structure of the problem, deterministic nature of variables, separability of functions and number of objective functions	**3**
UNIT-03	**Linear Programming:** Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Examples; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems. Simplex method with artificial variables.	**6**
UNIT-04	**Optimization using Calculus:** Stationary points - maxima, minima, and saddle points. Functions of single and two variables; Global Optimum; Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Examples; Optimization of function of multiple variables subject to equality constraints. Lagrangian function; Optimization of function of multiple variables subject to inequality constraints; Hessian matrix formulation; Eigen values; Kuhn-Tucker Conditions; Examples.	**8**
UNIT-05	**Nonlinear Programming**: One dimensional minimization method, elimination, sequential and descent methods, unconstrained optimization techniques, Direct search methods, Descent methods, 2nd order methods, quasi-newton method, Constrained optimization, Indirect methods, exterior penalty function, interior penalty function, geometric viewpoint, augmented Lagrange multiplier.	**8**
UNIT-06	**Dynamic Programming:** Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality; Recursive equations – Forward and backward recursions; Computational procedure in dynamic	**8**

	programming (DP); Discrete versus continuous dynamic programming. Multiple state variables; curse of dimensionality in DP, application example.	

Course Outcomes

Up on successful completion of the course, the students will be able to

CO1: Identify different types of optimization techniques and problems.

CO2: Describe techniques like calculus based classical optimization, linear programming, nonlinear programming, dynamic Programming.

CO3: Apply principles and techniques described in CO2 to solve sample mathematical and practical optimization problems.

CO4: Assess the results obtained by applying optimization techniques to solve mathematical programming problems

Textbooks

1. Engineering Optimization: Theory and Practice by S.S. Rao, New Age International (P) Ltd., New Delhi.
2. Numerical optimization with applications by Suresh Chandra, Jaydeva, and Aparna Mehta Publisher: Narosa
3. An Introduction to optimization by Edvin K.P. Chong, and Stanislaw H. Zak Publisher: John Wiley.

Reference Books

1. Optimization theory and practice by Mohan C. Joshi and Kannan M Moudgalya, Publisher: Narosa Electrical Machines by Husain Ashfaq, Dhanpat Rai & Sons.

Course Name: **Induction and Synchronous Machines** Course Code: **EE-311** Course Type: **Discipline Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To learn about operation, characteristics, testing and control of induction machines. • To have knowledge about operation, starting, characteristics and testing of synchronous machines. • To impart knowledge about synchronization methods and parallel operation of alternators.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Polyphase Induction Machines:** Principle of operation, slip, phasor diagram, equivalent circuits, expression for torque, maximum torque, starting torque and output power, torque-slip and power-slip characteristics, Circle diagram, Predetermination of characteristics from the circuit diagram, no load and blocked rotor test data, power factor control in three phase induction motor, Starting, braking and Speed control of induction motor, various applications.	**8**
UNIT-02	**Single Phase Induction Motors:** Principle of operation based on double-revolving field theory, Equivalent circuit, performance calculations and characteristics, Starting methods, Maximum starting torque conditions, Hysteresis motor, Reluctance motor and stepper motor and their applications.	**8**
UNIT-03	**Basics of Synchronous Machines:** Principal of operation, construction types, Starting as synchronous motor, phasor diagrams for cylindrical rotor synchronous machines, Operation as Generator, Armature reaction, open and short circuit characteristics, Leakage reactance, Synchronous reactance, operating characteristics of alternators and their ratings, Predetermination of regulation by EMF and Potier Triangle methods for non-salient pole alternators.	**8**
UNIT-04	**Characteristics of Synchronous Machines:** Steady state power flow equations, Power angle characteristics, Constant excitation and constant power output, slip test, V curves, Hunting and its suppression, Operation as a Synchronous condenser.	**4**
UNIT-05	**Parallel Operation of Alternators:** Synchronization of alternators by dark lamp method, Parallel Operation of alternators, Alternator on infinite bus bar, Effect of change of excitation and prime mover inputs	**4**
UNIT-06	**Special Electrical Machines**: Brushless DC machines (BLDC), Permanent Magnet Synchronous Machines (PMSM), stepper motor	**5**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Explain characteristics of induction machines from the testing data available. CO2: Draw and explain circle diagram and its utility. CO3: Carry out calculations for various parameters of synchronous machines. CO4: Explain various phenomena associated with synchronous machines. CO5: Describe and explain various methods of synchronization and conditions for parallel operation of alternators		

Textbooks

1. Electrical Machinery by P.S. Bhimbra, Khanna Publishers, Delhi.
2. Electric Machinery by A.E. Fitzerald, C. Kings leyand S.D. Umans, Tata Mc Graw Hill.
3. Theory of AC Machinery by A. S. Langsdorf, Tata McGraw-Hill.

References Books

1. Theory & Performance of Electrical Machines by J.B. Gupta
2. Electric Machines and Drives: A First Course by N. Mohan, Wiley, 2012.

Course Name: **Power System Protection** Course Code: **EE-312** Course Type: **Discipline Core**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To impart knowledge about the fault analysis and to understand the impact of faults in a power system. • To introduce the fundamental concepts relevant to per-unit system their usefulness in fault analysis. • To understand and implement the protection of transmission lines, transformer, and bus bar protection. • To explain the working principle, applications of circuit breakers.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Per-Unit System and Fault Analysis:** Change of base, per unit quantities in three phase system, selection of base values, base quantities in terms of KV and MVA, per unit load impendence, advantages of per unit representation, one-line diagrams, preparation of impendence and reactance diagrams. Type of faults and their occurrence, symmetrical short circuit on the terminals of an unloaded generator, unsymmetrical faults on the terminals of an unloaded generator, faults on power system and their simulation. Introduction to grounding system.	**8**
UNIT-02	**Introduction to Power System Protection:** Abnormal operating conditions, protective system and its attributes, system transducer, various principles of power system protection.	**4**
UNIT-03	**Protection of Transmission Lines:** Over current protection through fuse, thermal and over current relay, IDMT relay and application on distribution feeder, directional over current relays, differential and percentage differential protection, distance protection of transmission lines through impedance, reactance and mho relay, comparison between distance relays.	**6**
UNIT-04	**Transformer and Generator Protection:** Over current protection, percentage differential protection, incipient faults in transformers, inter-turn fault, protection against over fluxing. Differential protection of bus bars. Various faults and abnormal operating conditions in generators, protection against unbalanced loading, over speeding, loss of excitation, loss of prime mover.	**8**
UNIT-05	**Advance Protective Systems:** Carrier aided protection of transmission lines, static comparators as relays, synthesis of various distance relays using static comparators, numerical protection.	**5**
UNIT-06	**Circuit Breaker:** Arc initiation and arc quenching theories, circuit breaker ratings, air circuit breaker, minimum oil circuit breaker, bulk oil circuit breaker, air blast circuit breaker, SF6 circuit breaker and vacuum circuit breaker.	**5**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Understand and implement the per-unit system and utilize it for fault analysis. CO2: Realize the importance of power system protection and judicious selection of type of protection to be applied. CO3: Identify the various kinds of faults and competence to implement protection in power system components. CO4: Understand the various types of circuit breakers according to their application.		

Textbooks

1. Elements of Power System Analysis by W.D. Stevenson, McGraw Hill.
2. Modern Power System by D.P. Kothari and I.J. Nagrath, Tata McGraw Hill New Delhi.
3. Electrical Power system by Ashfaq Hussain, Vikas Publisher.

References

1. Power System Analysis by Hadi Saadat, Tata Mc Graw Hill, New Delhi.
2. Switchgear and Protection by Sunil S. Rao, B. Ravindranath & M. Chander, Khanna Publishers, Delhi.
3. Electrical Power Systems by Ashfaq Hussain, CBS Publication.

Course Name: **Methods of Signal & System Analysis**
Course Code: **EE-313**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To develop the ability to carry out frequency analysis of discrete-time signals.
- To introduce the concept of linear filtering and explain the importance of frequency domain analysis.
- To define & characterize random signals and describe the response of LTI systems to a random input.
- To understand and be able to use down-sampling and up-sampling techniques.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Review of types of signals and systems, convolution, and correlation.	**3**
UNIT-02	**Frequency Analysis of Discrete time Systems:** Introduction, representation for a periodic signal, Fourier series representation of a periodic signals, DTFT, Fourier transform for periodic signals, convergence of the Fourier transform Gibbs phenomenon, properties of discrete time Fourier transform convolution and mortification properties, system described by linear constant coefficient difference equations.	**4**
UNIT-03	**Time and Frequency Characterization of Signals and Systems:** Introduction, magnetic and phase representation of Fourier transform, magnitude and phase representation of frequency response of LTI system, Linear and nonlinear phase, group delay, log magnitude plot, time domain and frequency domain aspects of non-ideal filters 1st and 2^{nd} order continuous time and discrete time systems.	**6**
UNIT-04	**Implementation of Discrete Time Systems:** Structures for the realization of LTI systems, recursive and non-recursive realization of FIR systems, structures for FIR systems, direct form, cascade form, frequency sampling and lattice structures, structures for IIR systems, direct form, signal flow graphs and transposed structure, cascade, parallel form and lattice structures.	**8**
UNIT-05	**Random Variables and Processes**: Probability theory, Conditional Probability, Total probability and Bayes' theorem, random variable, Expectations of random variable, Two random variables, Random Processes, System Response to Random process and its Spectral Analysis.	**12**
UNIT-06	**Multi-rate Signals:** Down-sampling, up-sampling, decimation and interpolation, applications of multi-rate systems.	**3**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO5: Evaluate Fourier series/Transform for a given discrete signal.

CO6: Differentiate between ideal and practical frequency selective filters.

CO7: Elucidate the concepts of random signals.

CO8: Find the response of LTI system to a random input signal.

Textbooks

1. Signals and Systems by A.V. Oppenheim, A. S. Willsky and Hamid Nawab, PHI Publication
2. Digital Signal Processing by J. G. Proakis and D. G. Manolakis, PHI Publication.
3. Signals and Systems by M. J Roberts, McGraw Hill

References Books

1. Signals and Systems by H.P Hsu, McGraw Hill
2. Signals and Systems by Simon Haykin and Barry Van Veen, Wiley Publication.
3. Signal Processing and Linear systems by B. P. Lathi, Oxford University Press.

Course Name: **Linear Control Systems**
Course Code: **EE-314**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** | Course Credits: **03**

Course Objectives:

- To impart knowledge about developing mathematical models of physical systems and deriving their transfer function.
- To introduce the concept of analyzing the LTI systems for stability in time domain and frequency domain.
- To enable the students to understand the basic control design methods to meet out desired performance/specifications.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Control system:** Historical overview, system, servomechanism, open loop and closed loop systems, mathematical modeling of physical systems, mechanical and electrical system analogy.	**3**
UNIT-02	**Feedback and Non-Feedback Systems:** Block diagram representation and reduction techniques, Signal flow graphs, Mason Gain Formula, feedback and non-feedback systems, regenerative and degenerative feedback, effect of variation of system parameters on system performance, advantages of feedback, Control Components, general block diagram of a control system, A.C. and D.C. Servomotors, A.C. tachometer, synchro-transmitter and receiver, synchro pair as control transformer, A.C. and D.C. position control system, stepper motor etc.	**9**
UNIT-03	**Time Domain Analysis:** Introduction, standard input signals, Response of 1st and 2nd order systems, time domain specifications i.e. rise time, peak time, delay time, peak overshoot, settling time steady state error etc., different types of feedback systems, Steady state errors for unit step, unit ramp and unit parabolic inputs, Effect of addition of zero to the system.	**6**
UNIT-04	**Stability Analysis:** Introduction, concept of stability, conditions for stable system, asymptotic, relative, and marginal stability, Routh-Hurwitz criterion for stability, Root Locus Technique, concepts of root locus, construction of root loci, and various rules pertaining to locus diagram development	**7**
UNIT-05	**Frequency Domain Analysis:** Introduction, Relation between time and frequency response for 2nd order system, bode plot, construction procedure for bode plot, gain cross over and phase cross over frequency, gain margin and phase margin, Nyquist plot & Nyquist stability criterion.	**7**
UNIT-06	**Control System Design:** Selection and realization of basic compensators like lead, lag and lag-lead compensators etc., Introduction to PID Control.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different physical systems and classify them as open loop and close loop control
CO2: Describe the mathematical relation between input and output for LTI systems.
CO3: Apply different time domain and frequency domain tools to analyze the absolute and relative stability of LTI systems.
CO4: Assess the performance of LTI systems to different inputs and to design basic controllers to meet out desired performance.

Course Name: **Induction and Synchronous Machines lab**
Course Code: **EE-315**

Textbooks

1. Control System Engineering by I.J. Nagrath and M. Gopal, Wiley Eastern.
2. Modern Control Engineering by K. Ogata, Prentice Hall India.
3. Control System Engineering by N.S. Nise, Wiley India (P) Limited.

Reference Books

1. Automatic control Systems by B.C. Kuo, Prentice Hall India.
2. Digital control and State Variable Methods by M. Gopal, Tata McGraw Hill.

Contact Hours/Week**: 2P**	Course Credits**: 01**

Course Objectives

- To provide general understanding about electrical machines and their parts.
- To impart knowledge and understanding about induction and synchronous machine and their tests.
- Acquire knowledge about the starting and speed control of induction motors.

List of Experiments

1. To Obtain Open Circuit and Short circuit characteristics of a synchronous generator and calculate its synchronous impedance.
2. To estimate hysteresis and eddy currents losses of single-phase Transformer at rated voltage and frequency by conducting variable frequency at no load test.
3. To Perform load test on 3-phase induction motor.
4. To perform load test on self-excited induction generator.
5. To conduct slip test on the salient pole synchronous machine and calculate Xd and Xq parameters.
6. To perform no load and block rotor test on three phase induction motor and determine the equivalent circuit parameter from these tests.
7. To measure the zero-sequence reactance of synchronous machine.
8. To perform starting and the synchronization of three phase synchronous machine by light and dark lamp method.
9. To plot V-curves of a synchronous motor.
10. To study the dissectible machine system.
11. To control the speed of a 3-phase induction motor using pole changing method.
12. To control the speed of a slip ring induction motor by varying rotor resistance.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Students will gain knowledge of various parts of an electrical machine.

CO2: Ability to conduct experiments on A.C. Machines to find the characteristics.

CO3: Able to calculate torque and speed of given rotating machine.

Course Name: **Power System Protection Lab**
Course Code: **EE-316**

Contact Hours/Week: 2P Course Credits: **01**

Course Objectives

- To provide skills for performing experiments related to power system protection.
- To provide skills for practical applications related to power system protection.
- Toenablethestudentstounderstandtheapplicationofpowersystemprotection.

List of Experiments

1. To study the DMT and IDMT characteristics of micro controller based over current relay.
2. To study the DMT and IDMT characteristics of micro controller based over & under voltage relay.
3. To study the characteristics of micro controller-based earth fault relay using IDMT and DMT.
4. To study the DMT and IDMT characteristics of micro controller based over frequency relay.
5. To study the DMT and IDMT characteristics of microcontroller based under frequency relay.
6. To study the IDMT characteristics of electromechanical type earth fault relay.
7. To study the characteristics of electromechanical type over frequency relay.
8. To study the characteristics of electromechanical type over voltage relay.
9. To study the characteristics of electromechanical type under voltage relay.
10. To study the characteristics of electromechanical type over current relay at different current setting.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify the various practical problems of power system protection.
CO2: To know the practical concepts of power system protection.
CO3: To understand the fundamental practical concepts of various types of relays.

Course Name: **Control Engineering Lab**
Course Code: **EE-317**

Contact Hours/Week**: 2P** Course Credits**: 01**

Course Objectives

- To analyze transient and steady state behavior of a control system experimentally.
- To study different control components and their utility as error detectors.
- To learn and implement basic control mechanisms using compensators and PID controllers.

List of Experiments

1. To study potentiometer-based error detector and to draw its characteristics.
2. To study speed control and reversal of stepper motor using microprocessors.
3. To study synchro transmitter – receiver pair and its operation as an error detector.
4. Study of two-phase AC servo motor and draw its speed torque characteristics.
5. To study voltage sensitive bridges and to analyze its sensitivity and linearity.
6. To study D.C. position control system and to execute position control through continuous and step command.
7. To design, implement and study the effects of different cascade compensation networks for a given system.
8. To study the Digital control system and to implement digital PID control for a modeled process.
9. To study relay as nonlinear element and effect of dead-zone and hysteresis on the controlled process.
10. To study speed control of DC Servomotor using PID controller.
11. To study magnetic amplifier and to plot control current versus load current characteristics for series, parallel and self-saturation mode configuration.
12. To study and perform simple two step open loop control and proportional control on process control simulator kit.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand and evaluate the steady state and transient performance of LTI systems.
CO2: Design and develop simple control mechanisms for given LTI systems.
CO3: Understand the characteristic behavior of AC/DC actuators and their industrial applications.

Course Name: **Utilization of Electrical Energy and Illumination**
Course Code: **EE-351**
Course Type: **Discipline Elective (DE- II)**

Contact Hours /Week: **2L** Course Credit: **02**

Course objective:

- Introducing the principles of electrical drives and their applications in daily life.
- To provides knowledge on electrical traction systems.
- To familiarize the students about the fundamentals of illumination.

Unit Number	Course Content	Contact Hours
UNIT 01	**Electric Drives**: Types of electric drives, choice of motor, starting and running characteristics, speed control, temperature rise, specific applications of electric drives, types of industrial loads, continuous, intermittent, and variable loads and load equalization.	**4**
UNIT 02	**Electric Heating and Electric Welding:** Advantages and methods of electric heating- resistance heating, induction heating, and dielectric heating. Electric welding- resistance and arc welding, electric welding equipment, comparison between AC and DC welding, electrodes of various metals, defects in welding.	**5**
UNIT 03	**Electric Traction**: System of electric traction and track electrification. Review of existing electric traction systems in India. Special features of traction motor, methods of electric braking- plugging, rheostatic braking, and regenerative braking Mechanics of train movement. Speed-time curves for different services- trapezoidal and quadrilateral speed-time curves.	**8**
UNIT 04	**Illumination**: Introduction, terms used in illumination, laws of illumination, polar curves, photometry, integrating Sphere, sources of light, discharge lamps, MV and SV lamps, comparison between incandescent lamp, sodium vapor lamp, fluorescent lamp, CFL and LED Basic principles of light control, types and design of lighting and flood lighting.	**7**

Course outcomes:
Upon successful completion of the course, the students would be able:
CO1: To understand the operating principles and characteristics of traction motors with respect to speed, temperature, and load conditions.
CO2: To get acquainted with different types of heating and welding techniques.
CO3: To understand basic principles of illumination, its measurement and design of lighting system.

Textbooks

1. Utilization of Electric Energy by E. Openshaw Taylor, University Press.
2. Art and Science of Utilization of Electrical Energy by Pratap, Dhanpat Rai & sons.

Reference Books

1. Utilization of Electrical Power including Electric Drives and Electric Traction by NV Suryanarayana, New Age International Private Limited, Publishes

Course Name: **Non-Conventional Energy** Course Code: **EE-352** Course Type: **Discipline Elective (II)**		
Contact Hours/Week: **2L**		Course Credits: **02**
Course Objectives • Awareness about non-conventional energy Sources and technologies. • Adequate input on a variety of issues in harnessing wind energy and ocean energy. • To familiarize the students with energy sources like solar, geothermal, wind and fuel cells. • To familiarize the students with thermos-electric power generation.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Photovoltaic Power Generation:** Introduction, spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current, practical solar cell performance, commercial photovoltaic systems, test specifications for PV systems.	**5**
UNIT-02	**Magneto Hydrodynamics:** Introduction, Motion of charged particle and combined E and B field, conductivity in presence of B-field, principles of MHD power generation, Ideal MHD generator performance, Practical MHD generator, Faraday and Hall configuration, MHD technology.	**4**
UNIT-03	**Wind Energy:** Wind-power conversion, properties of air and wind, types of wind turbine and their operating characteristics, basics of airfoil theory and life force.	**3**
UNIT-04	**Ocean Energy:** Introduction, tides and tidal power stations, modes of operation of a tidal project, Examples of tidal power systems, turbines and generators for tidal power generation, wave energy conversion, properties of waves and power content, wave-energy conversion devices, ocean thermal energy conversion (OTEC) types, applications, and examples of OTEC Systems.	**4**
UNIT-05	**Miscellaneous Energy Conversion System:** Coal gasification & liquefaction, biomass conversion, geothermal energy, hydrogen energy, thermo-electric energy, fuel cells and batteries.	**4**
UNIT-06	**Environmental Effects:** Introduction, global energy position, environmental effects of energy conversion systems, pollution from coal and preventive measures, steam stations and pollution, acid rain, pollution free energy systems.	**4**
Course Outcomes Upon successful completion of the course, the students will be have: CO1: Ability to create awareness about non-conventional energy sources and technologies. CO2: Ability to recognize current and possible future role of non-conventional energy sources CO3: Ability to explain the various non-conventional energy sources, technologies, and their applications. CO4: Ability to understand basics about Energy Conversion Systems and their effects on environment.		

Textbooks

1. Energy Conversion Systems by Rakosh Das Begamudre, New Age International Publishers.
2. Solar Energy: Principles of Thermal Collection and Storage by S. P. Sukhatme and J. K. Nayak, TMH, New Delhi, 3rd Edition.

Reference Books

1. Renewable Energy Resources by John Twidell and Tony Weir, Taylor, and Francis.
2. Energy Science: Principles, Technologies and Impacts by John Andrews and Nick Jelly, Oxford.
3. Handbook of Renewable Technology by Ahmed and Zobaa, Ramesh C Bansal, World scientific, Singapore
4. Renewable Energy Technologies by Ramesh & Kumar /Narosa.
5. Renewable Energy Technologies – A Practical Guide for Beginners by Chetong Singh Solanki, PHI

Course Name: **Advance Topics in Electrical Insulations** Course Code: **EE-353** Course Type: **Discipline Elective (II)**		
Contact Hours/Week: **2L**		Course Credits: **02**
Course objectives • Familiarization of fundamental principles of electrical insulations, including types of insulations, properties, and aging mechanisms. • To introduce emerging trends in electrical insulation. • To present advanced topics on Insulation failure analysis and its relevance in power system asset management.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Review on Electrical Insulations:** Definition and types of electrical insulations, Properties of electrical insulations (dielectric strength, breakdown voltage, etc.), Insulation materials (polymers, ceramics, etc.), Aging mechanisms and degradation of insulations, Polarization mechanisms in dielectrics, Thermal and electrical properties of insulating materials, Standards and regulations for electrical insulations	**5**
UNIT-02	**Emerging Insulation Materials and Systems:** Newer Developments in Polymers for electrical insulations (e.g. polyethylene, polypropylene, silicone rubber),Ceramic insulations (e.g. alumina, zirconia), Composite insulations (e.g. polymer-ceramic, polymer-nanoparticle composites), Insulation systems for high voltage and power equipment, Nano-structured materials for electrical insulations, Biodegradable and eco-friendly insulating materials, Advanced manufacturing techniques for insulation materials and systems, Insulation selection criteria, various insulation levels and insulation materials, Surge protection of insulation systems used in power systems	**7**
UNIT-03	**Advanced Tools for Insulation Failure Analysis:** Causes of insulation failures (e.g. thermal, mechanical, electrical), Failure modes and mechanisms of insulations (e.g. thermal degradation, electrical breakdown, aging), Analytical methods for failure analysis (e.g. SEM, FTIR, DSC), & Statistical analysis of insulation failures, Failure analysis of insulation in harsh environments, Advanced tools and techniques for failure analysis	**6**
UNIT -04	**Advanced Topics in Electrical Insulations:** Advanced materials for electrical insulation (e.g. nano-composites, aerogels), Advanced techniques for insulation diagnosis (e.g. ultra-wideband technology, machine learning), Advanced insulation coordination methods for critical applications (e.g. offshore wind turbines, hybrid electric vehicles), Insulation materials for high-temperature applications, Smart insulation systems and materials (e.g. self-healing, self-monitoring, self-cleaning), Advanced insulation design and optimization techniques	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Understand the fundamental principles, types and aging mechanisms of electrical insulations.

CO2: Analyze and evaluate different types of insulation materials and systems.

CO3: Identify the causes of insulation failures and learn about analytical methods for failure analysis.

CO4: Gain knowledge about advanced topics in electrical insulations including advanced materials, techniques for insulation diagnosis, insulation coordination methods, and advanced insulation design and optimization.

Textbooks

1. High Voltage Engineering and Testing, 3rd edition by Hugh M. Ryan and Rodney J. Broadhurst - Institution of Engineering and Technology (IET)
2. Dielectric Phenomena in Solids: With Emphasis on Physical Concepts of Electronic Processes in Insulators by Kwan Chi Kao –Elsevier

Reference Books

1. High Voltage and Electrical Insulation Engineering by Ravindra Arora, Wolfgang Mosch, Wiley publications.

Course Name: **Energy Auditing and Management**
Course Code: **EE-354**
Course Type: **Discipline Elective (II)**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- Obtain knowledge of energy scenarios and energy management.
- Understanding the concepts of energy auditing, electrical systems, and relevant issues.

Unit Number	Course Content	Contact Hours
UNIT-01	**Energy Scenario and Government Programs:** Energy needs of growing economy, long term energy scenario, Energy pricing, Energy sector reforms, Energy and environment, Energy Conservation Act, BEE & State Development Agencies Government & EESL Programs, PAT Scheme, Municipal & Agriculture DSM Initiatives Standards and Labelling Program EEC initiatives in Other Sectors, Energy security, Energy strategy for the future, Energy conservation Act-2001 and its features.	**5**
UNIT-02	**Energy Management and Audit:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments	**5**
UNIT-03	**Material and Energy Balance:** Facility as an energy system, Methods for preparing process flow, Material, and energy balance diagrams. Case Studies / Best Practices Large Industries (Cement/ Iron & Steel/ Thermal Power Plants) SME Units Power Distribution Utilities / Railways Buildings/ Hotel/ Other Sectors.	**7**
UNIT-04	**Energy Efficient Electrical Systems:** Electricity tariff, Load management and maximum demand control, Power factor improvement, Distribution, and transformer losses. Losses in induction motors, Motor efficiency, Factors affecting motor performance, Rewinding and motor replacement issues, energy efficient motors. Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Understand the need for energy auditing and Energy Management
CO2: Understand concepts and application of best practices in industries.
CO3: Analyze the Load management and Energy conservation issues.

Textbooks

1. Handbook on Energy Audit and Environment Management by Abbi, Y.P. and Jain, S., Teri Press, 2006.
2. Energy Conservation by P. Diwan and P. Dwivedi, Pentagon Press, 2008.
3. Handbook of Energy Audits by A. Thumann, W.J. Younger, T. Niehus, CRC Press,8th Edition, 2008.

Reference Books

1. National Productivity Books by LC Witte, PS Schmidt, and DR Brown: Industrial Energy

Management and Utilization (Hemisphere Publishing Corporation, Washington, 1998).
2. Energy Management Handbook, Seventh Edition by WC Turner, (Fairmont Press Inc., 2007)
3. National Productivity Council, Website: (http://www.npcindia.gov.in/)
4. Bureau of Energy Efficiency, Website: (https://beeindia.gov.in/en /)
5. Petroleum Conservation Research Association, Website: (http://www.pcra.org/)
6. Energy Managers & Auditors Alliance Guidebooks, Website: (http://www.em-ea.org/)

Course Name: **Fundamentals of Control System**
Course Code: **EE-301**
Course Type: **Open Elective**

Contact Hours/Week: 3L **Course Credits: 03**

Course Objectives

- To discuss basic concepts of linear systems.
- To provide a basic understanding of mathematical model of linear systems.
- To introduce the fundamental concept of different control components.
- To enable the students to understand the concepts of time and frequency domain analysis.
- To learn stability analysis of control systems.
- To introduce the concept of state variables.

Unit Number	Course Content	Contact Hours
UNIT-01	**Basic Concepts:** Historical Review, Definitions, Classification, Relative Merits and Demerits of Open and Closed Loop Systems.	**3**
UNIT-02	**Mathematical Models of Control System:** Linear and Non-Linear Systems, Transfer Function, Mathematical Modeling of Electrical, Mechanical and Thermal Systems, Analogies, Block Diagrams and Signal Flow Graphs.	**7**
UNIT-03	**Control Components:** DC Servomotor, AC Servomotor, Potentiometers, Synchronous, Stepper Motor.	**5**
UNIT-04	**Time and Frequency Domain Analysis:** Transient and Frequency Response of First and Second Order Systems, Correlation Between Time and Frequency Domain Specifications, Steady-State Errors and Error Constants, Concepts and Applications of P, PD, PI and PID Types of Control.	**7**
UNIT-05	**Stability Analysis:** Definition, Routh-Hurwitz Criterion, Root Locus Techniques, Nyquist Criterion, Bode Plots, Relative Stability, Gain Margin and Phase Margin.	**7**
UNIT-06	**State Variable Analysis:** Introduction, Concept of State, State Variables & State Models, State Space Representation of Linear Continuous Time Systems, State Models for Linear Continuous Time Systems, State Variables and Linear Discrete Time Systems, Solution of State Equations, Concept of Controllability & Observability.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Demonstrate fundamentals of (feedback) control systems.
CO2: Explain mathematical model for different systems.
CO3: Explain different control components.
CO4: Explain the relation between time and frequency domain specification and employ controllers such as P, PD, PI and PID control design.
CO5: Understand significance of the different tools for control system design and analysis

such as Nyquist plots, Bode plots, and Evans plots (root locus).
CO6: Demonstrate concept of state variables and state model.

Textbooks

1. Control System Engineering by I.J. Nagrath and M. Gopal, Wiley Eastern.
2. Modern Control Engineering by K. Ogata, Prentice Hall India.
3. Control System Engineering by N.S. Nise, Wiley India (P) Limited.

Reference Books

1. Automatic control Systems by B.C. Kuo, Prentice Hall India.
2. Digital control and State Variable Methods by M. Gopal, Tata McGraw Hill.

Course Name:**Neural Networks and Fuzzy Logic Systems**
Course Code: **EE-302**

Course Type: **Open Elective**

Contact Hours/Week:**3L** CourseCredits:**03**

Course Objectives

- To impart knowledge about Neural networks and fuzzy logic systems.
- To impart knowledge about the application of artificial intelligence techniques in different fields of engineering.
- To identify, formulate and solve the neural network and fuzzy logic-based problems.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Biological foundation, mathematical model of biological neuron, feed-forward and feedback ANN models, types of activation function.	**5**
UNIT-02	**Learning Paradigms of ANN:** Supervised and unsupervised learning, learning rules, single layer and multilayer perceptron model, error back propagation learning algorithm, pattern classification, clustering, Kohonen self-organizing feature map, radial basis function network, Hopfield network, applications of ANN models to engineering problems.	**11**
UNIT-03	**Fuzzy Sets and Theory:** Crisp sets, fuzzy sets, fuzzy set operations, properties, membership functions, measures of fuzziness, fuzzification and defuzzification methods, fuzzy relations.	**6**
UNIT-04	**Fuzzy Arithmetic:** Operation on fuzzy relations, fuzzy numbers and arithmetic, fuzzy implications, approximate reasoning, systems based on fuzzy rules, fuzzy inference.	**4**
UNIT-05	**Fuzzy Control Systems:** Introduction, fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems.	**5**
UNIT-06	**Hybrid Intelligent Systems:** Genetic algorithms, neuro-fuzzy systems, adaptive neuro-fuzzy inference system, evolutionary neural networks, fuzzy evolutionary systems.	**5**

Course Outcomes

Successful completion of the course, the students will be able to

CO1: Describe the working of artificial neural network and fuzzy logic systems.

CO2: Apply the set techniques in different fields, which involve perception, reasoning, and learning.

CO3: Analyze and design a real-world problem for implementation and understand the dynamic behavior of a system and assess the results obtained by ANN and fuzzy systems.

Textbooks

1. Introduction to Artificial Neural Systems by Jacek M Zurada, West Publisher.
2. Neural Networks-Algorithms, Applications, and Programming Techniques by J.A. Freeman, & D.M. Skapura, Pearson Education.
3. Essentials of Fuzzy Modeling and Control by Ronald R. Yager and Dimitar P. Filev, John Wiley & Sons Inc.

References

1. Fuzzy System Theory and Applications by T. Terano K Asai and M. Sugeno, Academic

Press.
2. Neural Networks, Fuzzy Logic, and Genetic Algorithm: Synthesis and Applications by Rajasekaran S. and Pai G. A. Vijay Lakshmi Pal, PHI New Delhi.

Course Name: **Electrical Machines & Drives**
Course Code: **EE-303**
Course Type: **Open Elective**

Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To learn about operation, characteristics, and control of DC and AC machines. • To have knowledge about the operation, starting characteristics of synchronous machines. • To impart knowledge about synchronization methods and parallel operation of alternators. • To develop skills for the selection of suitable AC and DC electrical machines in any practical application as an electrical drive		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction:** Principle of Energy Conversion, Electromechanical Systems, D.C Machines, Construction, Types of DC Machines, Expressions of Generator Terminal Voltage, Characteristics. Motoring Mode, Expressions of Torque, Speed Control. Starting & Braking. Load Torque & Its Components, Dynamical Equation of an Electric Drive, Applications of DC Electrical Drives.	**8**
UNIT-02	**Polyphase Induction Machines:** Principle of operation, slip, phasor diagram, equivalent circuit, expression for torque, maximum torque, starting torque and output power, torque-slip and power-slip characteristics Open& Short Circuit Tests, Performance Estimation, Power factor control in three phase induction motor, Starting, braking and Speed control of induction motor, applications in Electrical Drives	**12**
UNIT-03	**Synchronous Machines:** Principal of operation, construction types, starting as synchronous motor, Operation as Generator, Operating characteristics of alternators and their ratings, Steady state power flow equations, Power angle characteristics, Constant excitation and constant power output, slip test-curves, Operation as a Synchronous condenser.	**7**
UNIT-04	**Single Phase Induction Motors:** Principle of operation based on double-revolving field theory, Equivalent circuit, performance calculations and characteristics, Starting methods, Maximum starting torque conditions, Hysteresis motor, Reluctance motor and stepper motor and their applications in Various drives.	**6**
Course Outcomes Upon successful completion of the course, the students will be able to: CO1: Explain characteristics of induction machines. CO2: Understand utility of AC and DC Electric Drives CO3: Carryout dynamics & performance analysis of AC and DC machines. CO4: Explain various phenomena associated with DC, AC and Synchronous machines.		
Textbooks 1. Electrical Machinery by P.S. Bhimbra, Khanna Publishers, Delhi. 2. Electric Machinery by A.E. Fitzerald, C. Kings ley and S.D. Umans, Tata Mc Graw Hill. **Reference Books** 1. Theory of AC Machinery by A.S. Langsdorf, Tata Mc Graw Hill 2. Electrical Machines and Drives, Fundamentals and Advanced Modelling by Jan A Malkebeek, Springer		

Course Name:	**Sensors and Transducers**
Course Code:	**EE-304**

Course Type: **Open Elective**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To make students familiar with the construction and working principle of different types of transducers.
- To know the methods of measurement, classification of transducers and to analyse errors.
- To understand the behaviour of transducers under static and dynamic conditions.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Static characteristics - accuracy, precision, and bias, static sensitivity, linearity, threshold, resolution, hysteresis, and dead space.	**4**
UNIT-02	**Generalized Performance characteristics of Instruments:** Dynamic characteristics- Step response of first order Instruments, Ramp response of first order Instruments. Step response of second order instruments.	**6**
UNIT-03	**Variable Resistive Transducers:** Principle of operation, construction details, characteristics and applications of potentiometer, strain gauge, resistance thermometer, Thermistor, hot-wire anemometer, Piezo-resistive sensor, and humidity sensor.	**6**
UNIT-04	**Variable Inductance Transducers:** Inductive transducers: Principle of operation, construction details, characteristics, and applications of LVDT, Induction potentiometer, Variable reluctance transducers, Synchros, Microsyn.	**6**
UNIT-05	**Variable Capacitance Transducers:** Principle of operation, construction details, characteristics of capacitive transducers, Different types and Signal Conditioning of capacitive transducers, Applications- Capacitor microphone, Capacitive pressure sensor, Proximity sensor.	**6**
UNIT-06	**Other Transducers:** Piezoelectric transducer, Hall Effect transducer, Magneto elastic sensor, Digital transducers, Fiber optic sensors, Environmental Monitoring sensors (Water quality & Air pollution), Introduction to MEMS – Introduction to Smart transducers and its interface standard.	**8**

Course Outcomes

Upon successful completion of the course, the students will have:

CO1: Ability to analyze the response characteristics of first and second order instruments.

CO2: Ability to determine the static and dynamic characteristics of transducers.

CO3: Ability to analyze the problems/limitations related to transducers.

Textbooks

1. Measurement Systems by Ernest.O. Doebelin, Tata McGraw-Hill Publishing Company Ltd.
2. Electrical Measurements and Measuring Instruments by R.K. Rajput, S. Chand & Company Ltd.

Reference Books

1. Transducers and Instrumentation by D.V.S. Murthy, Prentice Hall of India Pvt. Ltd., New Delhi.
2. Sensors and Transducers by D. Patranabis, Prentice Hall of India Pvt. Ltd., New Delhi.

Course Name: **Renewable Energy Sources**
Course Code: **EE-305**
Course Type: **Open Elective**

Contact Hours/Week: **3L** | Course Credits: **03**

Course Objectives

- To impart in depth knowledge of various types of renewable energy sources.
- To understand the concept of micro grid using different renewable energy sources.
- To understand the basic principles of operation of the various renewable energy sources.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Environmental aspects of electric power generation from conventional sources: Limitation of fossil fuels - Atmospheric pollution – effects of hydro-electric projects – disposal of nuclear waste – GHG emission from various energy sources and its effects – need for renewable energy sources.	**4**
UNIT-02	**Solar Photo-Voltaic System:** Solar radiation and its measurement – Angle of sun rays on solar collector – optimal angle for fixed collector – sun tracking, an introduction to solar cell, solar PV module, PV system design and applications – stand-alone and grid connected systems, environmental impacts.	**8**
UNIT-03	**Wind Energy:** Wind energy, classification of wind turbines – aerodynamic operation of wind turbine, extraction of wind turbine power, wind turbine power curve, horizontal axis wind turbine generator – modes of wind power generation – stand-alone and grid connected system, environmental impacts.	**8**
UNIT-04	**Fuel Cell System:** Principle of operation of fuel cell, technical parameters of fuel cell, Type of fuel cell – advantages of fuel cell power plants, energy output, efficiency and emf of fuel cell – operating characteristics, applications, and environmental impacts.	**6**
UNIT-05	**Hydro Energy:** Introduction, layout of powerhouse, types of hydro power schemes, types of hydraulic turbines, types of hydro generators.	**6**
UNIT-06	**Economics of Hydro Plants:** selection of number of units, capacity of power plant and energy generation, and economics of the hydro power plant.	**4**

Course Outcomes

CO1: Upon successful completion of the course, the students will be able to
CO2: Obtain knowledge of different types of renewable energy sources.
CO3: Obtain the solar energy geometry and characteristics of different types of thermal collectors and PV cells and related applications.
CO4: Understand the types, performance, integration of windmill and its applications.
CO5: Understand the fuel cell types, working principles and its related applications.
CO6: Understand the concept related to hydro generation.

Textbooks

1. Energy Conversion Systems by Rakosh Das Begamudre, New Age International Publishers.
2. Solar Energy: Principles of Thermal Collection and Storage by S. P. Sukhatme and J. K. Nayak, TMH, New Delhi, 3rd Edition.

3. Renewable Energy Resources by John Twidell and Tony Weir, Taylor, and Francis.
4. Energy Science: Principles, Technologies and Impacts by John Andrews and Nick Jelly, Oxford.

Reference Books

1. Handbook of Renewable Technology by Ahmed and Zobaa, Ramesh C Bansal, World Scientific, Singapore
2. Renewable Energy Technologies by Ramesh & Kumar, Narosa.
3. Renewable Energy Technologies: A Practical Guide for Beginners by Chetong Singh Solanki, PHI

Course Name: **Optimization Methods in Engineering** Course Code: **EE-306** Course Type: **Open Elective**	
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives

- To impart knowledge about the principles of optimization techniques
- To introduce the fundamental concepts relevant to classical optimization methods, linear programming, nonlinear programming and nontraditional methods
- To enable the students to understand the factors that cause the different optimization methods to provide different solutions for the same mathematical problem

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction and Classical Optimization Techniques, Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces.	**6**
UNIT-02	**Classification of Optimization problems:** Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints. Solution by method of Lagrange multipliers – multivariable Optimization with inequality constraints, Kuhn-Tucker Conditions, Constraint Qualification.	**6**
UNIT-03	**Linear Programming:** Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Elementary operations; Graphical method for two variable optimization problem; Examples; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Simplex criterion; Minimization versus maximization problems; simplex method with artificial variables	**6**
UNIT-04	**Unconstrained Optimization Techniques:** Introduction; Standard form of the problem and basic terminology; Direct search method, Univariate and pattern search method Indirect search method-Steepest Descent (Cauchy) method, Conjugate gradient method, Newton's method, application problems.	**6**
UNIT-05	**Constrained Optimization:** Introduction; Standard form of the problem and basic terminology; Direct method: Sequential Linear Programming, Indirect method: Penalty function method Interior and exterior penalty function method, Augmented Lagrangian method, application problems.	**6**
UNIT-06	**Introduction to Non-Traditional Methods:** Genetic Algorithm: Introduction, Representation of objective function and constraints, Genetic operators and numerical results. Introduction to Neural network-based optimization.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different types of optimization techniques and problems.

CO2: Describe techniques like calculus based classical optimization, unconstrained optimization, constrained optimization.

CO3: Apply principles and techniques described in CO2 to solve sample mathematical and practical optimization problems.

CO4: Assess the results obtained by applying optimization techniques to solve mathematical programming problems

Textbooks

1. Engineering Optimization Theory and Practice by Singiresu S. Rao, New Age International Publisher
2. Optimization Methods in Operations Research and Systems Analysis by K.V. Mital and C. Mohan, New Age International (P) Limited, Publishers, 3rd edition, 1996.

Reference Books

1. Operations Research: An Introduction by H.A. Taha, PHI Pvt. Ltd., 6th edition.
2. Introductory Operations Research by H.S. Kasene & K.D. Kumar, Springer (India), Pvt. Ltd

Course Name:**Signals & Systems** Course Code: **EE-307** Course Type: **Open Elective**	
Contact Hours/Week: **3L**	Course Credits: **03**

Course Objectives		
• To develop an understanding of signals, systems and their properties. • To describe the methods for computing the response of LTI systems. • To develop an ability to carry out frequency analysis of continuous and discrete- time signals. • To introduce the concept of linear filtering and explain the importance of frequency domain analysis.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction:** Continuous time and discrete time signals, periodic signals, energy and power signal, transformer of independent variables, even and odd signals, exponential and sinusoidal signal, unit impulse and unit step functions, interconnections of systems, systems with and without memory, causality, stability, linearity and time invariance.	**4**
UNIT-02	**Sampling:** Introduction, sampling theorem, sampling with zero order hold reconstruction of a signal from its samples, aliasing, sampling of discrete time signals.	**3**
UNIT-03	**Linear Time Invariant Systems:** Introduction, discrete LTI systems, Convolution continuous time unit impulse response and convolution integral representation of LTI systems, properties of LTI systems, Stability, causal LTI system described by difference equation, singularity functions.	**6**
UNIT-04	**Fourier Series Representation:** Fourier series representation for continuous time periodic signals, convergence and properties of continuous time Fourier series. Fourier series representation and properties of discrete time periodic signals, Fourier series and LTI system, frequency shaping and frequency selective filters, discrete time filters.	**8**
UNIT-05	**Continuous and Discrete Time Fourier Transform:** Introduction, representation for a periodic signal, Fourier series representation of a periodic signals, convergence of Fourier transform, Fourier Transform for periodic, properties of continuous time Fourier transform, convolution and multiplication properties systems described by linear constant coefficient different equations. Introduction representation for a periodic signal, DTFT, Fourier transform for periodic signals, convergence of the Fourier transform, Gibbs phenomenon, properties of discrete time Fourier transform convolution and mortification properties, system described by linear constant coefficient difference equations.	**8**
UNIT-06	**Continuous and Discrete-Time System Analysis-** Laplace Transform- Laplace transform and its properties, solution of Differential and Integro-Differential Equations, Block Diagram, System Realization, Bilateral Laplace Transform, Z-Transform, inverse Z-transform, Properties of Z- transform, Solution of Difference Equations.	**7**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Demonstrate and explain the properties of signals and systems.		

CO2:	Find out the response of a LTI system for an arbitrary input.
CO3:	Evaluate Fourier series/Transform for a given signal.
CO4:	Differentiate between ideal and practical frequency selective filters.

Textbooks

1. Signals and Systems by A.V. Oppenheim, A. S. Willsky and Hamid Nawab, PHI Publication
2. Digital Signal Processing by J. G. Proakis and D. G. Manolakis, PHI Publication.
3. Digital Signal Processing: A Computer Based Approach by Sanjit K Mitra, Tata McGraw Hill.

Reference Books

1. Signals and Systems by Simon Haykin and Barry Van Veen, Wiley Publication.
2. Signal Processing and Linear systems by B. P. Lathi, Oxford University Press.

Course Name: **Transducers and Signal Conditioning** Course Code: **EE-321** Course Type: **Discipline Core**		
Contact Hours/Week:3L		**CourseCredits:03**
Course Objectives • To identify, formulate and solve the Transducers and signal conditioning-based problems. • To provide the students with a strong foundation in subject fundamentals required to solve industry-based problems. • To acquire the basic knowledge of transducers and signal conditioning for research applications.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction** Introduction to transducers, Selection of transducers, Mechanical devices as primary detectors, Basic requirements of an electrical transducers, Mathematical model of transducer, Zero, I and II order transducers, Response to impulse, step, ramp and sinusoidal inputs.	**3**
UNIT-02	**Classification and application of transducers:**Type of transducers for measuring displacement, strain, vibration, pressure, flow, temperature, force, torque, liquid level, humidity, PH value, velocity (angular and linear), acceleration; Basic principles of operation, construction details, characteristics and applications of resistive transducers, Inductive transducers, Capacitive transducers, Thermoelectric transducers, Piezoelectric transducers, Hall effect transducers, Electromechanical transducers, Photoelectric transducers, Digital transducers.	**7**
UNIT-03	**Signal Processing Circuits** Introduction, Ideal op-amp, Operational amplifier specifications, Zero crossing detector, Zero crossing detector with hysteresis, Inverting and non-inverting amplifiers, Voltage-follower, Adder, Subtractor, Integrator, Differentiator, Voltage to current converter, Current to voltage converter, Phase shifter circuit, Absolute-value circuit, Peak detector, AC to DC converter, Logarithmic converter, Differential-amplifier, Instrumentation amplifier, Analog modulators and demodulators.	**8**
UNIT-04	**Data Display and Recording Systems** Introduction to analog and digital display methods, Analog recorders, C.R.O., digital input-output devices, Digital frequency meter, Digital voltmeter, multi-meters.	**7**
UNIT-05	**Data Transmission and Telemetry** Introduction, Methods of data transmission, General telemetering system, Electrical telemetering systems, Transmission channels and media, Multiplexing in telemetering systems, Characteristics of frequency division multiplexing, Time-division multiplexing.	**6**
UNIT-06	**Data Acquisition and Conversion** Introduction, Signal conditioning of the inputs, Single channel and multi-channel data acquisition system (DAS), Data conversion, Multiplexer, S/H circuit, A/D converter.	**5**
Course Outcomes Upon successful completion of the course, the students will be able to:		

CO1: Describe working principles of sensors and transducers.
CO2: Understand working principle of transducers used for measurement and comparative study of various transducers.
CO3: Understanding different transducers and sensors for applications in industry.

Textbooks

1. A course in Electrical, Electronic Measurements and Instrumentation by A.K. Sawhney, Dhanpat Rai & Sons.
2. Transducers and Instrumentation by D.V.S. Murty, Prentice Hall of India Private Limited.
3. Measurement Systems (Application & Design) by Ernest O. Doebelin, McGraw Hill Higher Education, New Delhi.

References Books

1. Instrumentation Devices and Systems by C.S. Rangan, G.R. Sharma, and V.S.V. Mani, TMH New Delhi.
2. Operational Amplifiers and Linear Integrated Circuits by Robert F. Coughlin and Frederick F. Driscoll, Prentice-Hall of India.

Course Name: **Digital Signal Processing** Course Code: **EE-322** Course Type: **Discipline Core**		
Contact Hours/Week: 3**L+1T**		Course Credits: **04**
Course Objectives • To provide an overview of applications of DSP and explain its advantages over ASP. • To develop an ability to compute DFT and understand efficient methods for computing it. • To explain the methods for designing FIR and IIR filters.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction:** Basic elements of digital signal processing, comparison of analog and digital signal processing, multi-channel and multi-dimensional signals, random and deterministic signals, FIR and IIR systems, recursive and non-recursive systems, correlation of discrete time signals.	**4**
UNIT-02	**Discrete Fourier Transform and Fast Fourier Transform:** Frequency domain sampling and reconstruction of discrete time signals, DFT, DFT as linear transformation, frequency analysis of signals using DFT, properties of DFT, circular convolution, linear filtering methods based on DFT, overlap save and overlap add method, FFT algorithms, decimation in time and decimation in frequency algorithms, applications of FFT algorithms, linear filtering approach to computation of the DFT, Goertzel algorithm.	**8**
UNIT-03	**Design of FIR Digital Filters:** Introduction, LTI systems as frequency selective filters, Paley-Wiener theorem, characteristics of frequency selective filters, design of linear phase FIR filters, design of digital filters by placement of poles and zeros in z-plane, digital resonators, Notch filters, Comb filters and all pass filters, design of linear phase FIR filters using windows and by frequency sampling method.	**9**
UNIT-04	**Design of IIR Digital Filters:** Introduction, design of IIR filters from their analog counterparts, design using approximation of derivatives, impulse invariance, bilinear transformation and matched z-transformation, frequency transformations in analog and digital domains, design of digital filters based on least squares method, design of IIR filters in frequency domain.	**7**
UNIT-05	**Analysis of Finite Word-Length Effects:** The quantization process and errors, Quantization of fixed and floating –point numbers, analysis of coefficient quantization effects, A/D conversion noise analysis, analysis of arithmetic round-off errors, dynamic range scaling, Signal-to-noise ratio in low-order filters, low sensitivity Digital filters, Limit cycle in IIR digital filters.	**5**
UNIT-06	**Digital Signal Processing Applications**: Overview of Image processing, speech processing and bio signal processing.	**3**
Course Outcomes CO1: Upon successful completion of the course, the students will be able to CO2: Understand and explain the efficient methods for computing Fourier transform. CO3: Realize FIR/IIR systems using efficient structures. CO4: Design simple FIR and IIR filters for given specifications.		

Text Books

1. Digital Signal Processing by J.G. Proakis and D.G. Manolakis, Pearson Education Publisher.
2. Digital Signal Processing by A.V. Oppenheim and R.W. Schafer, Prentice Hall Publisher.
3. Digital Signal and Image Processing by Tamal Bose, John Wiley and Sons Publisher

Reference Books

1. Digital Signal Processing by Sanjit K. Mitra, Tata McGraw Hill Publisher.
2. A Course in Digital Signal Processing by Boaz Porat, Wiley India Edition.

Course Name: **Power System Analysis**
Course Code: **EE-323**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

1. To impart knowledge about the modeling of power system components.
2. To introduce the fundamental concepts of electrical network modeling through Y-bus and Z-bus.
3. To enable the students to understand the concepts involved in short circuit, power flow and stability studies.

Unit Number	Course Content	Contact Hours
UNIT-01	**Power System Components modelling:** Mathematical model of transmission lines, tap changing transformer, generator, and loads.	**5**
UNIT-02	**Topological Analysis of Power Networks:** Primitive impedance and admittance matrices, system graph for transmission network, relevant concepts in graph theory, network representation, network matrices, network reduction.	**6**
UNIT-03	**Bus Impedance Algorithm**: Partial network, addition of link(s), addition of branch(es), removal of elements, implementation of bus building algorithm, 3-phase Z-bus formation.	**6**
UNIT-04	**Short Circuit Studies:** Types of faults, short circuit studies of large power system networks, calculating system conditions after the occurrence of fault, direct short circuit i.e. bolted faults. Comparison between symmetrical components and phase coordinate, method of short-circuit studies.	**7**
UNIT-05	**Power Flow Studies:** Mathematical model of power flow studies, Solution techniques: Gauss- Seidel method, Newton-Raphson method, fast decoupled load flow method, comparison of solution technique.	**8**
UNIT-06	**Stability Studies:** Types of stability, swing equation, point by point method, transient stability, equal area criteria, transient stability improvement.	**5**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify different power system analysis problems.
CO2: Describe problems related to power networks, bus impedance algorithms, short circuit, power flow and stability studies.
CO3: Apply principles to solve problems described in CO2.
CO4: Assess the results obtained by solving above problems.

Textbooks

1. Computer Techniques in Power System Analysis by M.A. Pai, Tata McGraw Hill, New Delhi.
2. Advanced Power System Analysis and Dynamics by L.P. Singh, New Age International

Reference Books

1. Modern Power System Analysis by DP Kothari and I.J. Nagrath, Tata McGraw Hill, New Delhi.

Course Name:**Transducers and Signal Conditioning Lab**
Course Code: **EE-324**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To understand scientific measurement principles and concepts behind modern electronic instrumentation.
- To understand the principle of various types of transducers.
- To know the construction and working of frequently used equipment's like CRO, Signal generator, etc.

List of Experiments

1. (i) Study of Cathode Ray Oscilloscope, its various controls, and their functions.
   (ii) Measurement of AC and DC voltage signals, current, frequency and phase shift using CRO.
2. To study the characteristics of LVDT and measurement of displacement using LVDT.
3. To study piezoelectric transducer and to measure vibration using piezoelectric accelerometer.
4. To study resistive potentiometer transducer and plot its characteristics.
5. Measurement of temperature using:
   (i) Thermistor (ii) Thermocouple (iii) RTD
6. To study the characteristics of LDR in following modes:
   (i) The lamp voltage is kept constant and the distance between the lamp and LDR is varied.
   (ii) The distance kept constant, and voltage is varied.
7. To study airflow sensor.
8. To measure speed of the motor shaft with the help of non-contact pickups:
   (i) Variable reluctance pickup
   (ii) Photoelectric pickup.
9. (i) To study strain gauge transducer.
   (ii) Measurement of force/load using strain gauge transducer.
10. To study and demonstrate X-T and X-Y recordings using a recorder.

Course Outcomes

Upon successful completion of the course, the students will be able:

CO1: To identify various errors in measurement systems and correct them.

CO2: To know the fundamentals of measuring systems including the limitations and capabilities of several measuring devices (LVDT, pressure transducers, strain gages, thermocouples, LDR, etc.) and Equipment's (oscilloscope, signal generator, recorders, etc.).

CO3: To learn characteristics of various transducers.

Course Name: **Power System Simulation Lab**
Course Code: **EE-325**

Contact Hours/Week:**2P** **Course Credits:01**

Course Objectives

- To learn about MATLAB.
- Provide hands-on experience to the students so that they can perform power system studies through simulation.
- To impart knowledge about economic dispatch and realize it through simulation.

List of Experiments

1. To learn basics of MATLAB based Simulation.
2. To build Y-bus by Inspection method and Singular transformation.
3. To frame Z-bus for an electrical network using bus-building algorithm.
4. To perform load flow studies for an electrical network using Gauss-Seidel method.
5. To perform load flow studies for an electrical network using Newton-Raphson method.
6. To perform power flow by fast-decoupled method.
7. To perform dc load flow for an electrical network.
8. To perform economic dispatch through lambda-iteration method
    I. Without transmission losses
    II. With transmission losses.

Course Outcomes

Upon successful completion of the course, the students will be able:

CO1: To perform load flow studies in power system.
CO2: To appreciate the importance of economic dispatch in power system operation.
CO3: To tabulate the results of power system studies for quick understanding of power system operators.

Course Name:**Hydro Power Station Design** Course Code: **EE-341** Course Type: **Discipline Elective -III**

Contact Hours/Week: **2L**		Course Credits: **02**
Course Objectives • To impart knowledge about the planning involved in setting up of a hydro power plant and to understand the impact of hydro units in a global and societal context. • To introduce the fundamental concepts relevant to hydro power plants. • To understand the importance of stability of hydro power plants. • To explain the parameters to be taken into consideration while designing a hydro power plant.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Layout and Planning of Hydro Power Plant:** Introduction, layout of powerhouse, types of hydro power schemes, stages of investigation, PFR, DPR, hydrology, water availability and water conductor system. Penstocks, types, penstock supports, trash racks	**6**
UNIT-02	**Power Potential Estimation of Hydro Power Plants:** Head, dependability analysis, layout of electrical equipment in hydro power station, selection of number of units, capacity of power plant and energy generation, and economics of the hydro powerplant.	**6**
UNIT-03	**Turbines:** Introduction, types of hydraulic turbines and their suitability for power plant, governing of turbines, electrohydraulic governors, time constants of governors and their importance, hydraulic turbine losses and efficiency, cavitation, silt erosion.	**7**
UNIT-04	**Hydro Generators:** Introduction, construction and types of hydro generators, specifications of hydro generators, characteristics of hydro generators, losses and efficiency of hydro generators, parallel operation of alternator in a hydro power plant. Insulation and temperature limits, testing of generators, generator cooling and ventilation, fire protection, design of auxiliary and grounding systems. Special features of hydropower plant stability.	**8**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Apply the fundamentals of hydrology to various hydraulic and civil structures as required for hydro-power projects. CO2: Analyze and design innovations in new technologies of hydraulic structures. CO3: Realize the requirement of pre-requisite measures required to maintain the stability in a hydro power plant. CO4: Design hydro power plant, particularly, electrical design part.		
Textbooks 1. Hydro Electric Engineering: Vol. I, II, III, by J. Guthrie Brown, Blackie & Son Ltd., London. 2. A Handbook of Hydro Electric Engineering by N.C. Nigam, Nem Chand Publishers, Roorkee. 3. Generation of Electrical Energy by B. R. Gupta, S. Chand & Co. **Reference Books** 1. Elements of Electrical Power Station, Design by M. V. Deshpande, A H Wheeler & Co. Ltd. 2. Electrical Machines by D. P. Kothari and I. J. Nagrath, TMH.		

Course Name:	**Deregulation of Power System**
Course Code:	**EE-342**
Course Type:	**Discipline Elective (III)**

Contact Hours/Week: **2L**		Course Credits: **02**
Course Objectives • To Impart knowledge about the restructuring and deregulation of the power sector. • To Introduce the fundamental concepts relevant to transmission pricing, models of deregulation, ancillary services, and international experience of deregulation. • Enable the students to understand the basic concepts of deregulation.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction:** Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, congestion management components of deregulated system, advantages of competitive system.	**6**
UNIT-02	**Transmission Pricing:** Marginal pricing of electricity, nodal pricing, zonal pricing, embedded cost, postage stamp method, contract path method, boundary flow method, MW mile method, VA-mile method, Comparison of different methods.	**7**
UNIT-03	**Deregulation of Power Sector:** Separation of ownership and operation deregulated methods, pool model, pool and bilateral trades model, multilateral trade model, ancillary services. Deregulation Scenario in England and Wales, Norway, China, California, New Zealand, and Indian Power System.	**8**
UNIT-04	**Power Market Development in India:** Institutional structure in Indian Power sector, generation, transmission and distribution utilities.SO& LCDs', REC, ERCs, traders, Power Exchanges, and their roles. Availability based tariff, Open access, Industry structure and regulatory framework, market development, RE policies, RPO, Tariff policies. Policy changes, regulatory changes, Critical issues / challenges before the Indian power sector.	**7**

Course Outcomes

Upon successful completion of the course, the students will be able to

- CO1: Identify different problems related to deregulation of the power industry.
- CO2: Describe problems related to transmission pricing, deregulation models, ancillary services, and international experience.
- CO3: Apply principles to solve problems described in CO2.
- CO4: Assess the results obtained by solving above problems.

Textbooks

1. Power System Restructuring and Deregulation by Loi Lei Lai, John Wiley & Sons Ltd.
2. Understand Electric Utilities and Deregulation by Lorrin Philipson and H Lee Willis, CRC Press.
3. Restructured Electrical Power System Operation, Trading and Volatility by M. Shahidehpour & M. Alomoush, Marcel Dekker Inc.
4. Power System Restructuring Engineering and Economics by M. llic, F. Galiana and L. Fink, Kluwer Academic Publisher, USA.

Reference Books

1. Power System Economics: Designing Markets for Electricity by Steven Stoft, John Wiley & Sons, 1st edition, 2002.

Course Name:**Flexible AC Transmission Systems**
Course Code: **EE-343**
Course Type: **Discipline Elective (III)**

<table>
<tr><td colspan="3">Contact Hours/Week: 2L Course Credits: 02</td></tr>
<tr><td colspan="3">Course Objectives
To provide basic knowledge of the various structures of the compensators and their techniques in FACTS.
To provide basic understanding of active and reactive power flow in the transmission line with and without compensations
To enable students to understand the various order of harmonics in VSIs when used in FACTS.
To learn the different configurations of shunt, series, and combined compensators to maximize the power flow</td></tr>
<tr><td>Unit Number</td><td>Course Content</td><td>Contact Hours</td></tr>
<tr><td>UNIT-01</td><td>AC Transmission Line and Reactive Power Compensation: Transmission interconnection, flow of power in AC system, brief description and definitions of FACTS controllers, analysis of uncompensated line: transmission line equations, performance of a line connected to unity power factor load, performance of a symmetrical line, passive reactive power compensation: compensation by a series capacitor connected at the mid-point of the line, shunt capacitor compensation connected at the midpoint of the line, comparison between series and shunt capacitor compensation.</td><td>10</td></tr>
<tr><td>UNIT-02</td><td>Analysis of VSIs and Static Shunt Compensators: Harmonic analysis of PWM controlled VSIs when used in FACTS, Objectives of shunt compensation: midpoint voltage regulation for line segmentation, methods of controllable VAR generation: variable impedance type static VAR generators: TSC and TCR, voltage source converter type VAR generators: Static Synchronous Compensator (STATCOM).</td><td>7</td></tr>
<tr><td>UNIT-03</td><td>Static Series Compensators: Objectives of series compensation: voltage stability, variable impedance type series compensators: Thyristor-Controlled Series Capacitor (TCSC), GTO Thyristor-Controlled Series Capacitor (GCSC), voltage source converter type series compensators: Static Synchronous Series Compensator (SSSC).</td><td>6</td></tr>
<tr><td>UNIT-04</td><td>Phase Shifters and Combined Shunt/Series Compensators: Basic operating principles, configurations, and characteristics: Phase shifter, Unified Power Flow Controllers (UPFC), Interline Power Flow Controller (IPFC), comparison of UPFC with the other configurations</td><td>5</td></tr>
<tr><td colspan="3">Course Outcomes
Upon successful completion of the course, the students will be able to:
CO1: Examine the interconnection system of the transmission line with their limitations.
CO2: Analyze the effect of series and shunt passive compensators.
CO3: Performance evaluation of different static, shunt, and series compensators.
CO4: Evaluation of different configurations of combined compensators.</td></tr>
<tr><td colspan="3">Text Books
Understanding FACTS by N. Hingorani and L Gyigyi. IEEE Press.
FACTS Controllers in Power Transmission and Distribution by K. R. Padiyar, New Age.</td></tr>
</table>

Reference Books

1. Thyristor-Based FACTS Controllers for Electrical Transmission Systems by R. Mohan Mathur, Rajiv K. Varma, IEEE and Willey.

Course Name: **Electric Drives & Transportation Systems** Course Code: **EE-344** Course Type: **Discipline Elective (III)**
Course Name: **Electrical Machine Design** Course Code: **EE-345** Course Type: **Discipline Elective (III)**
Contact Hours/Week:2L **Course Credits: 02**
Course Objectives • To impart basic knowledge about an electrical drive. • To introduce the fundamental concepts relevant to ac and dc motor drives. • To enable the students to understand the factors that causes the selection of drives for transportation systems.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Electric drive system-Introduction, advantages, parts, classification, equipment and choice criteria, dynamic equations of an electric drive, torque equations, Multi-quadrant operation, types of loads, energy loss during transients and load equalization.	**7**
UNIT-02	**Selection of Motor Drive Rating:** Selection of motor rating– thermal model of motor, classes of duty and determination of motor rating for different classes of drive operation duty.	**7**
UNIT-03	**DC Motor Drives and applications in transportation systems:** Starting, braking, speed control using single-phase and three-phase half and fully controlled rectifiers, chopper fed DC drives & its applications in transportation systems	**7**
UNIT-04	**AC Motors and Applications in Transportation Systems:** Variable voltage/ current, variable frequency control of induction motor fed from VSI of Slip-ring Induction Motor, Starting, braking, Self-controlled synchronous motor, Permanent magnet synchronous motor, Brushless dc motor, Switched reluctance motor, Stepper motors and applications of AC motor drive systems in 2-wheeler, 4-wheeler and in traction systems	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1 Identify suitable electric motor drive for application.

CO2: Describe the operation of dc motor drives to satisfy four-quadrant operation from prospective of transportation systems.

CO3: Explain the working of various phase-controlled converters used in AC Drives w.r.t transportation systems.

CO4: Understand on the operation, working, and controlling of VSI/CSI based drives from transportation system perspective

Textbooks

1. Electric Motor Drives by R. Krishnan, PHI.
2. Electric Drive by M. Chilikin. Mir publishers.
3. Fundamentals of Electrical Drives by GK Bubey, Alpha Science publisher

Reference Books

1. Power Semi-conductor Controlled Drives by G.K. Dubey, Prentice Hall.
2. Power Semiconductor Drives by S.B. Dewan, G. R. Slemon, and A. Straughen, John Wiley.

Contact Hours/Week: **2L**		Course Credits: **02**

Course Objectives

- To learn about the principle of and design of electrical machines.
- To have knowledge about operation and design of transformers.
- To understand about performance and characteristics of three phase induction motors
- To impart knowledge about computer aided tools.

Unit Number	Course Content	Contact Hours
UNIT-01	**Principles of Design of Machines:** Specific loadings, choice of magnetic and electric Loadings, Real and apparent flux densities, temperature rise calculation, Separation of the main dimension for DC. Brief Overview Heating and cooling of machines, types of ventilation and Machine Ratings	**8**
UNIT-02	**Design of Transformer:** General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling tubes, calculation of losses, efficiency and regulation, forces on windings during short circuits.	**6**
UNIT-03	**Design of Three Phase Induction Motors:** General considerations, output equation, idea on choice of specific electric and magnetic loadings, efficiency, power factor, number of slots in stator and rotor, elimination of harmonic torques, Design of stator and rotor winding, slot leakage flux, leakage reactance, equivalent resistance of Squirrel cage rotor, magnetizing current, Efficiency from design data.	**8**
UNIT-04	**Introduction to Computer-Aided Tools:** Introduction to various Computer-Aided Tools for Electrical Machines.	**4**

Course Outcomes:

Upon successful completion of the course, the students will be able to

CO1: Understand the basic design principles and design limitations of DC and AC machines.

CO2: Apply design concepts to design the winding, core, frame, and cooling circuit of single phase and three phase transformers.

CO3: Analyze the performance and accomplish complete design of single phase and three phase induction motors.

CO4: Learn the CAD tools currently used for reliable design of Various Electric Machine Systems.

Textbooks

1. A Course in Electrical Machine Design by A. K. Sawhney, Dhanpat Rai &Sons.
2. Principles of Electrical Machine Design with Computer Programs by S. K. Sen, Oxford and IBH.

Reference Books

1. Design of Transformers by Inderjit Das Gupta, Tata McGraw Hill.
2. Electric Machinery by A.E Fitzerald, Charles Kingsley, Tata McGraw Hill.

Course Name: **Embedded Systems**
Course Code: **EE-361**
Course Type: **Discipline Elective-IV**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives
- To familiarize the students with the basic design concepts for designing embedded systems
- To know about the quality attributes of embedded systems
- To be able to design and develop the embedded system

Unit Number	Course Content	Contact Hours
UNIT-01	**Typical Embedded System**: Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components. Characteristics and Quality Attributes of Embedded Systems: Hardware Software Co-Design and Program Modeling: Fundamental Issues in Hardware Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modeling Language, Hardware Software Trade-offs.	**10**
UNIT-02	**Embedded Hardware Design and Development:** EDA Tools, Use of EDA Tools, Schematic Design – Place wire, Bus, port, junction, creating part numbers, Design Rules check, Bill of materials, Netlist creation, PCB Layout Design – Building blocks, Component placement, PCB track routing.	**6**
UNIT-03	**ARM-32-bit Microcontroller family**: Architecture of ARM Cortex M3–General Purpose Registers, Stack Pointer, Link Register, Program Counter, and Special Register. Nested Vector Interrupt Controller. Interrupt behavior of ARM Cortex M3. Exceptions Programming. Design Approaches, Embedded Firmware Development Languages.	**4**
UNIT-04	**Real-Time Operating System (RTOS) based Embedded System Design:** Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads.	**4**

Course Outcomes
Upon successful completion of the course, the students will be able to
CO1: Define a real-life problem in terms of technical specification of relevant embedded system.
CO2: Understand the processor and memory and learn different types of I/O Devices, timer and counting devices.
CO3: Design the embedded system as per the specification and can understand the importance of Hardware Software Co-design in an Embedded System

Textbooks
1. Introduction to Embedded Systems by Shibu K V, Tata McGraw Hill Education Private Limited.
2. The Definitive Guide to the ARM Cortex-M3 by Joseph Yiu, Newnes, (Elsevier).
3. Embedded Systems – A contemporary Design Tool by James K Peckol, John Wiley.

Reference Books
1. Specification and Design of Embedded Systems by D. Gajski, F. Vahid, S. Narayan, and J. Gong., Prentice Hall.
2. Hardware Software Co-design: Principles and Practice by Jorgan Syaunstrup and W. Wolf., Kluwer Academic Publishers.

Course Name: **Biomedical Instrumentation**
Course Code: **EE-362**
Course Type: **Discipline Elective (IV)**

Contact Hours/Week: 2**L** Course Credits: **02**

Course Objectives

- To familiarize the students with the physiological systems and origin of bioelectric signals.
- To understand the acquisition process of bioelectric signal like ECG, EEG, EMG etc.
- To study invasive and non-invasive methods of patient monitoring and disease diagnosis.

Unit Number	Course Content	Contact Hours
UNIT-01	**Bioelectric Signals, Electrodes and Physiological Transducers:** Biometrics, physiological systems of the body and problems in measuring a living system. Pressure transducers, body temperature transducers, pulse sensors, respiration sensors, bioelectric potentials, bio-potential electrodes.	**8**
UNIT-02	**Biomedical Recorders and Display Systems:** Block diagrams of electro cardiograph, phonocardiograph, electroencephalograph and electromyograph	**6**
UNIT-03	**Patient Monitoring Instruments:** Block diagram of patient monitoring system, Basic cardiac arrhythmias and ambulatory monitoring instruments, measurement of heart rate, blood pressure, and temperature and respiration rate.	**4**
UNIT-04	**Patient Safety:** Physiological effects of electric current, electric shock hazards from electrical equipment, methods of accident prevention.	**3**
UNIT-05	**Biomedical Telemetry:** Single/multi-channel telemetry system and applications of telemetry in patient care.	**3**
UNIT-06	**Modern Imaging Systems:** X-ray machine and X-ray computed tomography, basic magnetic resonance imaging components, basic ultrasonic imaging system, computer applications in biomedical instrumentation.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the source of bioelectric signals.
CO2: Describe the acquisition of signals from cardiovascular and neuro-muscular systems.
CO3: Understand the importance of non-invasive diseases diagnosis methods.
CO4: Explain the role of telemetry in patient treatment.

Textbooks

1. Biomedical Instrumentation and Measurements by L. Cromwell, F. J Weibell. and E. A. Pfeiffer, PHI.
2. Introduction to Biomedical Equipment Technology by J.J. Carr and J.M. Brown, PHI

Reference Books

1. Handbook of Biomedical Instrumentation by R.S. Khandpur, TMH
2. Biomedical Instruments: Theory and Design by W. Welkowitz, S. Deutsch and M. Akay, Academic Press

Course Name: **Probability Random Variables and Stochastic Processes**
Course Code: **EE - 363**
Course Type: **Discipline Elective (IV)**

Contact Hours/Week:**2L** Course Credits:**02**

Course Objectives

- To mathematically model random phenomena with the help of probability theory concepts.
- To introduce the important concepts of random variables and stochastic processes.
- To analyze the LTI systems with stationary random process as input.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Probability Theory:** Definitions, probability space, conditional probability, probability of repeated trials and combined experiments.	**4**
UNIT-02	**Concept of Random Variable, and Functions of One Random variable:** Distribution and density functions, conditional distributions, and total probability. Functions of one random variable and their distribution, and density functions, Mean, Variance, Moments, and characteristic functions.	**8**
UNIT-03	**Two Random Variables, and Their Functions**: Joint (bivariate) distributions, one function of two random variables, two function of two random variables, joint moments of two random variables, joint characteristic functions, Central Limit Theorem.	**8**
UNIT-04	**Random Processes:** General concepts, classifications, mean and correlation functions. Response of the random process for LTI systems in time and frequency domain.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the basic concepts in probability, conditional probability and independent events.

CO2: Understand random variables, mathematical expectation, and different types of distributions, and modeling of natural phenomenon.

CO3: Analyze the response to LTI systems with stationary random process as input.

Textbooks

1. Probability, Random Variables and Stochastic Processes, A Papoulis, McGraw-Hill New Delhi
2. Probability, Statistics and Queuing Theory, V Sundarapandian, PHI Learning, Private Limited
3. Modern Probability Theory, B R Bhat, New Age International (P) Limited, Publishers
4. Probabilistic Methods of Signal and System Analysis, Georage R. Cooper, and Clare D. McGillem, Oxford University Press, New Delhi

Reference Books

1. Probability and Statistics with Reliability and Queuing and Computer Science Applications, K. S. Trivedi.

2. Modern Probability Theory and its Applications, by E. Parzan, Wiley publications.

Course Name: **Reliability Engineering**
Course Code: **EE- 364**
Course Type: **Discipline Elective (IV)**
Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- Demonstrate the approaches and techniques to assess and improve process and/or product quality and reliability.
- Introduce the principles and techniques of Statistical Quality Control and their practical uses in product and/or process design and monitoring.
- Illustrate the basic concepts and techniques of modern reliability engineering tools.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to reliability:** Probability concept, definition of reliability, failure data, mean failure rate, MTTF and MTBF, MTTF in terms of failure density, reliability in terms of hazard rate and failure density, constant hazard, linearly increasing hazard, the Weibull model, density function and distribution function, some important distributions, choice of distribution, expected value, standard deviation, and variance.	**6**
UNIT-02	**System reliability and Improvement**: Introduction, series configuration, parallel configuration, mixed configuration, k out of n systems, methods for solving complex systems, systems not reduced to mixed configurations, logic diagrams, Markov models. Reliability improvement using redundancy, different types of redundancy, optimization, reliability-cost trade off.	**10**
UNIT-03	**Fault tree analysis and other methods**: Introduction, fault tree construction, calculation of reliability from fault tree, tie set and cut set methods.	**6**
UNIT-04	**Maintainability and Availability**: Introduction, maintainability, availability, system down time, reliability, and maintainability trade off, instantaneous repair rate, MTTR, reliability and availability functions. Introduction, reliability allocation for a series system.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Attain the knowledge of evaluation and improvement of reliability.

CO2: Understand reliability cost trade-off.

CO3: Acquire basic knowledge of computing reliability from fault tree.

CO4: Understand the concepts of reliability and maintainability.

Textbooks

1. Reliability Engineering, LS Srinath (4^{th} Edition) EWP East-West Press Publication
2. Reliability Engineering, KK Aggarwal, Kluwer Academic Publisher.

Reference Books
1. Reliability Engineering by A. Elsayed John Wiley & Sons. 2. An Introduction to Reliability and Maintainability Engineering, Ebeling, Waveland Press.

Course Name: **Smart Grid Technologies** Course Code: **EE-381** Course Type: **Stream Core-1**		
Contact Hours/Week: **2L**		Course Credits: **02**
Course Objectives • Understand the features of Smart Grid • Assess the role of Smart Grid Communications and Measurement Technology • To introduce the impact of Distribution Generation Technologies in Smart grids • Understand the operation and Power Quality Management in Smart Grid • To introduce the fundamental concepts relevant to Demand Response in Smart Grid		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction to Smart Grid:** Basics of power systems, working definitions of smart grid, need for smart grid, smart grid domain, smart grid priority areas, regulatory challenges, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional grid & Smart Grid, Smart grid architecture, standards-policies, Smart-grid activities in India.	**6**
UNIT-02	**Smart Grid Communications and Measurement Technology:** Monitoring, PMU, Smart Meters, and Measurements Technologies, Wide Area Monitoring Systems (WAMS), Phasor Measurement Units (PMU) Smart Meters, Smart Appliances Advanced Metering Infrastructure (AMI), Multiagent Systems (MAS) Technology, Multiagent Systems for Smart Grid Implementation.	**8**
UNIT-03	**Power Quality Management in Smart Grid:** Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.	**6**
UNIT-04	**Distribution Generation Technologies:** Introduction to Renewable Energy Technologies, Micro grids, Storage Technologies, Electric Vehicles, and plug–in hybrids, Environmental impact and Climate Change, Economic Issues. Demand response, Potential benefits of demand response in smart grid, enabling smart technologies for demand response.	**8**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Describe the need of smart grid systems and its architecture. CO2: Demonstrate the concepts of Power Quality Management in Smart Grid CO3: Understand the usage and advantages of distribution generation technologies.		
Textbooks 1. Smart Grids Advanced Technologies and Solutions by Stuart Borlase, CRC Press, 2017. 2. Smart Grid Fundamentals of Design and Analysis by James Momoh, Wiley, 2012. **Reference Books** 1. Renewable and Efficient Electric Power System by Gil Masters, Wiley–IEEE Press, 2004.		

2. Wind Power in Power Systems by T. Ackermann, Hoboken, NJ, USA, John Wiley, 2005

Course Name: **Industrial Electronics**
Course Code: **EE-382**
Course Type: **Stream Core-I**

Contact Hours / Week: **2L** — Course Credit: **02**

Course Objectives:

- To impart knowledge about various kind of advanced power electronic converters & systems for industrial processes
- To introduce the fundamental concepts relevant to harmonic analysis of input and output waveforms of advanced converters.
- To highlight the importance of power line conditioners and their impact in real time applications
- To enumerate applications of advanced converters in performance control of industrial electrical drives.

Unit Number	Course Content	Contact Hours
UNIT-01	**Harmonic Analysis of AC to DC Converters:** Analysis of output voltage and input current for 2-pulse and 6-pulse controlled rectifiers and methods of reducing these harmonics, multi-pulse rectifiers. Analysis of output voltage waveforms of single phase and three phase voltage source inverters. Methods of reducing output harmonics.	**6**
UNIT-02	**Resonant Converters:** Classification, basic resonant converter, loads resonant converter, resonant switch converter and zero voltage switching, emerging trends in this field.	**7**
UNIT-03	**Power Conditioners and UPS:** Power line disturbances, generation of harmonics, harmonic standards and recommended practice, power conditioners and uninterruptible power supplies, EMI & EMC related issues, mitigation methods, recent trends.	**6**
UNIT-04	**Motor Drive Applications:** Converters for adjustable speed DC motor and induction motor drives. Methods of improving voltage, current profile of an electric drive, latest trends in the drive performance control.	**6**

Course Outcomes

Upon successful completion of the Course, the students will be able to

CO1: Identify and predict the impact of harmonics on Industrial power electronic system fed by modern power electronic converters.

CO2: Formulate and solve power electronics circuit equations dealing with harmonics in AC and DC Power electronic converters.

CO3: Realize the efficacy and requirement of power line conditioners in electric power control applications.

CO4: Identify the type of power electronic converters needed for electric drive performance

Textbooks

1. Power Electronics by Nedmohan, Undeland and Robbins, John Wiley India Publishers.
2. Power Electronics by P.S. Bhimbra, Khanna Publishers, Delhi.
3. Thyristorised Power Controllers by G.K. Dubey, Wiley Eastern.

Reference Books

1. Modern Power electronics & Drives by B. K. Bose, Prentice Hall,
2. Control of Electrical Drives by Werner Leonard, Springer, International Publication.

Course Name: **Digital Control Systems**
Course Code: **EE-383**
Course Type: **Stream Core-I**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To impart knowledge about discrete time control systems and data acquisition
- To introduce sampling and representation of discrete time control systems using pulse transfer function
- To analyze the stability of discrete time control systems and design the controller to meet out the performance requirements.
- To develop understanding about state space representation and analysis of discrete time control systems

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Discrete Control:** Introduction, digital control systems, quantization concept, data acquisition, conversion, and distribution systems	**4**
UNIT-02	**Analysis of Discrete Time Systems: z**-transform, Important properties, inverse z-transform, difference equation and solution using z-transform, Impulse sampling and data hold, reconstruction of original signals from the sampled version, Pulse transfer function for open loop and closed loop systems, Realization of digital controllers.	**8**
UNIT-03	**Stability and Design of Discrete Time Control Systems:** Introduction, mapping between z-plane and s-plane, stability analysis using Jury's test, bilinear transformation and Schur-Cohn criteria, transient and steady state response analysis, Design schemes based on root-locus method and frequency response method.	**10**
UNIT-04	**State Space Representation and Analysis of Discrete Time Control Systems:** Introduction, state space representation of DT	**7**

	systems, solution of state space equations, Controllability, and observability, Lyapunov stability analysis.	

Course Outcomes

Upon successful completion of the course, the students will be able to

- CO1: Write mathematical descriptions for discrete time control systems.
- CO2: Analyse discrete time control systems for stability and design controllers based on conventional schemes.
- CO3: Develop different state space representations for discrete time control systems.
- CO4: Perform stability analysis for discrete time control systems in state space

Textbooks

1. Discrete Time Control Systems by K. Ogata, Prentice Hall International.
2. Digital Control Systems by B.C. Kuo, Oxford University Press.

Reference Books

1. Digital Control and State Variable Methods by M. Gopal, Tata McGraw Hill.

Course Name: **Engineering Economics and Accountancy**
Course Code: **HS-321**
Course Type: **Institute Core**

Contact Hours/Week: 3L **Course Credits: 02**

Course Objectives

- To impart knowledge about Economics and its applicability to the Engineers
- To introduce the fundamental concepts of economics
- To enable the students to understand the factors that cause the changes in economic conditions of the entrepreneur.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Engineering Economics:** Definitions, Nature, Scope and application; Difference between Microeconomics and Macro Economics; Theory of Demand & Supply: Meaning, Determinants, Law of Demand, Elasticity of demand, Demand Forecasting, Law of Supply, Equilibrium between Demand & Supply.	**3**
UNIT-02	**Production and Cost:** Production functions, Least Cost combination, Laws of Returns to Scale. Cost and Cost curves, Revenue and Revenue curves, Break even analysis.	**7**
UNIT-03	**Costing and Appraisal:** Cost elements, Economic cost, accounting cost, Standard cost, Actual cost, Overhead cost, Cost control, Criteria of project appraisal, social cost benefit analysis.	**5**
UNIT-04	**Money:** Meaning, Functions, Types. Banking: Meaning, Types, Functions, Central Bank: its Functions, concepts CRR, Bank Rate, Repo Rate, Reverse Repo Rate, SLR.	**7**
UNIT-05	**Depreciation:** Meaning of depreciation, causes, object of providing depreciation, factors affecting depreciation, Methods of Depreciation: Straight line method, Diminishing balance method, Annuity method and Sinking Fund method.	**7**
UNIT-06	**Financial Accounting:** Double entry system (concept only), Rules of Double entry system, Journal (Sub-division of Journal), Ledger, Trial Balance	**7**

	Preparation of final accounts-Trading Account. Profit and Loss account, Balance Sheet.	

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Familiarize with the concepts of Engineering economics i.e. economic theory, decision making and management.

CO2: Understand and apply the fundamentals of microeconomics in achieving the consumers and entrepreneurs/manufacturers motive of maximize satisfaction & maximize profit respectively by using by optimization techniques.

CO3: Learn about the various concepts of cost and their role in determining the producer's behavior.

CO4: Money, Banking helps in increasing the trade in the economy and telling how it is going to affect the cost and profitability of the entrepreneur.

CO5: Understand the concept of depreciation, and valuation.

CO6: The Trading , Profit and loss account and the Balance sheet that a manufacturer needs to submit to the government and to attract the investors for making the investment in their company by purchasing the shares and debentures issued by them.

Textbooks

1. Principles of Microeconomics by Mceachern & Kaur, Cengage Publication.
2. Managerial Economics: by Craig Peterson & W Cris Lewis, PHI Publication.
3. Modern Microeconomics: by A. Koutsoyiannis, Macmillan.
4. Managerial Economics Theory and Applications: by D. M. Mithani. Himalaya Publication House.
5. Fundamental of Managerial Economics: Mark Hirschey, Southwestern Educational Publishing.
6. Engineering Economics: by Degramo, Prentice Hall.

Reference Books

1. Financial Accounting – A Managerial Perspective by R. Narayanaswamy, PHI.
2. Introduction to Accounting by J.R. Edwards, Marriot, Sage Publication.
3. Cost Accounting by Jawahar Lal, Tata McGraw Hill.
4. Project planning Analysis, Selection, Implementation and Review: by Prasanna Chandra, Tata McGraw Hill

Course Name:**Communication Systems** Course Code: **EE-411** Course Type: **Discipline Core**

<table>
<tr><td colspan="3">Contact Hours/Week:3L Course Credits: 03</td></tr>
<tr><td colspan="3">Course Objectives
• To introduce the fundamental concepts of communication systems.
• To understand the basic concept of analog modulation schemes using continuous wave and pulse train as carrier signal.
• To study the working of the practical receiver used in broadcasting applications.
• To learn the sampling process and different schemes for digital modulation.
• To introduce the fundamental concepts of advanced communication systems.</td></tr>
<tr><th>Unit Number</th><th>Course Content</th><th>Contact Hours</th></tr>
<tr><td>UNIT-01</td><td>Introduction to Communications Systems: Communication process, sources of information, communication channels, base band and pass band signals, representation of signals and systems.</td><td>5</td></tr>
<tr><td>UNIT-02</td><td>Continuous-wave Modulation: Amplitude modulation (AM), frequency spectrum of the AM wave, representation of AM, power relations in the AM wave, AM detector, vestigial side-band modulation.</td><td>10</td></tr>
<tr><td>UNIT-03</td><td>Angle Modulation: Frequency spectrum of Frequency Modulation (FM) and Phase Modulation, generation of FM (direct and indirect method), demodulation of FM signal. Tuned Radio frequency (TRF) receiver, super heterodyne receiver.</td><td>8</td></tr>
<tr><td>UNIT-04</td><td>Pulse Modulation: Sampling process, Pulse Amplitude Modulation (PAM), Time Division Multiplexing (TDM), Frequency Division Multiplexing (FDM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM).</td><td>8</td></tr>
<tr><td>UNIT-05</td><td>Digital Modulation Techniques: Quantization process, Pulse Code Modulation (PCM), Differential Pulse Code Modulation (DPCM), Delta Modulation (DM), Adaptive Delta Modulation, Amplitude –Shift Keying (ASK), Frequency-Shift Keying (FSK), Phase-Shift Keying (PSK).</td><td>6</td></tr>
<tr><td>UNIT -06</td><td>Advanced Communication System: Computer Communication System, Satellite Communication, Mobile Communication.</td><td>5</td></tr>
<tr><td colspan="3">Course Outcomes
Upon successful completion of the course, the students will be able to
CO1: Understand the basic communication systems, various sources of information, and communication channels.
CO2: Describe various analog modulation schemes and their relative merits and demerits.
CO3: Understand the basis for digital modulation scheme and its advantages over analog modulation scheme.
CO4: Realize the basic concept of advanced communication systems.</td></tr>
<tr><td colspan="3">Textbooks
1. Communication Systems by Simon Haykin, John Wiley &Sons Pvt. Ltd.
2. Modern Digital and Analog communication Systems by BP Lathi and Zhi Ding, Oxford Uni. Press
3. Principles of Communication Systems by H. Taub and D.L. Schilling, McGraw-Hill Education
Reference Books
1. An Introduction to Analog and Digital Communications by SimonHaykin, Wiley India Pvt. Ltd.</td></tr>
</table>

2. Analog and Digital Communication Systems, Martin S Roden, Shroff Publisher Pvt. Ltd Mumbai

Course Name: **High Voltage Engineering** Course Code: **EE-412** Course Type: **Discipline Core**		
Contact Hours/Week: 3L		**Course Credits: 03**
Course Objectives • To impart knowledge about the physical high voltage phenomena and their impact on HV systems. • To introduce the fundamental concepts relevant to high voltage insulations and their characterization. • To enable the students, understand about various factors that must be considered while design and safer use of high voltage systems.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction:** Levels of voltages, Electrical Insulation and Dielectrics, Importance of Electric Field Intensity in the Dielectrics, Types of Electric Fields, Degree of Uniformity of Fields (Schwaiger Factor), Stress Control.	**3**
UNIT-02	**Gaseous Dielectrics:** Properties of atmospheric air, SF6 and vacuum, Related Ionization Process, Development of Electron Avalanche, Breakdown Mechanisms, Townsend's Mechanism, Streamer Mechanism, Breakdown in Uniform Fields (Paschen's Law), Breakdown of gaseous dielectrics in Weakly Non-uniform Fields and the limiting value of η, Development of 'Partial Breakdown' (PB) in Extremely Non-Uniform Fields, Breakdown Characteristics' in air with stable PB (corona)	**10**
UNIT-03	**Liquid and Solid Dielectrics:** Classification and Properties of Liquid and Solid Dielectrics, Permittivity and Polarization in Dielectrics, Insulation Resistance, Conductivity and Losses in Dielectrics, Partial Breakdown Phenomenon and on the Surfaces of Solid and Liquid Dielectrics, Breakdown in Liquid and Solid Dielectrics, Measurement of Intrinsic Breakdown in Solid Dielectrics, Thermal and other Breakdown Mechanisms in Extremely Non-uniform Fields, Comparison of the Development of Breakdown in Extremely and Weakly Non-uniform Fields and the Requirement of Time for Breakdown in Solid Dielectrics.	**6**
UNIT-04	**Generation of High Test Voltages & Measurement Techniques:** Methods of Generation of Power Frequency High Test Voltage, Transformers in Cascade, Resonance Transformers, Generation of High DC Voltage, Voltage Multiplier Circuits and Ripple Minimization, Sources of Over-voltages, Standard Lightning and Switching Wave Shapes, Impulse Voltage Generator, Analysis of Single Stage Circuit, Multistage Impulse Generator and their Triggering Methods., Measurement of High Test Voltages, Peak High Voltage Measurement Techniques, Sphere Gap Method, Effects of Earthed Objects and Atmospheric Conditions, Electrostatic Voltmeters, Principle and Construction, Potential Dividers-Types and Applications	**12**
UNIT-05	**Non-destructive High Voltage Testing and Quality Control**: Measurable properties of dielectrics, Measurement of Dielectric Properties with Schering Bridge and Mega-ohm meter, Partial Breakdown (PB) Measurement Techniques in Dielectrics/ Equipment.	**3**
UNIT-06	**Insulation Coordination and Overvoltage in Power Systems:** Natural Causes of Overvoltages, Overvoltages Due to Switching Surges, System Faults and other Abnormal Conditions, Principles of Insulation Coordination in HV, EHV and UHV Power Systems.	**2**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify role of high voltage insulations and their impact in implementing design of HV systems.

CO2: Describe contribution of partial discharges and arcing which if ignored can lead to failure of HV system.

CO3: Apply principles of generation, measurements of all kind of high voltage waveforms in type tests of HV equipment.

CO4: Assess the role of insulation co-ordination and other performance parameters affecting safer application of High Voltages.

Textbooks

1. High Voltage Engineering by M.S. Naidu and V. Kamaraju, Tata McGraw Hill.
2. High Voltage Engine Engineering by E. Kuffel and M. Alldullah, Pergamon Press, Oxford.

Reference Books

1. High Voltage Engineering by E. Kuffel and Zaengal, Butterworth-Heinemann.

Course Name: **Modern Control Systems**
Course Code: **EE-413**
Course Type: **Discipline Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives:

- To impart knowledge about developing state space models from differential/transfer function-based descriptions of linear systems
- To introduce difference equation description of discrete time LTI systems
- To introduce the typical behaviors shown by nonlinear systems and to analyze the stability.
- To introduce the preliminary understanding about the advanced control methodologies used to handle systems with uncertainty.

Unit Number	Course Content	Contact Hours
UNIT-01	**State Variable Analysis and Design:** Introduction, concept of state, state variable and state model, state space representation of systems, block diagram for state equation, Transfer function decomposition, direct, parallel and cascade decomposition, solution of state equations, concept of controllability and observe ability, controller design using pole placement by state feedback, separation principle, controller design using state observer.	**12**
UNIT-02	**Nonlinear Systems:** Introduction, comparison of linear and non-linear systems, different non-linearities, typical behaviours depicted by nonlinear systems: limit cycle behaviour, jump resonance phenomena etc.	**6**
UNIT-03	**Stability Analysis of Nonlinear Systems:** Concept of phase plane and phase trajectories, Phase Plane Method, different singular points, construction of phase trajectories, stability analysis using phase plane method, concepts of describing function method, stability analysis using describing function method, Lyapunov stability, Stability analysis of linear and nonlinear systems using Lyapunov stability, stability of nonlinear systems with sector bound nonlinearities, Popov stability criterion.	**12**
UNIT-04	**Advanced Control Systems**: Introduction to Uncertain systems, robust and H-infinity control, Direct and Indirect adaptive control, Model Reference Adaptive Control (MRAC).	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Develop different state space representations for linear time invariant systems.

CO2: Write descriptions for discrete time systems and analyse the stability of such systems.

CO3: Understand and justify the peculier behaviours shown by nonlinear systems.

CO4: Analyse the stability of nonlinear systems using phase plane, describing function and Lyapunov method.

Textbooks

1. Modern Control Engineering by K. Ogata, Prentice Hall International.

2. Control System Engineering by I.J. Nagrath and M. Gopal, Wiley Eastern.
3. Digital Control Systems by B.C. Kuo, Oxford University Press.

Reference Books

1. Digital Control and State Variable Methods by M. Gopal, Tata McGraw Hill.
2. Applied Nonlinear Control by J.J.E. Slotine & W. Li, Prentice Hall, Englewood Cliffs New Jersey.

Course Name**: Simulation Lab**
Course Code: **EE-414**

Contact Hours/Week:**2P** Course Credits:**01**

Course Objectives

- To develop ability to analyse signals and systems.
- To understand MATLAB based Control System Analysis and Design.
- To understand design of FIR and IIR filters.

List of Experiments

1. To represent basic signals (unit step, unit impulse, ramp, exponential, sine and cosine)
2. Plot unit step response of given transfer function and find peak overshoot, peak time.
3. Plot root locus of given transfer function and to find out δ, ω_d, ω_n at given root & to discuss stability.
4. Plot bode plot of given transfer function and find gain and phase margins.
5. Plot the Nyquist plot for given transfer function and to discuss closed loop stability, gain and phase margin.
6. To compute Linear and circular convolution of two sequences.
7. Auto and cross correlation of sequences and verification of their properties.
8. Computation of N-point DFT of a given sequence and to plot magnitude and phase spectrum.
9. Design and implement a FIR filter.
10. Design and implement an IIR filter.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Compute the response of an arbitrary input for an LTI system.
CO2: Study the stability of a linear control system.
CO3: Analyze signals in time and frequency domain.
CO4: Design basic Digital Filters –FIR and IIR.

Course Name: **High Voltage Engineering Lab** Course Code: **EE-415**	
Contact Hours/**Week:2P**	**Course Credits: 01**

Course Objectives

- To learn the operation and characteristics of different insulator parameters for high voltage system.
- To understand the procedure for analysis and testing of dielectric for transformers.

List of Experiments

1. To measure earth resistance of a typical earth wire system by using digital earth tester.
2. To measure soil resistivity using four-probe method.
3. To calculate breakdown voltage of a solid insulator like power cable insulation, paper etc.
4. To study and plot equipotential lines for an insulator by using electrolytic tank, assembly equipment.
5. To measure the breakdown voltage of a given sample of liquid dielectric.
6. Demonstration of the corona phenomenon by 200kV AC voltage generator set.
7. To carry out the investigation on air insulation breakdown using uniform and non-uniform electrode system.
8. To determine moisture content in given oil sample of a transformer.
9. To perform dissolved gas analysis (DGA) of a given sample of the transformer oil.
10. Testing of 11kV insulator**.**

Course Outcomes

Upon successful completion of the lab work, the students will be able to:

CO1: conduct test of high voltage insulations and study the operational requirements of HV systems.

CO2: Analyse partial discharges and arcing of HV system.

CO3: Understand corona phenomenon.

Course Name: **Transformer Engineering** Course Code: **EE- 431** Course Type: **Discipline Elective (V)**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To impart knowledge about transformer engineering. • To introduce the fundamental concepts relevant to maintenance, winding and insulation, cooling, magnetic circuits and tap changer of transformer. • To enable the students to understand the concepts of transformer.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction to Transformers:** Review of Transformer Types, Transformer Losses, Operating Principles, and Transformer connections.	**5**
UNIT-02	**Transformer Maintenance:** Insulation Testing, High Potential Testing, Turns Ratio Testing, Polarity Testing, Power Factor, Excitation Current, DC Winding Resistance, Polarization Recovery, Insulating Fluid, Dielectric, Dissolved Gas Analysis.	**6**
UNIT-03	**Materials for Transformers:** Winding and Insulation: Insulating oil, insulating paper, pressboard, and wood, insulated copper conductor for windings, crepe paper, sealing. Materials, and cold – rolled grain oriented electrical steel sheet. Types of windings, surge voltage, heat transfer, insulation design.	**7**
UNIT-04	**Cooling of Transformers:** Air cooled oil-immersed, water-cooled, forced-oil cooling, self-cooling with air blast temperature limits, transformer loading	**7**
UNIT-05	**Magnetic Circuit:** Materials, design of magnetic circuit, optimum design of core.	**5**
UNIT-06	**Tap Changers and Transformer Auxiliaries:** Off - circuit tap changer, on load tap changer, automatic control of tap changer. Buchholz relay, temperature indicators, oil level indicators, oil preservation systems.	**7**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Identify different problems related to transformer engineering. CO2: Describe problems related to winding, insulation, cooling, magnetic circuits and tap changer of transformer. CO3: Apply principles to solve problems described in CO2. CO4: Assess the results obtain by solving above problems.		
Textbooks 1. Transformers by BHEL, Bhopal, Tata McGraw Hill. 2. Transformer Engineering design and practices, S.V. Kulkarni and S.A. Khaparde, Marcel Dekker Inc. New York. **Reference Books** 1. Electrical Machines by Husain Ashfaq, Dhanpat Rai & Sons. 2. Electric Machinery by A.E. Fitzgerald, C. Kingsley Jr and Alexander Kusko, McGraw Hill.		

Course Name: **Distributed Generation & Microgrid**
Course Code: **EE-432**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- Obtain knowledge of different distributed generations, energy storage devices and Microgrid systems.
- Understanding the concepts of electric power system development and relevant issues.

Unit Number	Course Content	Contact Hours
UNIT-01	**Basics of Distributed Generation:** DG Units - Micro turbines, reciprocating engines, wind generators, photovoltaic generators, fuel cells, biomass, and tidal sources - Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation.	**6**
UNIT-02	**Interconnection Issues and Standards of DGs:** Concept of distributed generations (DG) or distributed energy resources (DERs), topologies, selection of source, dependence on storage facilities, regulatory standards/ framework, standards for interconnecting DGs to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Grid code and Islanding & non-islanding system.	**6**
UNIT-03	**Economics and Regulatory Aspects of DGs**: Selection of sources, regulatory standards/ framework, Standards for interconnecting DG installation classes, security issues in DG implementations. Economic and control aspects of DGs –Market facts, issues and challenges - Limitations of DGs.	**6**
UNIT-04	**Basics of a Microgrid:** Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.	**6**
UNIT-05	**Control in Micro grid:** Impact of load characteristics, Local control, Centralized Control, Decentralized Control, Microgrid control for islanded operation.	**6**
UNIT-06	**Microgrid Energy Management Systems:** Load Sharing and Power Management Strategy in Microgrid - Stand-alone – Grid connected – energy storage - Voltage Control and Active Power Management	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Study the need for DG's and various types.
CO2: Understand microgrid types and configurations.
CO3: Analyze various types of control in micro grid in islanded and grid connected operation.

Textbooks

1. Distributed Generation by N. Jenkins, J.B. Ekanayake and G. Strbac, IET Press, 2010.
2. Microgrids: Architectures and Control by Nikos Hatziargyiou, Wiley-IEEE Press December 2013.

3. Power Electronic Converters for Microgrid Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orphanides’s, Babar Hussai, Wiley-IEEE Press, 2014.
4. Microgrids and Active Distribution Networks by S. Chowdhury, S.P. Chowdhury, and Peter Crossley ISBN978-1-84919-014-5, IET renewable Energy series, 2009.
5. Renewable Energy - Power for a Sustainable Future, third edition, Edited by Godfrey Boyle, Oxford University Press, 2013.

Reference Books

1. Voltage Source Converters in Power Systems: Modeling, Control and Applications by Amirnaser Yezdani, and Reza Iravani, IEEE John Wiley Publications, 2009.
2. Power Switching Converters: Medium and High Power by Dorin Neacsu CRC Press, Taylor & Francis, 2006. New Delhi.

Course Name: **Process Modeling and Control** Course Code: **EE-433** Course Type: **Discipline Elective (V)**		
Contact Hours/Week**: 3L**		Course Credits**: 03**

Course Objectives:

- To impart knowledge about the process dynamics/Mathematical modeling and their control schemes generally used to get optimized output.
- To introduce the fundamental concepts of classical and adaptive controller design in various loops.
- To make students aware of decoupling of control loops, real-time systems, and distributed Computing in industrial process.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction & General Concepts:** Review of general concepts, terminology, applications of process control, mathematical modeling, process dynamics of fluid flow and heat transfer systems, mass transfer dynamics and distillation column.	**9**
UNIT-02	**Advanced Control Schemes:** Structure, analysis and application of Cascade control, Selective control, Ratio Control, Design of steady state and dynamic Feed forward controller, Feed forward combined with feedback control, Structure, analysis and applications of inferential control, dead time and inverse response compensators, Concepts and applications of Adaptive control, Model reference adaptive control, Self-tuning regulator.	**12**
UNIT-03	**Design of Multi-loop Controllers:** Interactions and decoupling of control loops. Design of cross controllers and selection of loops using Relative Gain Array (RGA).	**7**
UNIT-04	**Real Time Control:** Characteristics and classes of real-time systems, program classification: sequential, multi-tasking, real time, concurrency and synchronization, design strategies. Distributed Computing Systems: Distributed processing issues in distributed data base systems.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Handle any kind of process by framing its block diagram, mathematical model, and different process variables.

CO2: Handle different types of classical controller like PID as well as adaptive controllers such as Model reference adaptive control and Self tuning regulator.

CO3: Implement different control schemes to various processes.

CO4: Understand real time and distributed computing systems.

Textbooks

1. Process Systems Analysis and Control by Donald R. Coughanowr, Tata McGraw-Hill.
2. Modern Control Engineering by Katsuhiko Ogata, Pearson.
3. Process Control by K. Krishnaswamy, New Age.

Reference Books

1. Process Control: Theory and Applications by Jean-Pierre Corriou, Springer.
2. Process Dynamics and Control by Sudheerr S. Bhagde and Govind Das Nageshwar.
3. Principles of Process Control by D Patranabis, Tata McGraw Hill.

Course Name: **Image Processing**
Course Code: **EE-434**
Course Type: **Discipline Elective (V)**

Contact Hours/Week: **3L** | Course Credits: **03**

Course Objectives

- To become familiar with the various steps involved in digital image processing.
- To study the image fundamentals and mathematical transformations necessary for image processing.
- To develop the ability to process the image in spatial and transform domain for enhancement and restoration.
- To become familiar with image compression and recognition methods.

Unit Number	Course Content	Contact Hours
UNIT-01	**Digital Image Fundamentals**: Elements of visual perception – Image sampling and quantization, Basic relationship between pixels – Basic geometric transformations.	**5**
UNIT-02	**Image Transforms**: Two-dimensional orthogonal and Unitary transforms, Optimum transform, Properties of Unitary transforms, 2D DFT, Cosine transform, Haar transform, Hadamard transform, KL transform, 1-D and 2-D discrete wavelet transform and relation to filter banks.	**6**
UNIT-03	**Image Enhancement and image restoration**: Spatial Domain methods – Spatial filtering, Frequency domain filters – Model of Image Degradation/restoration process, histogram-based processing, homomorphic filtering, Noise models – Inverse filtering - Least mean square filtering – Constrained least mean square filtering – Blind image restoration – Pseudo inverse.	**7**
UNIT-04	**Image compression**: Redundancies and their Removal Methods, Fidelity Criteria, Image Compression Models, Huffman and Arithmetic Coding, Error Free Compression, Lossy Compression, Lossy and Lossless Predictive Coding, Transform Based Compression, Standards of Image compression standards: JPEG, JPEG 2000, MPEG.	**7**
UNIT-05	**Image Segmentation and Image Analysis**: Edge detection – Thresholding - Region Based segmentation, Hough Transform, Object Recognition	**5**
UNIT-06	**Color Image Processing:** Color Fundamentals, Color models, Pseudo color Image processing, Color transformation, Basics of Full- Color Image Processing, Color Transformation, Smoothening and Sharpening, Color Segmentation.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Explain the fundamentals of digital image and its processing.

CO2: Perform image enhancement techniques in spatial and frequency domain.

CO3: Analyze images in the frequency domain using various transforms.

CO4: Learn the basics of segmentation, features extraction, compression, and recognition methods.

Textbooks

1. Digital Image Processing by Rafael C. González, Richard E. Woods, PHI
2. Fundamentals of Digital image Processing by Anil K. Jain, Prentice Hall,

Reference Books

1. Digital Image Processing by Willam K Pratt, Wiley-Interscience Publication.
2. Handbook of Image and Video Processing by AL Bovik (Editor), Academic Press.

Course Name:**Power Quality and Harmonics**
Course Code: **EE-435**
Course Type: **Discipline Elective (V)**

Contact Hours/Week:**3L** CourseCredits:**03**

Course **Objectives**

- To impart knowledge about the power system and power quality.
- To introduce the fundamental concepts relevant to harmonics, and their mitigation.
- To enable the students, understand various factors that cause the power pollution in the distribution system.
- To enable the students, understand efficacy of adopted strategies to mitigate harmonics by using advance tools.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Introduction to power quality, voltage quality. Overview of power quality, Power quality phenomena and classification of power quality issues.	**4**
UNIT-02	**Power Quality Measures and Standards:** THDTIF-DIN-message weights-flicker factor-transient phenomena-occurrence of power quality problems-power acceptability curves-IEEE guides, EMC standards and recommended practices.	**6**
UNIT-03	**Harmonic Device Modelling:** Harmonics background, basic concepts, Fourier analysis. Harmonics-individual and total harmonic distortion-RMS value of harmonic waveform-triplex harmonic-important harmonic introducing devices-Transformer, Three phase power converters-arcing devices-saturable devices. Harmonic distortion due to fluorescent lamps. Effect of power System harmonics on power system equipment and loads.	**8**
UNIT-04	**Modelling of Networks:** Modelling of networks and components under non-sinusoidal conditions, transmission and distribution systems, shunt capacitors, transformers, electric machines, ground systems, loads that cause power quality problems, power quality problems created by drives and impact on drives.	**8**
UNIT-05	**Harmonic Mitigation:** Harmonic resonance, Impedance Scan Analysis-Passive filtering. Introduction to active power filtering. Control methods for single phase APFC.	**6**
UNIT-06	**Grounding:** Grounding and wiring –introduction-NEC grounding requirements-reasons for grounding-typical grounding and wiring problems-solutions to grounding and wiring problems.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify and understand the power quality concepts.
CO2: Characterize various types of power quality problems.
CO3: Apply principles of harmonic mitigation to bring down the level of harmonics within the standard limits.
CO4: Assess the impact of power quality and harmonics in an industrial distribution system.

Textbooks

1. Understanding Power Quality Problems by Math H. Bollen, John Wiley IEEE Press.
2. Power System Quality Assessment by J. Arrillaga, John Wiley.
3. Power System Harmonic Analysis by J. Arrillaga, B.C. Smith, N.R. Watson & A.R. Wood, John Wiley.
4. Electrical Power System Quality by Surya Santoso, H. Wayne Beaty, Roger C. Dugan, and Mark F. Mc Granaghan, McGraw Hills.

Reference Books

1. Electric Power Quality by G.T. Heydt, Starsina Circle Publishers.

Course Name: **Power System Dispatch and Control**
Course Code: **EE-451**
Course Type: **Stream Core (II)**

Contact Hours/Week: **2L** CourseCredits:**02**

Course Objectives

- To impart knowledge about the power system operation and control.
- To introduce the fundamental concepts relevant to economic dispatch, load frequency control.
- To formulate and solve multimachine transient stability problem.

Unit Number	Course Content	Contact Hours
UNIT-01	**Economic Dispatch:** Characteristics of power generation units, incremental cost curve, heat rate curve, analytical solution of economic dispatch without generator limits and considering limits, lambda iteration method for economic dispatch, reduced gradient method, lambda projection by newton method, economic dispatch including losses, co-ordination equations with losses, approximate penalty factor, interpretation of penalty factor, transmission loss computation, derivation of approximate loss coefficients, iterative procedure for solution to economic dispatch with losses.	**8**
UNIT-02	**Automatic Voltage Regulation:** Types of alternator exciters, exciter modeling, modeling of alternator, static performance of AVR loop, dynamic performance of AVR loop, compensation in AVR loop.	**6**
UNIT-03	**Load Frequency Control:** automatic load frequency control, types of turbine representation, steady state performance of the speed governing system, complete structure of primary ALFC loop and its responses, secondary ALFC loop and its performance, tie-line power flow model, static and transient responses of two area system, application aspects of primary and secondary ALFC loop, interfacing of AGC with economic dispatch.	**6**
UNIT-04	**Multimachine Transient Stability:** Mathematical formulation of multimachine transient stability, solution techniques: Partitioned explicit method, Direct integration method	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Describe and solve economic dispatch problems.
CO2: Model and describe AVR and ALFC by applying principles of control system.
CO3: Apply various methods for solving multimachine transient stability problems.
CO4: Assess the application aspects of primary and secondary ALFC loop, interfacing of AGC with economic dispatch.

Textbooks

1. Power System Analysis by Hadi Saadat, Tata McGraw Hill, New Delhi.
2. Power System Analysis Operation and Control by Abhijit Chakrabarti and Sunita Halder, PHI New Delhi

Reference Books

1. Computer Techniques in Power System Analysis by M.A. PAI, Tata Mc Graw-Hill.
2. Power System Operation & Control by K. Uma Rao, Wiley India Pvt. Ltd.

Course Name: **Optimal Control Theory**
Course Code: **EE-452**
Course Type: **Stream Core-II**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To understand various optimal control problems existing in practice.
- To formulate optimal control problems for continuous systems with and without constraints.
- To develop analytical solutions of continuous-time and discrete-time optimization problems.
- To develop solution for Time, Fuel and Energy optimal control problems

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Optimal control problem, classification of optimal control problems, performance measures for optimal control problems, selection of performance measures.	**3**
UNIT-02	**Static Optimization:** Static optimization problem formulation, direct method, Lagrange multiplier method, optimization without constraints, optimization with equality constraints.	**4**
UNIT-03	**Calculus of Variation**: Fundamental concepts, Euler-Lagrange equation for different two-point boundary value problems with free or fixed final condition, Dynamic optimization with equality constraints, Pontryagin minimum principle.	**7**
UNIT-04	**Linear Quadratic Regulator Problem:** Problem formulation for continuous time systems and discrete time systems, Matrix-Riccati equation, output regulator and tracking problem.	**6**
UNIT-05	**Multistage Optimization Process:** Introduction to multistage decision process, principle of optimality, Dynamic Programming based optimization, Hamilton-Jacobi-Bellman principle.	**4**
UNIT-06	**Constrained Optimal Control Problems:** Time optimal control of LTI systems, problem formulation, solution of time optimal control problem, Bang-Bang control.	**2**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand and frame performance objectives for practical systems
CO2: Develop analytical solutions for optimal control problems.
CO3: Analyse linear quadratic reguation and tracking problems
CO4: Develop dynamic programming based solutions for multi stage decision processes

Textbooks

1. Modern Control System Theory by Gopal M, Wiley Eastern, New Delhi.
2. Optimal Control Systems by D. S. Naidu, CRC Press, USA.
3. Optimum Systems Control by Sage A. P. and White C. C., Englewood Cliff New Jersey, Prentice Hall.

Reference Books

1. Optimal Control by Anderson B.D.O., Moore J.B, Englewood Cliff New Jersey, Prentice Hall.
2. Optimal Control Theory by Kirk D.E, Englewood Cliff New Jersey, Prentice Hall.

Course Name: **Hybrid Electric Vehicles**
Course Code: **EE-453**
Course Type: **Stream Core-II**

Contact Hours/Week: 2L		Course Credits: 02
Course Objectives • To develop understanding of fundamentals of Electric and Hybrid Electric Vehicle starting from theory and operation to its practical applications • To impart the knowledge about the motor drives for electric vehicles, energy storage system for vehicle and their energy management		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction and fundamentals of HEVs:** History and importance of hybrid and electric vehicles, Concept of Hybridization of the automobile, Challenges and Key Technology of HEVs, Architecture of HEV: Series/parallel HEV, Diesel hybrid, Plug-in Hybrid vehicles, Fuel Cell vehicles, Other approaches in Vehicle Hybridization, Vehicle Model, Vehicle performance, Types of motors used in EVs, performance characteristics of electric motors.	**6**
UNIT-2	**Batteries, Ultracapacitors, Fuel Cells, and Energy Management in HEVs:** Battery Characterization and types, Comparison of Different Energy Storage Technologies for HEVs, Modeling Based on Equivalent Electric Circuits: Battery Modelling, Ultracapacitor, Battery Charging Control, Charge Management of Storage Devices, Flywheel Energy Storage System, Fuel Cells and Hybrid Fuel Cell Energy Storage System, Introduction to energy management strategies used in Electric Vehicles, classification and comparison among the different energy management strategies.	**8**
UNIT-3	**Charging Infrastructure:** Battery Chargers: Forward/Flyback Converters, Half-Bridge DC–DC Converter, Full-Bridge DC–DC Converter, Power Factor Correction Stage, Bidirectional Battery Chargers, Other Charger Topologies, Inductive Charging, Wireless Charging, Buck Converter Used in HEVs, Rectifiers Used in HEVs, non-isolated and isolated Bidirectional DC–DC Converter.	**8**
UNIT-04	**Grid Application and Standards:** Concept of Vehicle-to-Grid Technology (V2G, G2V), integration of EVs in smart grid, Current standards, and protocols of EV and HEV in India.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the Electric Vehicle concepts and its importance in Indian energy scenario.

CO2: Assess the role of EV in modern distribution systems and smart grids.

CO3: Realize the technology, design methodologies and control strategy of electric vehicles.

CO4: Apply energy management techniques for electric vehicles.

Textbooks

1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals, Theory, and Design by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, CRC PRESS.
2. Hybrid & Electric Vehicles by Tom Denton, Taylor and Francis, CRC Press.
3. Power Electronics by Daniel W. Hart, Tata McGraw Hill.
4. Hybrid Electric Vehicles, by Chris Mi, M. Abul Masrur,2017, Wiley.

Reference Books

1. Electric &Hybrid Vehicles by A.K. Babu, Khanna Publications.
2. Electric Vehicle Technology Explained by James Larminie, John Lowry. Wiley-Blackwell, 2nd Edition, 2012.
3. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles by Sheldon S. Williamson. Springer, 1st Edition, 2016
4. Electric & Hybrid Vehicles Design Fundamentals by Iqbal Hussain. 2nd Edition, CRC Press, 2011

5. Vehicle-to-Grid: Linking electric vehicles to the smart grid by J. Lu, and J. Hossain. IET, 1st Edition, 2015

Course Name: **Electrical Safety & Standards**

Course Code: **EE-471**
Course Type: **Stream Core - III**

Contact Hours /Week: **2L** Course Credit: **02**

Course objective:

- To provide comprehensive exposure to electrical hazards.
- To introduce various grounding and bounding techniques for electrical systems and equipment.
- To provide acquaintance to electrical maintenance techniques and safety standards.

Unit Number	Course Content	Contact Hours
UNIT-01	**Hazards of Electricity and Electrical Safety Equipment:** Primary and secondary hazards- Arc, Blast, Shocks. Causes and effects. Safety equipment, Flash and thermal protection, Head and eye protection, Rubber insulating equipment, Hot sticks, insulated tools, Barriers and signs, Safety tags, locking devices, Voltage measuring instruments, Proximity and contact testers, Safety grounding equipment, Safety electrical one-line diagram, Electrician safety kit.	**6**
UNIT-02	**Grounding and Bonding of Electrical Systems and Equipment:** General requirements for grounding and bonding-Definitions, grounding of electrical equipment, bonding of electrically conducting materials and other equipment, connection of grounding and bonding equipment, System grounding- purpose of system grounding, grounding electrode system, grounding conductor connection to electrodes, use of grounded circuit conductor for grounding equipment, grounding of low voltage and high voltage systems.	**7**
UNIT-03	**Safety Procedures and Methods:** The six step safety methods – pre-job briefings, hot-work decision tree, safe switching of power system- lock out. tag out-procedures and methods, flash hazard calculation and approach distances, calculating the required level of arc protection, safety equipment and procedures for low, medium, and high voltage systems, electrical safety around electronic circuits, safety hazards of stationary batteries and safety procedures- electrical hazards in the home, one minute safety audit.	**6**
UNIT-04	**Maintenance of Electrical Equipment and Safety Standards:** Safety related case of electrical maintenance- reliability centered maintenance (RCM), eight step maintenance programme, frequency of maintenance, maintenance requirement for specific equipment and location, regulatory bodies, national electricity safety code, standards for electrical safety in workplace, Occupational Safety and Health Administration standards, Indian electricity acts related to electrical safety.	**6**

Course outcomes:

Upon completion of the course, the students would be able to

CO1: Describe electrical hazards and safety equipment.

CO2: Analyze and apply various grounding and bonding techniques.

CO3: Select appropriate safety methods for low, medium, and high voltage equipment.
CO4: Carry out proper maintenance of electrical equipment by understanding various standards.

Textbooks

1. Electrical Safety Handbook by John Cadick, Mary Copelli-Schellpfeffer, Dennis Neitzel, Al Winfield, McGraw-Hill Education, 4th Ed 2012.
2. Electrical Safety - A Guide to the Causes and Prevention of Electrical Hazards by Maxwell Adams J, The Institution of Electric Engineers, IET 1994.

Reference Books

1. Electric Safety Practice and Standards by Mohamed A. El-Sharkawi, CRC Press.
2. Electrical Safety and the Law by John Madden, Routledge.

Course Name: **Modelling & Analysis of Electrical Machines**
Course Code: **EE-472**
Course Type: **Stream Core -III**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives

- To impart basic knowledge on advanced electrical machines.
- To introduce the fundamental concepts modelling of electrical machines.
- To enable the students to understand the modelling of electrical machines.

Unit Number	Course Content	Contact Hours
UNIT-01	**Analysis of Magnetic Circuits:** Basics of magnetic circuits - flux, mmf, reluctance, leakage, magnetizing, self and mutual inductances, analysis of magnetic circuits with airgap and permanent magnets, nonlinear magnetics.	**5**
UNIT-02	**Singly & Doubly Excited Machines:** Analysis of singly excited electromechanical system with linear magnetics -nonlinear magnetics using energy and co-energy principles, derivation of force from co-energy, inductances of distributed windings - salient pole, cylindrical rotor, analysis of the doubly excited rotational system with two coils on stator and two on rotor - electrical and mechanical equations.	**5**
UNIT-03	**Reference Frames & DC Machines:** Reference frames - stator attached alpha-beta, synchronous reference frame, arbitrary speed reference frame - power invariance and non-power invariance. Derivation of dc machine systems from the generalized machine - electrical and mechanical equations.	**5**
UNIT-04	**Analysis of Induction and Synchronous Machines:** Analysis of induction machine - synchronous reference frame - with currents as variables - with rotor flux as variables - basis for vector control - small signal modelling of induction machine. Analysis of the alternator - synchronous reference frame - derivation of salient and cylindrical rotor machine phasor diagrams - three phase short circuit of alternator and various time constants	**10**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the fundamental aspects of modelling of electromagnetic circuits.

CO2: Analyse and model DC machines.

CO3: Analyse and model Induction Machines.

CO4: Analyse and model Alternators.

Textbooks

1. Electric Motor Drives by R. Krishnan, PHI.
2. Analysis of Electric Machinery and Drive Systems by Paul Krause, Wiley.
3. Matrix Analysis of Electric Machinery by Hancock, Pergamon.

Reference Books

1. Electric Machinery by Fitzgerald and Kingsley, McGraw-Hill.
2. Generalized Theory of Electrical Machines by PS Bimbhra, Khanna Pub.

Course Name: **Robust Control System**
Course Code: **EE-473**
Course Type: **Stream Core-III**

Contact Hours/Week: **2L** Course Credits: **02**

Course Objectives:

- To develop learning related to robust performance of systems.
- To understand system uncertainties and their modelling
- To learn specification of performance in terms of H_2 and H_∞ measures
- To learn design of compensators for robust control of multivariable systems

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Definition of robust control, feedback and uncertainty, classical compensator design method, model uncertainty.	**4**
UNIT-02	**Nominal and Robust Stability:** Process model, uncertainty-based models, nominal stability, robust stability, robust performance measures, norms of systems and transfer functions, performance requirements, H_2 and H_∞ optimal control, H_2 and H_∞ robust performance, concept of loop shaping	**9**
UNIT-03	**Multivariable systems and their Robustness Analysis**: Poles and zeros of multivariable systems, nominal stability of multivariable systems, frequency response of multivariable systems, norms of signals for multivariable systems, small gain theorem and robustness using mixed sensitivity functions.	**9**
UNIT-04	**Robust Control Design:** Loop shaping in multivariable systems, development of H_∞ control solutions, design of robust compensators using μ- analysis, μ- synthesis	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the interaction systems and uncertainites
CO2: Formulate problems for control systems in terms of robust performance measures
CO3: Analyse nominal and robust stability of multivariable systems
CO4: Design robust compensators for multivariable control systems

Textbooks

1. Robust Control by K. Zhou and J. C. Doyle (2nd Edition), Prentice Hall, New Jersey, 1998.
2. Robust Control of Linear Dynamical Systems by P C Chandrasekharan, Academic Press, 1996.

Reference Books

1. Robust Control by S. T. Clausen, P. Anderson, and J. Straustrup, 2001.

2. Robust Control Systems Theory and Case Studies by U. Mackenroth, Springer Publisher, 2004.
3. Robust Control Design by D. W. Gu, P. H. Petkov, and M M Konstantinov, Springer International, 2005.

Course Name: **Time Frequency Analysis and Wavelet Transforms**
Course Code: **EE-461**
Course Type: **Stream Elective-1**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To provide the understanding of basics concepts of time-frequency analysis (TFA).
- Familiarization of the discrete wavelet transform /continuous wavelet transform.
- To study implementation of TFA tools for various applications.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Time Frequency Analysis:** Introduction to time frequency analysis- Basic definitions and concepts-Continuous time Fourier series and Fourier Transform-Discrete-Time Fourier Series Discrete-Time Fourier Transform Discrete Fourier Transform & Periodogram-Bandwidth Equation Instantaneous Frequency Analytic Signals Multicomponent Signals	**7**
UNIT-02	**Bases for Time-Frequency Analysis STFT:** Duration-Bandwidth Principle – Band width equation and Instantaneous Frequency-Requirements of time frequency analysis techniques-STFT: Definition and Interpretations- Uncertainty Principle, Localization/Isolation in time and frequency- General Properties - Theorem and need for joint time-frequency Analysis- Concept of non-stationary signals- STFT: Application	**7**
UNIT-03	**Wigner Ville Distribution:** WVD: Definition and Interpretations - Properties of WVD- Discrete WVD- Pseudo and smoothed WVD- Cohen's class - Connections with Spectrogram -WVD: Application	**9**
UNIT-05	**Wavelet Transform:** CWT: Definition and Interpretations – Scale to frequency- Computational aspects of wavelets CWT - TFA and Filtering Perspective- Scalogram- Scaling Function – Wavelets- CWT: Application -DWT: Definition and Interpretations- Orthonormal Bases and Multiresolution Approximation- Wavelet filter and fast DWT algorithm-Wavelets for DWT-Applications of wavelets	**8**
UNIT-06	**Hilbert Huang Transform:** The Hilbert-Huang transform, the empirical mode decomposition method (the sifting process), the Hilbert spectral analysis, confidence limit, statistical significance of IMFs, mathematical problems related to the HHT, EMD Equivalent Filter Banks, Denoising and detrending with EMD.	**8**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Understand importance of Time frequency analysis, Short Time Fourier Transform and duration Bandwidth principle.
CO2: Explain the concept of Wigner Ville Distribution.
CO3: Explain both CWT and DWT.
CO9: Apply the concept of Time frequency Analysis for Non-stationary signal processing

applications.

Textbooks

1. A Wavelet Tour of Signal Processing by S. Mallat, Academic Press, 3rd Edition, 2009.
2. Time-Frequency Analysis by L. Cohen, Prentice Hall, 1995.

Reference Books

1. Time-Frequency Signal Analysis and Processing: A Comprehensive Reference by Boashash, Elsevier Science, 2003.
2. Wavelet Transforms: Introduction to Theory & Applications by R.M. Rao and A.S. Bopardikar, Prentice Hall, 1998.
3. Time- Frequency Analysis of Seismic Signals by Yanghua Wang, Wiley, 2022.

Course Name: **Distributed System and Grid Integration**
Course Code: **EE-462**
Course Type: **Stream Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To have a broad and up-to-date coverage of the principles and practice in distributed systems.
- To understand operation and control of power systems focussed on issues related to integration of distributed generation.
- To have deep understanding about integration techniques for renewable energy sources.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Renewable Energy Sources:** Review of renewable energy technology, Requirements of the grid for renewable energy systems.	**5**
UNIT-02	**Solar Energy Extractions:** PV system configurations, Solar cell technologies, Maximum power point tracking, DC-DC converters, conventional and multilevel converters and their PWM control strategies.	**8**
UNIT-03	**Wind Power Extractions:** Wind power energy system, types of wind turbines, fixed speed and variable speed operation, Grid converters for wind power, control of converters for wind power extraction.	**8**
UNIT-04	**Grid Synchronization Techniques:** Synchronization techniques for single-phase and three-phase renewable energy system, Islanding operation, grid filters.	**9**
UNIT-05	**Grid Current Control:** Current control technique, Control of converters for fault-ride operation.	**6**
UNIT-06	**Storage Systems:** Configuration of battery energy and Fuel cells storage systems, sizing of storage elements, energy management and control.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the operation of photovoltaic and wind energy systems and their control.
CO2: Understand the grid synchronisation techniques with the renewable energy sources.
CO3: Understand the maximum power Point (MPP) technique and the grid current control techniques.

Textbooks

1. Distributed Generation Systems Design, Operation and Grid Integration by G.B. Gharehpetian, and S. Mohammad Mousavi Agah, Elsevier Science, 2017.
2. Grid Converters for Photovoltaic and Wind Power Systems by Remus Teodorescu, Marco Liserre and Pedro Rodríguez, John Wiley & Sons, Ltd, 2011.
3. Electric and Hybrid Vehicles by Tom Denton, CRC Press, 2020.

Reference Books

1. Power Electronics by Daniel W. Hart, McGraw-Hill Education, 2010.
2. Integration of Distributed Generation in the Power System by Math H. J. Bollen and Fainan Hassan, Wiley, 2011.

Course Name: **Control System Design** Course Code: **EE-463** Course Type: **Stream Elective-I**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To impart knowledge about the control system and its analysis on all practical systems. • To introduce the fundamental concepts relevant to Controllers. • Highlight the importance of state space design of systems. • To explain the parameters to be taken into consideration while designing a compensator.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Control System and Analysis:** Differential equations, Lap lace Transforms, Transfer functions of linear systems, Transient response characteristics and system stability, Disturbance and Sensitivity, Transient performance, and effects of zeros	**8**
UNIT-02	**Frequency Domain Design:** System Bode plot, Open loop and closed-loop behaviour infrequency domain, Frequency response analysis, Gain and Phase Margins.	**7**
UNIT-03	**Classical Control Design Techniques:** Introduction to system design using compensators, Root locus rules, Root locus compensation design, Lead, Lag, Lead-Lag compensation.	**7**
UNIT-04	**Controllers and Compensation Techniques:** PI, PD and PID controllers, Feedback compensation, Feed forward control.	**6**
UNIT-05	**State Space Design of Systems:** Introduction to state space formulation, Concepts of controllability and observability, Full state feedback control design.	**8**
UNIT-06	**Observer Design**: Integrated full state feedback and observer design. Separation Principle.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply the fundamentals of control system analysis to understand the design of various controllers.

CO2: Contribute as well as bring about innovations and developments in some areas like control design methods.

CO3: Realize the requirement of pre-requisite measures required to carry out state space design of the system.

CO4: Identify the type of controllers.

Textbooks

1. Modern Control Engineering by K. Ogata, Pearson Education.
2. Discrete Time Control Systems by K. Ogata, Prentice Hall International.
3. Control System Engineering by Nagrath and Gopal, New Age International.

Reference Books

1. Digital Control Systems by B.C. Kuo, Oxford University Press.
2. Linear Systems by Thomas Kailath, Prentice Hall International.

Course Name: **Switched Mode Power Supply**
Course Code: **EE-464**
Course Type: **Stream Elective -1**

Contact Hours/Week:**3L** CourseCredits:**03**

Course Objectives

- To introduce the fundamental concepts of analyzing the operations of soft switching (resonant) converters
- To understand the basic concept of unity power factor rectifiers for SPMS and its applications.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction and review of basics switched mode power converter topologies:** Introduction to switch mode power supplies (SMPS), linear regulator vs. switching regulator; review of non-isolated dc-dc switch mode converters and analysis: buck, boost, buck-boost, cuk, sepic, continuous conduction mode (CCM) and discontinuous conduction mode (DCM) analysis, non-idealities in the SMPS; review of isolated dc-dc switch mode converters and analysis: fly-back, forward, push-pull, half-bridge and full-bridge topologies; dc-ac switched mode driven inverters.	**8**
UNIT-02	**Modeling of SMPS:** Dynamic modeling using generalized state-space average method to obtain small-signal linear model of the switch mode power converters under CCM and DCM, input, and control transfer functions of converters (input and output impedances, control voltage and current gains, audio susceptibility).	**5**
UNIT-03	**Control of SMPS:** Closed loop control performance requirements of converters using frequency response analysis, effect of input filter on converter performance, voltage mode and current model control, instability in current control and slope compensation technique, methods of regulating multi-output power supply.	**5**
UNIT-04	**Resonant SMPS:** Review of resonant converter topologies and principle of operations: Resonant load converters, Resonant inverter based SMPS, full power circuit of a resonant load SMPS, resonant switch converters with ZCS and ZVS; resonant transition phase modulated converters, resonant switching converters with active clamp.	**6**
UNIT-05	**Design Considerations:** Selection of filter capacitors and selection of energy storage inductor, design of transformer, transformer design for high frequency isolation, selection of ratings for devices, steps for design of DC-DC converter, EMI Filter components, conducted EMI suppression, radiated EMI suppression.	**6**
UNIT-06	**Protection and Applications of SMPS:** Over current protection, over voltage protection, Inrush current protection, unity power factor converter Active front end – power factor correction, High frequency power source for fluorescent lamps, power supplies for portable electronic gadgets.	**6**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Analyze the operations of various dc-dc and dc-ac switch mode power converter topologies.

CO2: Develop dynamic modeling and control of different switch mode dc-dc power converters.
CO3: Evaluate steady-state and dynamic performances of different switch mode dc-dc power converters.
CO4: Select different power circuits and protection circuit components of SMPS for various. applications.
CO5: Evaluate steady-state and dynamic performances of different switch mode dc-dc power converters.
CO6: Analyze the operations of soft switching (resonant) converters and unity power factor rectifiers for SPMS and its applications
CO7: Select different power circuit and protection circuit components of SMPS for various applications.

Textbooks

1. Course Material on Switched Mode Power Conversion by V. Ramanarayanan, Department of Electrical Engineering, Indian Institute of Science, Bangalore
2. Elements of Power Electronics by Philip T. Krein, Oxford University Press
3. Power Electronics: Essentials and Applications by L. Umanand Wiley India.
4. Switch mode power supply: Reference Manual on Semiconductor. SMPSRM/D. Rev,4, Apr-2014, SCILLC, www.onsemi.com
5. Power Electronic Converters Modeling and Control: with Case Studies by Seddik Bacha, Lulian Munteanu and Antoneta Luliana Bratcu, Springer

Reference Books

1. Power Electronics: Converters, Applications and Design by Ned Mohan, Tore M. Undeland and William P. Robbins, John Wiley & Sons, Inc.
2. Switch mode power supply handbook by Keith H Billings and Taylor Morey, Mc-Graw hill Publishing Company.
3. Switching power supplies A to Z, by Sanjaya Maniktala, Elsevier.

Course Name: **Special Electrical Machines** Course Code: **EE-465** Course Type: **Stream Elective-I**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To impart basic knowledge on advanced electrical machines. • To introduce the fundamental concepts relevant to permanent magnet motor drives. • To enable the students to understand the selection of suitable drive for a particular application.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Stepper Motors:** Constructional Features-Principle of operation-Modes of excitations-Theory of torque predictions, Types motor-Variable reluctance motor, Single and multi-stack configurations Hybrid motor, Disc Magnet motor, Claw tooth motor Linear and non-linear analysis-Static and Dynamic Characteristics, Drive Circuits Microprocessor based control of stepper motors, Closed loop control Applications of stepper motors.	**8**
UNIT-02	**Switched Reluctance Motors:** Construction; principle of operation; torque production, modes of operation, Steady state performance, Power converter circuits- Control of SRM Rotor position sensors-Hall effect sensing scheme, Optical position sensing scheme, Current Regulators-Voltage PWM type, Hysteresis type, Sensor-less operation.	**8**
UNIT-03	**Permanent Magnet Synchronous Machines:** Types of permanent magnets and their magnetization characteristics, demagnetizing effect, Principle of operation, Ideal PMSM, EMF and Torque equations, Armature reaction MMF, Synchronous Reactance Sine wave motor with practical windings, Control of PMSM, Power Converter-Volt-ampere requirements-Torque speed characteristics, Linear Synchronous Motors.	**9**
UNIT-04	**PM Brushless DC Motors and Servomotors:** Permanent Magnet Materials-Magnetic Characteristics – Permeance coefficient Magnetic circuit analysis, electronic commutation-Principle of operation –Types of motor, Theory of brushless DC Motor as variable speed synchronous motor, EMF and torque equations, Commutation Power controllers, Motor characteristics and control, Closed loop control DC Servomotors, AC servomotors, Two-phase AC servomotor, Three-phase AC servomotors and modern trends.	**11**
Course Outcomes Upon successful completion of the course, the students will be able to: CO1: Understand constructional and operational aspects, characteristic of stepper motors and PM motors. CO2: Identify suitable PM motor drive for a particular application. CO3: Describe the operation and applications of BLDC motors.		

CO4: Explain the operation of servo motor drives.

Textbooks

1. Electric Motor Drives by R. Krishnan, PHI.
2. Stepping Motors and their Microprocessor Controls by T. Kenjo, Clarendon Press, Oxford.
3. Switched Reluctance Motor Drives by R. Krishnan, CRC Press.

Reference Books

1. Permanent Magnet Synchronous and Brushless DC Motor Drives by R. Krishnan, CRC Press.
2. Design of Brushless Permanent Magnet Machines by J.R. Hendershot and T.J.E. Miller, Motor Design Books LLC.

Course Name:**Over Voltages and Transients**
Course Code: **EE-466**
Course Type: **Stream Elective-I**

Contact Hours/Week:**3L** Course Credits:**03**

Course Objectives

- To gain knowledge in sources of transients like lightning, switching and temporary Overvoltages.
- To analyse travelling wave phenomena against different over voltages
- To model power system components and estimate the over voltages in power system.
- To coordinate the insulation of power system and protective devices.
- To compute transient over voltages using Electromagnetic Transient Program (EMTP).

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Lightning over voltages, Classification of over voltages, Mechanism and parameters of lightning flash, protective shadow, striking distance, electro geometric model for lightning strike.	**4**
UNIT-02	**Grounding for Protection:** Protection against lightning – Steady state and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires.	**5**
UNIT-03	**Switching and Temporary Over Voltages:** Switching transients – concept – phenomenon – system performance under switching surges- Ferranti Effect, Temporary over voltages – load rejection – line faults – Ferro resonance, VFTO.	**7**
UNIT-04	**Travelling Waves on Transmission Line:** Circuits and distributed constants, wave equation, reflection, and refraction – behaviour of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multi conductor system and multi velocity waves.	**8**
UNIT-05	**Insulation Co-ordination:** Insulation co-ordination –volt –time characteristics, Insulation strength and their selection Evaluation of insulation strength standard BILs-Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS.	**7**
UNIT-06	**Computation of Power System Transients:** Computation of transients using electromagnetic transient program-Modelling of power system components- Simple case studies - Application of simplified method: single line station, two-line station, gas insulated substations.	**6**

Course Outcomes

Upon successful completion of the course, the students will have:
CO1: Ability to analyse various sources of transients.

CO2: Ability to compute possible over voltages in power systems.
CO3: Ability to predict over voltages in power system using travelling wave theory.
CO4: Ability to compute over voltages using EMTP with multiple sources.
CO5: Ability to coordinate the insulation level of the power system.

Textbooks

1. Electromagnetic Transients in Power System by Pritindra Chowdhari, John Wiley and Sons Inc., Second Edition, 2009.
2. Electrical Transients in Power System by Allan Greenwood, Wiley & Sons Inc. New York, 2012.
3. Insulation Coordination for Power Systems by Andrew R. Hileman, CRC press, Taylor & Francis Group, New York, 1999.
4. Surges in High Voltage Networks by Klaus Ragaller, Plenum Press, New York, 1980.

Reference Books

1. Extra High Voltage AC Transmission Engineering by Rakosh Das Begamudre, New Age International (P) Ltd., 2006.
2. IEEE Guide for Safety in AC Substation Grounding IEEE Standard 80-2000. 8. Working Group 33/13-09 (1988), 'Very fast transient phenomena associated with Gas Insulated System', CIGRE, 33-13, pp. 1-20.
3. Computational Electromagnetic Transients: Modelling, Solution Methods, and Simulation by R. Ramanujam, I.K. International Publishing House Pvt. Ltd, New Delhi, 2014.

Course Name: **Electrical Distribution System Analysis** Course Code: **EE-467** Course Type: **Stream Elective-I**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To understand the electric distribution system alongside its structure. • To study the approximate methods of analysis. • To explore modelling of distribution system components. • To learn about Distribution system analysis.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Structure of a Distribution System:** Distribution feeder configurations and substation layouts, Nature of loads	**5**
UNIT-02	**Approximate Methods of Analysis:** Computation of transformer and feeder loading, K" Factors, voltage drop and power loss calculations, Distribution of loads and various geometric configurations.	**8**
UNIT-03	**Modeling of Distribution System Components:** Overhead lines, feeders and cables, Single and three phase distribution transformers, Voltage regulators, Load models, Capacitor banks, Distributed generation	**9**
UNIT-04	**Distribution System Analysis**: Load flow analysis for Backward sweep, Load flow analysis for forward sweep, Load flow analysis by Direct approach, Load flow analysis Direct approach for weakly meshed systems, Load flow analysis by Gauss Implicit Z-matrix Method, short-circuit analysis, Sequence-components vs. phase-variable, Short-circuit analysis for LG, LLG, LLLG, and LL Faults, Short-circuit analysis, Weakly meshed system, Applications of distribution system analysis.	**14**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Apply mathematical concepts to solve modelling of a distribution system. CO2: Model the approximate methods of analysis. CO3: Integrate the Distributed systems. CO4: Implement knowledge of distribution system analysis. CO5: Utilize neural networks for enhancing robotic control. CO6: Develop intelligent control solutions for complex robotic systems.		
Text Books 1. Distribution System Modelling and Analysis by W. H. Kresting, CRC Press, New York, 2002. 2. Electric Distribution System by A. A. Sallam and O. P. Malik, IEEE Press, Piscataway, NJ, 2011. 3. J. H. Teng, "A direct approach for distribution system load flow solutions," IEEE Trans. on Power Delivery, vol. 18, no. 3, pp. 882–887, 2003.		

Reference Books

1. Power Distribution Automation, Edited by B. Das, IET Power and Energy Series, 75, London, 2016.
2. Distribution system analysis and the future smart grid, by R. F. Arritt and R. C. Dugan, IEEE Trans. on Industry Applications, vol. 47, no. 6, pp. 2343-2350.

Course Name: **Computer Control of Industrial Processes**
Course Code: **EE-481**
Course Type: **Stream Elective-II**

Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To provide an overview of process control. • To introduce Controller design and tuning methods. • To study the PLC, DCS & SCADA systems. • To design multi-loop and multivariable controller for multivariable system.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction & General Concepts:** Introduction to process control, review of general concepts of system simulation and modeling, Process dynamics of fluid flow, heat transfer systems and chemical processes, Feedforward-Feedback Control structures, cascade control, Hydraulic devices for motion control, Pneumatic devices for process control.	**8**
UNIT-02	**Basic Principles of Feedback Control in Process Industry:** Feedback Control System Characteristics, Proportional mode, Integral Mode, Derivative mode, Alternative control Configurations, Multivariable Control Systems.	**8**
UNIT-03	**Hardware Implementation of Compensators in Process Control:** Passive Electric Networks, Operational Amplifier usage, digital computer as compensator device, Basic computer-control configuration schemes, Digital implementation of analog compensators, Tunable PID Controllers, Ziegler-Nichols methods for controller tuning.	**8**
UNIT-04	**Multi Loop Regulatory Control:** Multi-Loop Control: Introduction, Process Interaction, Pairing of Input and Outputs, Relative Gain Array (RGA) - Properties and Application of RGA, Multi-loop PID Controller - Decoupler. Computer based controller, Programmable Logic Controllers, DCS and SCADA Systems.	**12**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Understand the basics of process control industry. CO2: Design various compensators used in process control. CO3: Learn PLC's, DCS and SCADA systems. CO5: Design multi-loop and multivariable controller for multivariable system.		
Textbooks 1. Digital Control Systems Theory, Hardware, and Software by C.M. Houpis and G.B. Lamount, International Student Edition, McGraw Hill Book Co., 1985. 2. Chemical Process Control by G. Stephanoupoulis, Prentice Hall of India, New Delhi, 1990. 3. Computer-Aided Process Control by S.K. Singh, Prentice Hall India Pvt., Limited, 2004. **Reference Books** 1. Process Control: Theory and Applications by Jean-Pierre Corriou, Springer. 2. Control Systems: Principles and Design by M. Gopal, Tata McGraw Hill. 3. Process Dynamics: Modelling, Analysis, and Simulation by B. Wayne Bequette, Prentice Hall PTR.		

Course Name: **Bio Signal Processing** Course Code: **EE-482** Course Type: **Stream Elective-II**		
Contact Hours/Week: **3L**		Course Credits: **03**
Course Objectives • To make students understand the sources, types & characteristics of different noises and artifacts present in biomedical signals. • To make students able to design time domain and frequency domain filters for noise and artifact removal from biomedical signals. • To make students able to understand and apply various methods for analyzing biomedical signal characteristics. • To motivate students to explore alternative techniques of analyzing biomedical signals in time and frequency domain.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Introduction to Biomedical Signals:** Action Potential and Its Generation, Origin and Waveform Characteristics of Basic Biomedical Signals Like: Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG), Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG), Objectives of Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Computer-Aided Diagnosis.	**9**
UNIT-02	**Removal of Noise and Artifacts from Biomedical Signal:** Random and Structured Noise, Physiological Interference, Stationary and Non-stationary Processes, Noises and Artifacts Present in ECG, Time and Frequency Domain Filtering.	**9**
UNIT-03	**EEG Signal Processing and Event Detection in Biomedical Signals:** EEG Signal and Its Characteristics, EEG Analysis, Linear Prediction Theory, Autoregressive Method, Sleep EEG, Application of Adaptive Filter for Noise Cancellation in ECG and EEG Signals; Detection of P, Q, R, S and T Waves in ECG, EEG Rhythms, Waves and Transients, Detection of Waves and Transients, Correlation Analysis Ad Coherence Analysis of EEG Channels.	**9**
UNIT-04	**Analysis of Non-Stationary Signals:** Heart Sounds and Murmurs, Characterization of Non-stationary Signals and Dynamic Systems, Short-Time Fourier Transform, Considerations in Short-Time Analysis and Adaptive Segmentation.	**9**
Course Outcomes Upon successful completion of the course, the students will be able to CO1: Understand the about different biomedical signals. CO2: Understand the removal of Noise and Artifacts from Biomedical Signal. CO3: Understand the EEG signal and event detection in different biomedical signals. CO4: Analyze different non-stationary signals.		

Textbooks

1. Biomedical Signal Analysis by Rangaraj M. Rangayyan, Wiley, 2015.
2. Biomedical Signal Processing: Principles and Techniques by Reddy, D.C. McGraw-Hill, 2005.

Reference Books

1. Biomedical Digital Signal Processing by W.J. Tompkins, Editorial Prentice Hall, 1993.
2. Bioelectrical Signal Processing in Cardiac and Neurological Applications by Sörnmo, L. and Laguna, P., Academic Press, 2005.

Course Name: **Vehicular Power System**
Course Code: **EE-483**
Course Type: **Stream Elective-II**

Contact Hours/Week:**3L** Course Credits:**03**

Course Objectives

- To provide the fundamentals concepts necessary for understanding of Vehicular Power System
- To inculcate knowledge to perform analysis and comprehend the various operating modes of different configurations of Vehicular Power System.
- To impart required skills to formulate strategies for operators' safety.

Unit Number	Course Content	Contact Hours
UNIT-01	**Vehicle Management Systems:** Energy Management system for electric vehicles- for sensors, accelerators, brake Battery management, Electric Vehicles-Electrical loads, power management system-electrically assisted power steering system	**5**
UNIT-02	**Fuel cell for Automotive Power:** Fuel Cell-Introduction-Proton exchange membrane FC (PEM), Solid oxide fuel cell (SOFC)-properties of fuel cells for vehicles-power system of an automobile with fuel cell-based drive, and their characteristics	**8**
UNIT-03	**Electronic Diagnostics for Vehicles:** System diagnostic standards and regulation requirements –On board diagnosis of vehicles electronic units & electric units-Speedometer, oil and temperature gauges, and audio system.	**8**
UNIT-04	**Automotive Telemetric:** Role of Bluetooth, CAN, LIN and flex ray communication protocols in automotive applications; Multiplexed vehicle system architecture for signal and data / parameter exchange between EMS, ECUs with other vehicle system components and other control systems; Realizing bus interfaces for diagnostics, dashboard display, multimedia electronics. Configuration of battery energy and Fuel cells storage systems, sizing of storage elements, energy management and control.	**14**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand the operation of Vehicular Power System.
CO2: Understand the operation of Vehicular battery storage System.
CO3: Analyze the operation of Automotive telemetric.

Textbooks

1. Vehicular Electric power system- land, Sea, Air and Space Vehicles by Ali Emedi, Mehrdedehsani, John M Miller, Marcel Decker, 2004.
2. Intelligent Vehicle Technologies by L. Vlacic, M. Parent, F. Harahima, SAE International,2001.

Reference Books

1. Alternate Fuel Technology-Electric, Hybrid & Fuel Cell Vehicles by Jack Erjavec, Jeff Arias Cengage ,2012
2. Electronic Engine Control technology by Ronald K Jurgen, SAE International, Second edition.

Course Name: **Intelligent Robotic Control** Course Code: **EE-484** Course Type: **Stream Electives-II**		
Contact Hours/Week: **3L** Course Credits: **03**		
Course Objectives • To introduce the mathematical foundations necessary for robotic control. • To understand the dynamics and kinematics of robots. • To study the design and control of robotic systems. • To explore advanced topics in nonlinear control theory. • To learn about neural networks and their applications in robotic control. • To apply intelligent control techniques to robotic systems.		
Unit Number	**Course Content**	**Contact Hours**
UNIT-01	**Mathematics Preliminaries:** Sets, Metric Space, Vector Space, Matrices, Basic Topology, Sequences, Function, Differentiability, Lipschitz Continuity, Contraction Mapping, Existence and Uniqueness of the Solution of a Differential Equation.	**4**
UNIT-02	**Kinematics of Robots:** Introduction to Robots, Spatial Description and Transformation, Link description, Link-connection description, Convention for affixing frames to links, Manipulator kinematics, Actuator Space, Joint Space, and Cartesian Space, Kinematics of Industrial Robots, Frames with standard names, Inverse manipulator kinematics, Jacobians: velocities and static forces.	**7**
UNIT-03	**Dynamics of Robots:** Acceleration of a rigid body, Mass distribution, Newton's equation, Euler's equation, Iterative Newton—Euler dynamic formulation, Iterative vs closed form, Structure of a Manipulator's dynamic equations, Lagrangian formulation of manipulator dynamics, Manipulator dynamics in cartesian space, Nonrigid body effects	**7**
UNIT-04	**Manipulator-mechanism Design:** Basing the design on Task Requirements, Kinematic configuration, Quantitative measures of workspace attributes, Redundant and closed-chain Structures, Actuation schemes, Stiffness and deflections, Position sensing, and Force Sensing.	**4**
UNIT-05	**Stability Analysis and Approximation of Robotics System:** Robotics Systems as a Nonlinear System, Stability Analysis of Robotic Systems, Lasalle's invariance principle, Barbalat Lemma, Universal Approximation Theorem, Offline and Online Learning, and Modelling using Neural Networks.	**7**

UNIT-06	**Intelligent Control of Robots:** Intelligent control, Adaptive Control, Introduction to Backstepping and Sliding Mode Control, Trajectory generation, Intelligent control in joint and cartesian space, Intelligent Observer design for Robots, Intelligent observer-based controller.	**9**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Apply mathematical concepts to solve robotic control problems.

CO2: Model the dynamics and kinematics of robotic systems.

CO3: Design control systems for robots.

CO4: Implement nonlinear control strategies for robotic applications.

CO5: Utilize neural networks for enhancing robotic control.

CO6: Develop intelligent control solutions for complex robotic systems.

Textbooks

1. Introduction to Robotics: Mechanics and Control by John Craig, Pearson.
2. A Mathematical Introduction to Robotic Manipulation by Richard M. Murray, S. Shankar Sastry, Zexiang Li, CRC Press.
3. Neural Network Control of Robot Manipulators and Nonlinear Systems by A. Yesildirak, F. W. Lewis, and S. Jagannathan, Taylor & Francis Ltd.

Reference Books

1. Neural Networks and Learning Machines by Simon Haykin, Pearson.
2. Nonlinear Control Systems: Analysis and Design by Horacio J. Marquez, Wiley-Interscience.
3. Intelligent Systems and Control by L. Behera and I. Kar, Oxford University Press.

Course Name: **Soft Computing**
Course Code: **EE-485**
Course Type: **Stream Electives-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- Familiarization of various components of soft computing.
- Understand concepts of ANNs, Fuzzy Logic and Genetic Algorithm.
- Differentiate between knowledge-based systems and Algorithmic based systems.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Soft Computing**: Concept of computing systems, "Soft" computing versus "Hard" computing, Characteristics of Soft computing, various types of soft computing techniques, Fuzzy Computing, Neural Computing, Genetic Algorithms, Associative Memory, Adaptive Resonance Theory, Classification, Clustering, Bayesian Networks, Probabilistic reasoning, Some applications of soft computing techniques	**6**
UNIT-02	**Fuzzy Logic**: Introduction to Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets, Fuzzy relations, rules, propositions, implications, and inferences, Defuzzification techniques, Fuzzy logic controller design, Some applications of Fuzzy logic.	**4**
UNIT-03	**Genetic Algorithms:** Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques, Basic GA framework and different GA architectures. GA operators: Encoding, Crossover, Selection, Mutation, etc. Solving single-objective optimization problems using GAs.	**6**
UNIT-04	**Multi-Objective Optimization Problem Solving: -**Concept of multi-objective optimization problems (MOOPs) and issues of solving them, Multi-Objective Evolutionary Algorithm (MOEA), Non-Pareto approaches to solve MOOPs, Pareto-based approaches to solve MOOPs, Some applications with MOEAs.	**8**
UNIT-05	**Artificial Neural Networks:** Biological neurons and its working, Simulation of biological neurons to problem solving, Different ANNs architectures, Training techniques for ANNs, Applications of ANNs to solve some real-life problems.	**8**
UNIT-06	**Introduction to Deep Neural Network:** CNN, Recurrent neural network.	**4**

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand Fuzzy logic and its applications.

CO2: Understand Artificial neural networks and its applications.

CO3: Solve multi-objective optimization problems using Evolutionary algorithms (MOEAs).
CO4: Applications of Soft computing to solve problems in varieties of application domains.

Textbooks

1. Neuro-Fuzzy and Soft Computing by J.S. R. Jang, C.T. Sun, and E. Mizutani, PHI Learning, 2009.
2. Fuzzy Sets and Fuzzy Logic: Theory and Applications by G. J Klir and B Yuan, Prentice Hall.

Reference Books

1. Neural Network Design by Martin T Hagan et.al., 2014.
2. Neural Networks, Fuzzy Logic & Genetic Algorithms by S. Rajasekaran and G. A.V. Pai, PHI, New Delhi, 2003
3. An Introduction to Genetic Algorithms by Melanie Mitchell, MIT Press, 2000.
4. Genetic Algorithms in Search by David E. Goldberg, Optimization and Machine Learning, Pearson Education, 2002

Course Name:**System Identification & Parameter Estimation**
Course Code: **EE-486**
Course Type: **Stream Electives -II**

Contact Hours/Week: **3L** CourseCredits:**03**

Course Objectives

- To acquire the basic knowledge of systems and models
- To study and apply various system identification techniques to solve real world problems
- To acquire mathematical foundations of parameter estimation methods

Unit Number	Course Content	Contact Hours
UNIT-01	**Systems and Models:** Time invariant systems, impulse response, disturbances, and transfer functions, frequency domain expressions, signal spectra, multivariable systems. Simulation prediction, observers. Models of linear time invariant systems, linear models and sets of linear models, state space models, distributed parameter models, model sets structures and identifiability, identifiability of some model structures, Models of time varying and nonlinear systems, linear time varying models, nonlinear state space models, nonlinear black box models, neural networks, wavelets and classical models, fuzzy models, formal characterization of models.	**10**
UNIT-02	**Model Estimation Methods:** Nonparametric time and frequency domain methods, transient response analysis, frequency response analysis, Fourier analysis, Spectral analysis, estimating disturbance spectrum, Parameter estimation methods, guiding principles, minimizing prediction errors, linear regressions, and least squares method, statistical framework for parameter estimation and maximum likelihood estimation, correlation of prediction error with past data, Instrumental variable methods, using frequency domain data to fit linear models.	**10**
UNIT-03	**Convergence, Consistency, and Distributions of Parameter Estimates:** Conditions of data set, prediction error approach, consistency and identifiability, linear time invariant models, correlation methods. Prediction error approach, basic theorem expressions for asymptotic variance, frequency domain expressions for asymptotic variance, correlation approach, use and relevance. Computing the estimate, linear regression and least squares, computing gradients, two stage and multistage methods, local solutions and initial values, subspace methods, Recursive methods, recursive forms of least squares, IV, prediction error and pseudo linear regression methods, choice of updating step, Implementation problems.	**12**
UNIT-04	**Experiment Design:** General Considerations, informative experiments, input design and open loop experiments, closed loop identification, approaches, optimal experiment design, choice of sampling interval, preprocessing of data, drifts de-trending, outliers and missing data, selecting segments of data and merging	**8**

	experiments, pre-filtering, formal design of pre-filtering and input properties.	

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Understand and apply the concepts of different system identification methods.

CO2: Estimate parameters using statistical framework.

CO3: Identify multivariable and closed loop systems.

CO4: Design experiments to identify systems on a practical basis and proposing validation techniques.

Text Books

1. System Identification Theory for the User by Lennart Ljung, Prentice Hall Inc, 1999.
2. System Identification and Modelling of Systems by Sinha N K, Kuztsa, 1983.
3. Parameter Estimation: Marcel Dekker Inc by Harold W Sorensen, New York. 1980.

Reference Books

1. Filtering and System Identification a Least Squares Approach by Michel Verhagen and Vincent Verdult, Cambridge Univ. Press, 2007.
2. Lessons in Estimation Theory for Signal Processing, Communications and Control by Jerry M. Mendel, Prentice-Hall, 1995.

Course Name: **High Voltage DC Transmission** Course Code: **EE-487** Course Type: **Stream Elective -II**

Contact Hours/Week: 3L Course Credits**: 03**

Course Objectives

- Students will be able to learn different types of HVDC in HVDC Transmission.
- To learn the various rectifiers and inverters operation in the HVDC system for the power flow.
- To study the different harmonics in the HVDC system and filtering.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction& Types of HVDC Links:** Introduction to HVDC transmission, Comparison between HVAC and HVDC systems - Economic, technical- Power Handling Capabilities of HVDC Lines and reliability, limitations, Types of HVDC links - Monopolar, Bipolar and Homopolar links, Components of HVDC transmission system. Applications of HVDC lines, Basic Conversion principle.	6
UNIT-02	**Control operation and analysis:** Analysis of HVDC Converters-Rectifier and Inverter operation of Graetz circuit without and with overlap angle. Complete Equivalent circuit of HVDC link. Complete characteristics of converter as Rectifier and Inverter. Analysis of 12-pulse converter. Power flow in HVDC Links.	8
UNIT-03	**Control of HVDC Converter & Systems:** Basic principles of HVDC system control, necessity of control in HVDC link, power reversal, Basic controllers - constant current and constant extinction, power control, high level controllers. Firing angle control- Individual phase control and equidistant firing angle control. Summary of converter control.	8
UNIT-04	**MTDC Systems and applications:** Multi-terminal DC links and systems- series, parallel and series parallel systems, their operation. HVDC system applications in wind power generation	4
UNIT-05	**Reactive power control, Harmonics, and filtering:** Harmonics in HVDC system - Characteristic and uncharacteristic harmonics - Troubles due to harmonics – Harmonic filters - Active and passive filters - Reactive power control of converters	6
UNIT-06	**Over voltages, Converter Faults and Protection in HVDC Systems** Over voltages due to disturbances on DC side, AC side & internal converter side. Converter faults- misfire, arc through, commutation failure, over current protection - valve group, and DC line protection. Over voltage protection of converters	4

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Select the appropriate type of HVDC link and converter.

CO2: Analyze the operation of Graetz circuit as rectifier and inverter without and with overlap.

CO3: Evaluate the operation and efficacy of different controllers.

CO4: Evaluate the issues related with harmonics, reactive power control and protection of HVDC system.

Textbooks

1. HVDC Transmission Systems, by Padiyar, K.R., ‘Wiley Eastern Ltd., 2010.
2. HVDC Transmission, 1st Edition, by Kamakshaiah, S and Kamaraju, V, Tata McGraw Hill Education (India), New Delhi 2011.
3. High Voltage Direct Current Transmission by J. Arrilaga, 2nd Edition, Institution of Engineering and Technology, London, 1998.

Reference Books

1. Direct Current Transmission-vol.1by Kimbark, E.W., Wiley Inter science, New York, 1971
2. Electric Power Generation, Transmission and Distribution, by S. N Singh, PHI, New Delhi 2nd edition, 2008.

3. HVDC and FACTS Controllers by Vijay K. Sood, Kluwer Academic Publishers, New York, 2004.
4. Power Transmission by Direct Current by E.Uhlman, Springer Verlag, Berlin Helberg, 1985.

Course Name: **Holistic Assessment**
Course Code: **EE-498**
Course Type: **Discipline Core**

Course Name: **UG Project**

Course Code: **EE-499**

Course Type: **Discipline Core**

Course Objectives:

- Students will be able to learn to effectively communicate their ideas and views.
- To learn the ability to acquire self-confidence, knowledge, and leadership skills.
- To learn how to be an all-rounder, versatile, and attain adaptability in various situations.

- **The Holistic Assessment will be done by the appropriate committee to evaluate the overall performance and contributions made by the student during his/ her entire B. Tech Program.**
- **The evaluation of the same shall be done according to the provisions contained in Bachelor Ordinance.**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Apply critical thinking skills when listening, reading, thinking, and speaking.
CO2: Create, organize, and support ideas for various types of oral presentations.
CO3: Evaluate contexts, attitudes, values, and responses of different audiences.

Course Objectives

- Students will be able to learn the necessary skills for analysis and synthesis of engineering problems.
- To design and demonstrate engineering solutions to complex problems utilizing a specific approach.
- To build software and hardware design skills for solving engineering problems.
- To develop research and innovative thinking approach.
- To develop the knowledge, skills and attitudes of a professional engineer.

- **The major project will be a group activity, and each group must undertake hardware/software projects under the mentorship of Electrical Engineering Faculty.**
- **The evaluation of the same shall be done according to the provisions contained in Bachelor Ordinance.**

Course Outcomes

Upon successful completion of the course, the students will be able to:

CO1: Apply fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study.

CO2: Demonstrate skill and knowledge of current information and technological tools and techniques specific to the professional field of study.