GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA
ELECTRICAL ENGINEERING DEPARTMENT

Semester-III

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
EE-14301	Engineering Mathematics-III	3	1	--	40	60	100	4
EE-14302	Network Analysis and Synthesis	3	1	--	40	60	100	4
EE-14303	Electrical Measurements & Measuring Instruments	3	1	--	40	60	100	4
EE-14304	Transformers & Direct Current Machines	3	1	--	40	60	100	4
EE-14305	Electronic Devices and Circuits	3	1	--	40	60	100	4
EE-14306	Laboratory-I: Transformers& Direct Current Machines	--	--	3	30	20	50	2
EE-14307	Laboratory-II: Electronic Devices and Networks	--	--	3	30	20	50	2
EE-14308	Laboratory-III: Electrical Measurements & Measuring Instruments	--	--	2	30	20	50	1
TR-14301	Workshop Training (Undertaken after 2nd semester)	--	--	--	60	40	100	2
Total		**15**	**5**	**8**	**350**	**400**	**750**	**27**

Semester-IV

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
EE-14401	Asynchronous Machines	3	1	--	40	60	100	4
EE-14402	Control Systems	3	1	--	40	60	100	4
EE-14403	Electromagnetic Field Theory	3	1	--	40	60	100	4
EE-14404	Power System-I (Transmission & Distribution)	3	1	--	40	60	100	4
EE-14405	Digital Electronics	3	1	--	40	60	100	4
EE-14406	Object Oriented Programming	3	1	--	40	60	100	4
EE-14407	Laboratory-IV: Control Systems	--	--	2	30	20	50	1
EE-14408	Laboratory-V: Digital Electronics	--	--	2	30	20	50	1
EE-14409	Laboratory-VI: Object Oriented Programming	--	--	2	30	20	50	1
GF-14401	General Fitness	--	--	--	100	**--**	100	1
Total		**18**	**6**	**6**	**430**	**420**	**850**	**28**

Semester-V

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
EE-14501	Synchronous Machines	3	1	--	40	60	100	4
EE-14502	Numerical & Statistical Techniques	3	1	--	40	60	100	4
EE-14503	Industrial Electronics	3	1	--	40	60	100	4
EE-14504	Instrumentation Engineering	3	1	--	40	60	100	4
DEEE-145XX	Elective-I	3	1	--	40	60	100	4
EE-14505	Laboratory-VII: Asynchronous & Synchronous Machines	--	--	2	30	20	50	1
EE-14506	Laboratory-VIII: Industrial Electronics	--	--	2	30	20	50	1
EE-14507	Laboratory-IX: Instrumentation & Measuring Devices	--	--	2	30	20	50	1
EE-14508	Laboratory-X: Numerical & Statistical Techniques	--	--	2	30	20	50	1
TR-14501	Industrial Training - I (Undertaken after 4th semester)	--	--	--	60	40	100	2
Total		**15**	**5**	**8**	**380**	**420**	**800**	**26**

Semester-VI

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
EE-14601	Power System-II (Switchgear & Protection)	3	1	--	40	60	100	4
EE-14602	Electrical Drives & Utilization	3	1	--	40	60	100	4
EE-14603	Electrical Generation & Economics	3	1	--	40	60	100	4
EE-14604	Microcontroller & Programmable Logic Controllers	3	1	--	40	60	100	4
DEEE-146XX	Elective-II	3	1	--	40	60	100	4
OEEE-146XX	Open Elective	3	--	--	40	60	100	3
EE-14605	Laboratory-XI: Power System	--	--	2	30	20	50	1
EE-14606	Laboratory-XII: Electric Drives	--	--	2	30	20	50	1
EE-14607	Laboratory-XIII: Microcontroller & Programmable Logic Controllers	--	--	2	30	20	50	1
PREE-14601	Minor Project	--	--	1	60	40	100	1
GF-14601	General Fitness	--	--	--	100	**--**	100	1
Total		**18**	**5**	**7**	**490**	**460**	**950**	**28**

Semester-VII/VIII

Course Code	Course Title	Marks Distribution		Total Marks	Credits
		Internal	External		
Industrial Training (One Semester)					
TREE-14701	Industrial Training - II	450	350	800	13
TREE-14702	Industry Oriented Training (02 week)	200	---	200	2
Total		**650**	**350**	**1000**	**15**

Semester-VII/VIII

Course Code	Course Title	L	T	P	Marks Distribution		Total Marks	Credits
					Internal	External		
EE-14801	Computer Aided Power System Analysis	3	1	--	40	60	100	4
EE-14802	Digital Control System	3	1	--	40	60	100	4
EE-14803	High Voltage Engineering	3	1	--	40	60	100	4
DEEE-148XX	Elective-III	3	1	--	40	60	100	4
DEEE-148XX	Elective-IV	3	1	--	40	60	100	4
EE-14804	Laboratory-XIV: Computer Aided Power System Analysis	--	--	2	30	20	50	1
EE-14805	Laboratory-XV: High Voltage Engineering	--	--	2	30	20	50	1
EE-14806	Seminar	--	--	2	100	--	100	2
PREE-14701	Major Project	--	--	3	120	80	200	3
GF-14701	General Fitness	--	--	--	100	--	100	1
Total		**15**	**5**	**9**	**580**	**420**	**1000**	**28**

Course Code	Course Title
Elective-I	
DEEE-14501	Renewable Energy Resources
DEEE-14502	Electrical Design & Illumination Engineering
DEEE-14503	Electrical Engineering Materials
DEEE-14504	Energy Auditing & Management
DEEE-14505	Solar Technologies
DEEE-14506	Analog Integrated Circuits
Elective-II	
DEEE-14601	Power System Operation & Control
DEEE-14602	Computer Aided Electrical Machine Design
DEEE-14603	Optimization Techniques
DEEE-14604	Energy Conversion
DEEE-14605	Robotic Control System
DEEE-14606	Process Dynamics and Control
Elective III	
DEEE-14801	Fuzzy Logics &Systems
DEEE-14802	Power System Planning
DEEE-14803	Power System Restructuring & Deregulation
DEEE-14804	System Engineering & Reliability
DEEE-14805	Advanced Microprocessors
Elective IV	
DEEE-14806	Digital Signal Processing
DEEE-14807	Signals and Systems
DEEE-14808	Flexible AC Transmission Systems
DEEE-14809	Neural Networks
DEEE-14810	Energy Efficient Machines
Open Elective*(To be offered by Electrical Engineering Department to other Departments)*	
OEEE-14601	Non-Conventional Energy Sources
OEEE-14602	Energy Auditing and Management

EE-14301ENGINEERING MATHEMATICS-III

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Analyse Fourier series applications for electrical Engineering problems
b. Evaluate linear differential equations which are often the part of electrical engineering problems using techniques of Laplace Transforms.
c. Evaluate the special functions which arise as a result of differential equations with variable coefficients.
d. Analyse different types of partial differential equations.
e. Apply the methods of partial differential equations to solve one dimensional heat equation and wave equation.
f. Analyze the differential and integral calculus for complex functions.

CONTENTS

1. FOURIER SERIES

Periodic functions, Euler's formula, Even and Odd functions, Half range expansions, Fourier series of different wave forms.

2. LAPLACE TRANSFORMS

Laplace transforms of various standard functions, properties of Laplace transforms, inverse Laplace transforms, transform of derivatives and integrals, Laplace transform of unit step function, periodic function, applications to solution of ordinary linear differential equations with constant coefficients, and simultaneous differential equations.

3. SPECIAL FUNCTIONS

Power series solution of differential equations, Frobenius method, Legendre's equation, Legendre polynomial, Bessel's equation, Bessel functions of the first and second kind, Recurrence relations.

4. PARTIAL DIFFERENTIAL EQUATIONS

Formation of partial differential equations, Linear partial differential equations, Homogeneous partial differential equations with constant coefficients.

5. APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Wave equation and Heat conduction equation in one dimension, Two dimensional Laplace equations in Cartesian Coordinates, Solution by the method of separation of variables.

6. FUNCTION OF COMPLEX VARIABLE

Limits, continuity and derivative of the function of complex variable, Analytic function, Cauchy-Riemann equations, conjugate functions, harmonic functions; Conformal Mapping: Definition, standard transformations, translation, rotation, inversion, bilinear. Complex Integration: Line integrals in the complex plane, Cauchy's theorem, Cauchy's Integral Formula and derivatives of analytic function. Taylor's and Laurent's expansions (without proofs), singular points, poles, residue, Integration of function of complex variables using the method of residues.

BOOKS RECOMMENDED

1. Kreyszing, E., *Advanced Engineering Mathematics*, 8th edition, John Wiley, New Delhi.
2. Grewal, B. S., *Higher Engineering Mathematics*, Khanna Publishers, New Delhi.
3. Ian N. Sneedon, *Elements of Partial Differential Equations*, McGraw- Hill Publisher.
4. Peter. V. O'Nil, *Advanced Engineering Mathematics*, Wadsworth Publishing Company.
5. Taneja, H. C., *Engineering Mathematics*, Volume-I& Volume-II, I. K. Publisher.
6. Babu Ram, *Advance Engineering Mathematics*, Pearson Education.
7. Bindra, J. S., *Applied Mathematics*, Volume-III, Kataria Publications.
8. O'Neil, *Advanced Engineering Mathematics*, Cengage Learning.

EE-14302 NETWORK ANALYSIS AND SYNTHESIS

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Evaluate the circuit quantities using the circuit theorems.
b. Create graph from given circuit.
c. Analyze the transient response of a circuit to test signal.
d. Analyze AC circuits.
e. Analyze filters.
f. Analyze the given equations to find out the circuit parameters.

CONTENTS

1. DC CIRCUITS

Basic concepts: Current, Voltage and Power, Sources: Dependent and Independent sources; their circuit representation, Ideal Sources, source transformation, Ohm's law: applications and limitations, Kirchoff's laws: current and voltage, Nodal and Mesh analysis, Series and parallel circuit analysis, star and delta connected loads, Superposition theorem, Thevenin theorem, Norton theorem, Maximum Power transfer theorem, Tellegen's Theorem.

2. NETWORK TOPOLOGY

Concept of graph, tree, co-tree, branch, link of a network and their application to formation of incidence matrices, Tie-set, Cut-set matrix formation.

3. STEADY STATE AND TRANSIENT ANALYSIS

Concept of steady state and transient state, Introduction to Laplace transform, Conversion of circuit from Time domain to frequency domain, Test signals: Unit Impulse, Unit step, Unit Ramp, Unit Doublet, Parabolic signals and their graphical and mathematical representation, Application of Laplace transform to solution of transient state of a simple network with independent sources only, First order and Second order networks, Poles and zeros and transfer function, Convolution theorem and Convolution Integral.

4. AC CIRCUITS

Instantaneous Power, Average Power, Effective Power, Apparent Power and Reactive Power, Polyphase circuits, Analysis of series and parallel RLC circuits, Application of Superposition, Thevenin, Norton and Maximum power transfer theorems to AC circuits.

5. TWO PORT NETWORKS & FILTERS

Concept of two port network, Impedance parameters, Admittance parameters, ABCD parameters, h-parameters, g-parameters, Concept of filters, Need for filters, Prototype filters, half section, m-derived filters, Composite filters.

6. NETWORK SYNTHESIS

Synthesis of simple networks using Foster and Cauer forms.

BOOKS RECOMMENDED

1. Hayt W. H., Kemmerly J. E. and Durbin S. M., *EngineeringCircuit Analysis*, McGraw Hill Publications, 7th edition.
2. Bruce Carlson A., *Circuits*, Cengage Learning.
3. David Irwin J. and Robert M. Nelms, *Engineering Circuit Analysis,* Wiley Publications, 10th edition.
4. Sudhakar A. Rao and Shyammohan, *Circuits and Networks*, Tata McGraw Hill Publications.
5. Sukhija M.S. and Nagsarkar T.K., *Circuits Networks*, Oxford University Press.
6. Chakravorty Abhijeet, *Circuit Theory*, Dhanpat Rai and Sons.

EE-14303 ELECTRICAL MEASUREMENTS & MEASURING INSTRUMENTS

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Analyze and compare different types of analog measuring instruments and their applications.
b. Evaluate power and energy by using energy meter and power factor meters.
c. Understand bridges and calculate unknown values.
d. Understand techniques and acquire skills related to application of potentiometers.
e. Evaluate the different types of errors using instrument transformers.
f. Understand various magnetic measurements.

CONTENTS

1. UNITS, SYSTEMS AND STANDARDS

Review of MKS & Rationalized MKSA System, SI Units, Standards of EMF, Resistance, Capacitance and Inductance, Systematic errors.

2. ANALOG MEASURING INSTRUMENTS

Operating, damping & controlling torques, Torque/Weight ratio, Pointers & Scales. Principles of operation of various types of electro-mechanical indicating/registering instruments viz. PMMC, moving iron, dynamometer, induction, thermal for DC&AC measurement of voltage, current, power, frequency, phase & power factor, energy meter(Single Phase induction type): their sources of error & compensation, shunts & multipliers, insulation testing using Meggar.

3. POTENTIOMETERS

Basic DC potentiometer circuit, Modern form of DC potentiometer, measurement of voltage, current, Resistance and calibration of voltmeter & ammeter using DC potentiometer, volt ratio box, Self balancing potentiometer, AC potentiometers and their applications.

4.BRIDGES

Sources and Detectors, General equation for bridge balance, Wheatstone bridge and its sensitivity analysis, Kelvin double bridge, AC bridges: applications and conditions for balance, Maxwell's bridge, Hay's bridge, Schering bridge, Wien bridge, Anderson bridge, DeSauty's bridge, Insulation testing, Sources of errors in bridge circuits, Shielding of bridge elements, Wagner Earthing Device.

5. MAGNETIC MEASUREMENTS

Determination of B–H curve and hysteresis loop, Flux meter, Measurement of iron losses by Wattmeter and Bridge methods.

6. INSTRUMENT TRANSFORMERS

Theory and construction of current and potential transformers, ratio and phase angle errors and their minimization, Characteristics of current transformers (CT) and potential transformers (PT) and their Testing, Burden and its ratings.

BOOKS RECOMMENDED

1. Golding Edward William and Widdis Frederick Charles, *Electrical Measurements and Measuring Instruments*, Wheelers India.
2. Bell David A., *Electronics Instrumentation and Measurements*, Prentice Hall, India.
3. Reissland Martin V, *Electrical Measurements Fundamentals, Concepts, Applications*, Wiley Eastern Limited, New Delhi.
4. Erenest O. Doebelin, *Measurement Systems-Application and Design,* McGraw Hill, 5th edition, 2005.
5. Helfrick A.D. and Cooper W.D., *Modern Electronic Instrumentation& Measurement Techniques*, Prentice Hall.
6. Murthy D. V. S., *Transducers and Instrumentation*, Prentice-Hall, India.

EE-14304 TRANSFORMERS AND DIRECT CURRENT MACHINES

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the principle, construction and analyze the operation of transformers and DC machines.
b. Testing of transformer and evaluate efficiency and voltage regulation.
c. Develop basic skills in construction and analysis of equivalent circuit, phasor diagram and circuit parameters of transformer and DC machine.
d. Analyze the performance characteristics of DC machines for different operating conditions.
e. Evaluate the speed control and starting method of DC motor for specific purpose.
f. Explore knowledge in context of applications of transformer and dc machines in industry.

CONTENTS

1. SINGLE PHASE TRANSFORMERS

Overview: Magnetic circuits, Working principle of transformer, constructional features and E.M.F equation, Phasor diagram on no-load and loaded conditions, Referred parameters equivalent circuit, In rush phenomenon, Voltage regulation and efficiency, All day efficiency. Testing: Open-circuit test, short-circuit test and back-to-back test.

2. THREE PHASE TRANSFORMERS

Construction of three phase transformer & its comparison with single-phase transformer, poly phase transformer connections, Scott connections, power and distribution transformers, Operational features of on-load tap changer (OLTC), Parallel operation of transformers, Different diagnostic techniques of transformers.

3. SPECIAL TYPE TRANSFORMERS

Constructional details and principle of Auto transformer, Saving of copper, Applications of auto transformer, Introduction to special purpose transformer: dry type and amorphous core.

4. D.C. GENERATOR

Working principle, construction of DC machines, armature windings, E.M.F. and torque equations, armature reaction: effect of brush shift and compensating winding. Commutation: causes of bad commutation, methods of improving commutation. D.C. generator characteristics.

5. D.C. MOTOR

Working principle, characteristics, starters (3-point, 4-point and soft starters), speed control methods (field and armature control). Braking: plugging, dynamic and regenerative braking.Estimation of losses and efficiency by Swinburn's test and Hopkinson test.Introduction to brushless direct current (BLDC) machines.

BOOKS RECOMMENDED

1. Say M. G., *Alternating Current Machines*, 5th edition, Sir Isaac Pitman & Sons Ltd.
2. Fitzgerald A.E., Kingsley C. and Umans S.D., *Electric Machinery*, 6th edition, McGraw Hill.
3. Langsdorff E.H., *Principles of D.C. Machines*, McGraw Hill.
4. Bimbhra P.S., *Electrical Machinery*, Khanna Publishers.
5. Nagrath I.J. and Kothari D.P., *Electrical Machines*, 4th edition, Tata McGraw Hill.
6. Charles I. Hubert, *Electrical Machines*, 2nd edition, Pearson Education.
7. B.H.E.L., *Transformers*, Tata McGraw-Hill Education.

EE-14305 ELECTRONIC DEVICES AND CIRCUITS

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Comprehend the principle, construction, characteristics, operation and application of various electronic devices viz: Diode, BJT, FET, Special purpose Diodes and MOSFET.
b. Analyze and understand different electronic devices as a circuit element.
c. Troubleshoot, design and create electronic circuits meant for different applications.
d. Evaluate performance of electronic circuits.
e. Understand the applications of amplifiers.
f. Understand the working and application of power supplies.

CONTENTS

1. SOLID STATE DEVICSS

Solid-State electronic materials, Characterize resistivity of insulators, semiconductors, and conductors. Diode, *pn* junction electrostatics, Space charge region formation at the *pn* junction, Internal diode currents, diodes I-V characteristics, Diode as a circuit element Half wave rectifier, Full wave (Center tap and Bridge type) rectifier. Wave shaping and voltage multiplier circuits.Special purpose diodes Principle, construction, characteristics and applications of LED's, Schottky, Varactor and Photodiodes.

2. BIPOLAR JUNCTION TRANSISTOR (BJT)

Physical structure and operation regions of Bipolar transistors, *I-V* Transistor characteristics and parameters, Common Base, Common Emitter and Common Collector Configurations. Transistor biasing (Two resistor bias networks and four resistor biasing), Four resistor bias network for BJT: Design objectives. Transistor thermal runaway and thermal stability, transistor cut off region model (switch).

3. BJT AC ANALYSIS

Basics characteristics of an amplifier, Simple transistor model (r_e model), hybrid equivalent circuit, circuit analysis using h-parameters. CE Fixed bias configuration, emitter follower, Difference between BJT and FET. Junction field effect transistor (JFET) and Metal oxide semiconductor field effect transistor (MOSFET): Characteristics, parameters and biasing. BJT Frequency Response Decibels, General Frequency considerations, Low frequency response-BJT amplifier.

4. OPERATIONAL AMPLIFIERS AND APLICATIONS

Introduction, Differential amplifier circuit, Op-Amp basics, Practical Op-Amp circuits, Op-Amp specification- DC offset parameters, Op-Amp specifications- Frequency parameters, Op-Amp unit specifications, differential and common mode operation. Constant gain multiplier, voltage summing, voltage buffer, controlled sources, Instrumentation circuits, Active filters.

5. POWER AMPLIFIERS

Difference between small signal and large signal amplifiers Introduction and types. Series fed Class A amplifier and transformer coupled amplifier, Class B amplifier circuits. Amplifier Distortion, Heat Sinks, Class C and Class D amplifier

6. POWER SUPPLIES

RC and LC filters and their design. Surge Current and PIV rating, discrete voltage regulators, Line and Load regulations, Transistor Series and Shunt regulators, Current limiting, IC voltage regulators, Practical applications of Power Supply.

BOOKS RECOMMENDED

1. Mottershead A., *Electronic Devices and Circuits: An Introduction*, Prentice Hall of India Learning Pvt ltd, 2011,New Delhi.
2. Boylestad R.L., and Nashelsky L., *Electronic Devices and Circuit Theory*, 10th edition, Pearson (LPE) India.
3. Floyd T.L., *Electronic Devices*, 9th Edition, Pearson (LPE), India.
4. Malvino A., *Electronic Principles*, Tata Mc-Graw Hill.
5. Millman and Halkias, *Electronic Devices and Circuits*, Tata Mc-Graw Hill.
6. Jaeger R.C. and Blalock T.N., *Microelectronic Circuit Design*,4th Edition, Mc-Graw Hill.
7. Deshpande N.P., *Electronic Devices and Circuits: Principles and Applications*, 2007, Mc-Graw Hill companies.

EE-14306 LABORATORY-I: Transformers & Direct Current Machines

Internal Marks	: 30	L	T	P	C
External Marks	: 20	0	0	3	2
Total Marks	: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Evaluation of equivalent circuit parameters, efficiency and voltage regulation by performing various tests on transformer.
b. Analyze three-phase transformer connections.
c. Analyze parallel operation of transformers.
d. Analyze performance characteristics of DC generators.
e. Evaluate various speed controls and starting methods of DC motor.
f. Construct and analyze torque slip characteristics of DC motor.

LIST OF EXPERIMENTS

1. To perform open circuit and short circuit tests on a single-phase transformer and hence find equivalent circuit parameters, voltage regulation and efficiency.
2. To find the efficiency and voltage regulation of single-phase transformer under different loading conditions.
3. To perform back-to-back test (Sumpner's Test) two single-phase transformers.
4. To perform polarity test and parallel operation of two single-phase transformers.
5. To make Scott connections on three-phase transformer to get two phase supply.
6. To verify the outputs of various connections in three-phase transformer.
7. To start the dc motor and study in detail the three-point and four-point starters.
8. To measure armature and field resistance of direct current (d.c.) shunt generator and to obtain its open circuit characteristics.
9. To perform speed control on dc shunt motor by field current and armature voltage.
10. To draw speed-torque characteristics of dc shunt/series /compound motor.
11. To perform Swinburne's test (no load test) to determine losses of dc shunt motor.
12. Application of MATLAB for solution of problems regarding transformers and dc machines.

EE-14307 LABORATORY-II: ELECTRONIC DEVICES AND NETWORKS

Internal Marks	: 30	L	T	P	C
External Marks	: 20	0	0	3	2
Total Marks	: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Identify and test different types of electrical and electronic components.
b. Ability to make circuits on bread-board and understand the use and importance of various types of equipment's used in the laboratory.
c. Analyze, take measurements to understand circuit behavior and performance under different conditions.
d. Troubleshoot, design and create electronic circuits meant for different applications.
e. Acquire experience in creating and troubleshooting simple projects employing semiconductor devices.
f. Evaluate the performance electronic circuits and working small projects employing semiconductor devices

LIST OF EXPERIMENTS

1. Verification of KVL and KCL law.
2. Verification of Superposition theorem.
3. Verification of Thevenin's and Maximum Power Transfer theorem.
4. Verification of Norton's theorem using Current sources.
5. To obtain transient response of RL& RC circuits (dc).
6. To obtain frequency response of RLC Circuits.
7. To design a full wave and half wave rectifier and observe the waveforms with and without filters.
8. To design a voltage regulator using Zener diode and also see the effect of line and load regulation.
9. To design various clippers and clampers using diodes.
10. To plot the transistor characteristics in common emitter configuration and also determine the h-parameters from these characteristics.
11. To design, study and compare various transistor biasing techniques and also see the effect on operating point (Q-point) when using various transistors at different temperatures.
12. To obtain the frequency response and calculate the gain bandwidth of the amplifier.
13. To analyze a voltage follower circuit.
14. To plot the VI characteristics of FET.
15. To plot the characteristics of a class B amplifier and also calculate the overall efficiency.

16. To plot the characteristics of a class AB amplifier.
17. To plot the characteristics of symmetry amplifier.
18. To design various type of oscillators and to determine the frequency of oscillations.
19. To design a transistor series voltage regulator with current limits and observes current feedback characteristics.
20. To plot the characteristics of a complementary symmetry amplifier.

EE-14308 LABORATORY-III: ELECTRICAL MEASUREMENTS & MEASURING INSTRUMENTS

Internal Marks : 30	L	T	P	C
External Marks : 20	0	0	2	1
Total Marks : 50				

COURSE OUTCOMES

After studying this course, the students will

a. Measure precisely R, L, C, M & F by using different bridges.
b. Determine ratio error by using current & potential transformers.
c. Compute frequency by using Weston Frequency Meter.
d. Measure three phase power and power factor by two wattmeter method
e. Construct characteristic graph of potentiometer and hysteresis loop using flux meter.
f. Measurement of insulation resistance using Earth Tester.

LIST OF EXPERIMENTS

1. Measurement of resistance using Wheatstone bridge.
2. Measurement of resistance using Kelvin's Bridge.
3. Measurement of frequency using Wein's Bridge.
4. Measurement of capacitance using Schering Bridge
5. Measurement of self-inductance using Anderson's Bridge.
6. To find the ratio error of Current and Potential Transformers.
7. To measure power consumed by a 3-phase load and to find its power factor using 2 Wattmeter methods.
8. To plot EMF vs. Displacement characteristics of a potentiometer.
9. To plot Hysteresis loop for a magnetic material using Flux Meter.
10. To calibrate the induction type Energy Meter.
11. To find ‘Q’ of an inductance coil and verify its value using Q-meter.
12. To measure insulation resistance using Meggar.
13. To measure the earth resistance by Earth Tester.
14. To measure frequency of ac supply using Weston Frequency meter.

EE-14401 ASYNCHRONOUS MACHINES

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the principle, construction and analyze the operation of three phase induction motor.
b. Design and analysis of equivalent circuit for construction of phasor diagram and evaluation of various circuit parameters of induction machine.
c. Interpolate the performance and construct torque slip characteristics of an induction motor.
d. Interpret the different techniques for the speed control and starting of an induction motor.
e. Analyze different types of fractional horse power motors.
f. Comprehend and solve industry related problems in context of induction motors.

CONTENTS

1. THREE PHASE INDUCTION MOTORS

Analogy between induction motor and transformer, constructional features, production of rotating field in space distributed three-phase winding, concept of slip, rotor frequency, current and power, Development of circuit model (equivalent circuit), phasor diagram, torque-slip characteristics, effect of rotor circuit resistance, starting torque, crawling and cogging, High torque cage motors: double cage and deep bar motor.

2. STARTING METHODS AND SPEED CONTROL

Starting methods, Speed control methods, Motor tests for estimation of equivalent circuit parameters, Introduction to variable frequency drives (VFD).

3. INDUCTION GENERATOR

Operation: Isolated and Grid mode, method of excitation, application of induction generator in wind mills and micro hydel power plants.

4. SINGLE –PHASE MOTORS

Double revolving field theory, types of single phase motors, characteristics. Shaded pole motor: working principle and characteristics.

5. SPECIAL PURPOSE MOTORS

Stepper Motors: construction, principle of operation and applications. Linear Induction Motor: construction, principle of operation and applications. Universal Motor: construction, principle of operation and applications.

BOOKS RECOMMENDED

1. Fitzgerald A.E., Kingsley C. and Umans S.D., *Electric Machinery*, McGraw Hill.
2. Say M. G., *Alternating Current Machines*, Sir Isaac Pitman & Sons Ltd.
3. Bimbhra P.S., *Electrical Machinery*, Khanna Publishers.
4. Nagrath I.J. and Kothari D.P., *Electrical Machines*, Tata McGraw Hill.
5. Guru B.S. and Hiziroglu H.R., *Electric Machinery and Transformers*, Saunders College Publishing.
6. Bandyopadhyay M.N., *Electrical Machines*, PHI Learning Private Ltd.

EE-14402 CONTROL SYSTEMS

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Analyze the Control Systems by Transfer Function Models.
b. Evaluate the Transfer Function Models using Block Diagram Reduction or Signal Flow Graph.
c. Evaluate critical Time Response of Control Systems.
d. Design and construct the Frequency Response of Control Systems.
e. Evaluate the Stability Analysis of Control Systems.
f. Design various types of Compensators.

CONTENTS

1. SYSTEMS AND THEIR REPRESENTATION

Basic elements in Control Systems, Open and Closed loop systems, Electrical analogy of Mechanical and Thermal systems, Concept of Linear and Non Linear System, Use of Laplace Transforms, Transfer function, Block Diagram reduction techniques, Signal Flow Graphs, Synchros, potentiometers, AC and DC servomotors, AC and DC Tacho-generators.

2. TIME RESPONSE

Time response, Time domain specifications, Types of Test Input,first and second order system response, Error Coefficients, Generalized error series, Steady State Error, Proportional (P), Proportional Integral (PI), Proportional Integral Derivative (PID) modes of feedback control.

3. FREQUENCY RESPONSE

Frequency response, Bode plot, Polar plot, Determination of Closed loop response from Open loop response, Correlation between Frequency domain and Time domain specifications.

4. STABILITY OF CONTROL SYSTEM

Characteristics Equation, Location of roots in S- plane for stability, Routh-Hurwitz Criterion, Root Locus construction, Effect of Pole-Zero addition, Gain Margin and Phase Margin, Nyquist Stability criterion.

5. COMPENSATOR DESIGN

Performance Criterion, Lag, Lead and Lag-Lead networks, Compensator design using Bode Plots.

BOOKS RECOMMENDED

1. Nagrath I.J. and Gopal M., *Control Systems Engineering*, New Age International Publishers, 2003.
2. Benjamin C. Kuo, *Automatic Control systems*, Pearson Education, New Delhi, 2003.
3. Ogata K, *Modern Control Engineering*, 4th edition, PHI, New Delhi, 2002.
4. Norman S. Nise, *Control Systems Engineering*, 4th Edition, John Wiley, New Delhi, 2007.
5. Gopal M., *Control Systems, Principles and Design*, Tata McGraw Hill, New Delhi, 2002.

EE-14403ELECTROMAGNETIC FIELD THEORY

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Apply vector calculus to solve field theory problems.
b. Comprehend the relations between divergence, curl & gradient and analysis for different coordinate systems in electromagnetics and their interrelations.
c. Understand the concept of electric and magnetic fields and associated quantities in different coordinates.
d. Understand the concept of time varying fields and boundary conditions.
e. Demonstrate different aspects of plane wave in dielectric and conducting media
f. Acquire skills to examine technical issues related to electromagnetic fields.

CONTENTS

1. REVIEW OF VECTOR ANALYSIS

Vector Analysis, Physical Interpretation of Gradient, Divergence and Curl; Vector Relations in Other Coordinate Systems, Integral Theorems: Divergence Theorem, Stoke's Theorem, Green's Theorem and Helmholtz Theorem.

2. ELECTROSTATIC FIELD AND APPLICATIONS

Introduction, Coulomb's Law, Charge Distribution, Gauss's Law (Integral & Differential Form) and its Applications; Potential Function; Field due to Continuous distribution of charges; Equipotential Surfaces; Poisson's and Laplace's Equation, Capacitors and its applications, Energy Stored in a Capacitor, Electric Dipole, Dielectric Constant and Dielectric Strength, Polarization Density, Electrostatic Energy, Uniqueness Theorem, Boundary Conditions between Dielectrics Interface.

3. MAGNETOSTATIC FIELD AND APPLICATIONS

Biot-Savart's Law, Faraday's Laws of Electromagnetic Induction; Magnetic Flux Density; Magnetic Field Strength and Magnetomotive Force; Ampere's Work Law in the differential vector form; Permeability; Energy Stored in a Magnetic Field ; Ampere's Force Law; Magnetic Vector Potential, Analogies between Electric and Magnetic Fields, Magnetic Boundary Conditions.

4. TIME VARYING FIELD AND MAXWELL'S EQUATIONS

Equation of Continuity for Time Varying and Steady Fields, Maxwell's Equations in Integral and Differential form for Static and Time Varying Fields, Conditions at a Boundary Surface, Poynting Theorem and Physical Interpretation of E X H.

5. ELECTROMAGNETIC WAVES

Solutions for Free-Space Conditions; Uniform Plane Wave Propagation; Wave Equations for a Conducting Medium; Sinusoidal Time Variations; Polarization; Conductors and Dielectrics; Direction Cosines; Reflection by Perfect Conductor -Normal and Oblique Incidence, Perfect Dielectric-Normal Incidence, Perfect Insulator –Oblique Incidence; Brewster Angle, Reflection at a Surface of Conductive Medium, Surface Impedance.

BOOKS RECOMMENDED

1. William Hayt, *Engineering Electromagnetics*, McGraw Hill, 7th edition, 2005.
2. Halliday D., Resnick R. and K. S. Krane, *Engineering Electromagnetics*, Volume II, Wiley-Hayt, TMH.
3. Edward C. Jordan and Keith G Balmain, *Electromagnetic Waves and Radiating Systems*, Prentice- Hall Inc.
4. Kraus John D., *Electromagnetics*, McGraw-Hill Publishers.
5. Edminister Joseph A., Schaum's, *Theory and Problems of Electromagnetics*, McGraw-Hill.
6. David J Griffiths, *Introduction to Electrodynamics*, PHI, 3rdedition, 2008.

EE-14404 POWER SYSTEM - I (Transmission & Distribution)

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Calculate and justify the economical size of conductor to be used in power system.
b. Distinguish and propose the types of transmission lines on the basis of tower and conductor configuration.
c. Evaluate surge impedance loading and string efficiency of insulators.
d. Construct the circle diagram of long transmission line based on ABCD constants.
e. Compare the different types of underground cables and perform tests on these cables.
f. Understand line parameters of transmission lines and judge its effects on efficiency of transmission line

CONTENTS

1. POWERSUPPLY SYSTEM

Introduction to Transmission and Distribution systems, Comparison between DC and AC systems for Transmission and Distribution, comparison of cost of conductors, choice of working voltage for transmission and distribution, economic size of conductors - Kelvin's law, Radial and mesh distribution networks, Voltage regulation.

2. TRANSMISSION LINE CONSTRUCTION

Conductor materials; solid, stranded, ACSR, hollow and bundle conductors. Different types of supporting structures for overhead lines, Elementary ideas about transmission line construction and erection, Stringing of conductors, spacing, sag and clearance from ground, overhead line insulators, concept of string efficiency.

3. TRANSMISSION LINE PARAMETERS

Introduction to line parameters, Resistance of transmission line, inductance of single phase two wire line, concept of G.M.D., Inductance of three phase line, Use of bundled conductor, transposition of power lines, capacitance of 1-phase and 3-phase lines, effect of earth on capacitance of conductors.

4. PERFORMANCE OF TRANSMISSION LINES

Representation of short transmission line, medium length line (nominal T &π circuits), long length line by hyperbolic equations and equivalent T &π circuits, Power flow through transmission lines, ABCD constants, Voltage regulation.

5. CIRCLE DIAGRAM AND LINE COMPENSATION

Receiving end circle diagram for long transmission lines based on ABCD constants, equivalent-T circuits, power loci, surge impedance loading, reactive power requirement of system series and shunt compensation, Synchronous phase modifiers, rating of phase modifiers.

6. UNDERGROUND CABLES

Classification of cables based upon voltage and dielectric material, insulation resistance and capacitance of single core cable, dielectric stress, Capacitance of 3 core cables, methods of laying, testing of cables, heating effect, Maximum current carrying capacity, causes of failure, comparison with overhead transmission lines.

BOOKS RECOMMENDED

1. Elgerd O. I., *Electrical Energy System Theory - An introduction*, Tata McGraw-Hill Publication.
2. Gupta B.R., *Power System Analysis & Design*, Wheeler Publishing.
3. Nagrath I.J. and Kothari D.P., *Power System Analysis,* Tata McGraw-Hill Publication.
4. Stevenson Jr. W.D., *Elements of Power System Analysis*, Tata McGraw-Hill Publication.
5. Wadhwa C.L., *Course in Electrical Power*, New Age International (P) Ltd.

EE-14405 DIGITAL ELECTRONICS

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the difference between analog and digital systems.
b. Retrieve different laws and rules of Boolean algebra.
c. Analyze the steps involved in designing digital systems which involve combinational, sequential and state machines.
d. Acquire programming skills in VHDL.
e. Create different digital to analog and analog to digital Converter.
f. Understand the concept of semiconductor memories and create digital specific application based working projects.

CONTENTS

1. NUMBER SYSTEM & CODES

Review of numbers system and conversions, BCD Code, Gray code, signed & unsigned binary numbers, 1's & 2's complement of a number, different types of codes, Binary operations-addition, subtraction, multiplication, division, Parity for error detection, Check sum and Hamming Code for error detection and correction.

2. COMBINATIONAL CIRCUITS

Review of Logic gates, Concept of positive and negative logic, Introduction to Boolean operations and expressions, Laws and rules of Boolean algebra and De-Morgan's Theorem, Standard forms of Boolean expressions, Duality, Minimization of logical functions using Karnaugh maps. Combinational Logic Analysis Basic combinational logic circuits, Universal property of NAND and NOR gates, adders, comparators, decoders, encoders, code converters, multiplexers, demultiplexers, parity generators and parity checkers.

3. SEQUENTIAL LOGIC CIRCUITS

Latches, Edge triggered and clocked flip-flops (SR, D, JK and T), Flip-Flop operating characteristics and applications. Analysis of Synchronous & Asynchronous circuits, Counters: Synchronous & Asynchronous counters, Up and Down counters. Design of synchronous counters and counter applications. Registers: Series and Parallel registers. Bidirectional shift registers and shift register applications.

4. INTRODUCTION TO VHDL

Overview of digital design with very-high-speed integrated circuits (VHSIC) hardware description language (VHDL), HDL format and Syntax, entity, Data representation in VHDL, Truth table using VHDL, Decision Control structure and Sequential Circuit using VHDL.

5. DIGITAL TO ANALOG (D/A) AND ANALOG TO DIGITAL (A/D) CONVERTERS

Introduction, weighted register *D/A* converter, binary ladder, *D/A* converter, specifications for *D/A* converters, parallel *A/D* converter, successive approximation *A/D* converter single & dual slope *A/D* converter, *A/D* converter using voltage to frequency conversion, *A/D* converter using voltage to time conversion, countertype *A/D* converters.

6. SEMICONDUCTOR MEMORY

Basics of semiconductor memories**,** Random-Access memories (RAM), Read Only Memories (ROM), Programmable ROM's and Flash Memories. Programmable Logic Devices: Programmable Logic Array (PLA), Programmable Array Logic (PAL), Complex programmable logic devices (CPLD), Field Programmable Gate Array (FPGA).

BOOKS RECOMMENDED

1. Floyd Thomas S., *Digital Fundamentals*, Pearson Education.
2. Jain R.P., *Modern Digital Electronics*, Tata McGraw Hill.
3. Kumar Anand, *Fundamentals of Digital Circuits*, Prentice Hall of India.
4. Malvino Albert Paul, *Principles of Digital Electronics*, Tata McGraw Hill.
5. Mano Morris, *Digital Logic and Computer Design*, Prentice Hall of India.
6. Tocci Ronald J. Widmer Neal S. and Moss Gregory L., *Digital Systems: Principles and Applications*, Prentice Hall of India.

EE-14406 OBJECT ORIENTED PROGRAMMING

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Compare the features of procedural-programming and object-oriented programming paradigms.
b. Explore the control structures of C++ for looping and decision making applications.
c. Explore the concept of classes and objects for constructing programs for simple applications.
d. Explore alternative and efficient ways to do experimentation with pointers in C++.
e. Apply features of object-oriented programming for developing simple C++ programs.
f. Explore and incorporate exception and file handling features of C++ programs.

CONTENTS

1. OBJECT-ORIENTED PROGRAMMING CONCEPTS

Introduction, Comparison between procedural programming paradigm and object-oriented programming paradigm, Basic data types, Derived data types, Constants, Tokens, Keywords, Identifiers and variables, Concepts of an object and a class, Abstraction, Encapsulation, Data hiding, Inheritance, Overloading, Polymorphism, Messaging.

2. CONTROL STRUCTURES

Input and Output statements in C++, Various operators, Operator precedence, if statement, Switch-case, break, go-to, continue, for, while and do-while loops, Dynamic initialization, Type modifiers, Type casting.

3. CLASSES, OBJECTS, FUNCTIONS AND ARRAYS

Implementation of a class, Operations on objects, Relationship among objects, Specifying a class, Creating class objects, Accessing class members, Access specifiers, Static members, Empty classes, Nested classes, Local classes, Abstract classes, Container classes, Bit fields and Classes. Function components, Passing parameters, Call by reference, Call by value, Return by reference, Inline functions, Default arguments, Function prototyping, Overloaded function, Recursion, Array of objects, Dynamic allocation operators, Dynamic objects.

4. DYNAMIC MEMORY MANAGEMENT USING POINTERS

Declaring and initializing pointers, Accessing data through pointers, Pointer arithmetic, Memory allocation (static and dynamic), Dynamic memory management using new and delete operators, Pointer to an object, this pointer, Pointer related problems - dangling/wild pointers, Null pointer assignment, Memory leak and Allocation failures.

5. **CONSTRUCTORS, DESTRUCTORS AND OPERATOR OVERLOADING**

Need for constructors and destructors, Copy constructor, Dynamic constructors, Explicit constructors, Destructors, Constructors and destructors with static members, Initializer lists, Order of execution of constructors and destructors. Overloading operators, Rules for overloading operators, Overloading of various operators, Type conversion - basic type to class type, class type to basic type, class type to another class type.

6. **INHERITANCE, VIRTUAL FUNCTIONS AND POLYMORPHISM**

Introduction, Defining derived classes, Forms of inheritance, Ambiguity in multiple and multipath inheritance, Virtual base class, Objects slicing, overriding member functions, Object composition and delegation. Concept of binding - early binding and late binding, Virtual functions, Pure virtual functions, Abstract classes, Virtual destructors, Function overloading, Friend function.

7. **EXCEPTIONS AND FILE HANDLING**

Review of traditional error handling, Basics of exception handling, Exception handling mechanism, Throwing mechanism, Catching mechanism, Rethrowing an exception, Specifying exceptions. Files Handling: File streams, Hierarchy of file stream classes, Error handling during file operations, Reading/writing of files, Accessing records randomly, Updating files.

BOOKS RECOMMENDED

1. Lafore R., *Object Oriented Programming in C++*, Waite Group.
2. Balagurusamy E., *Object Oriented Programming with C++*, Tata McGraw Hill.
3. Kanetkar Yashwant P., *Let Us C++*, BPB Publications.
4. Bjarne Stroustrup, *The C++ Programming Language*, Addison Wesley.
5. Herbert Schildt, *The Complete Reference to C++ Language*, McGraw Hill-Osborne.
6. Lippman F. B, *C++ Primer*, Addison Wesley.
7. Farrell, *Object Oriented using C++,* Cengage Learning.

EE-14407 LABORATORY-IV: CONTROL SYSTEMS

Internal Marks	: 30	L	T	P	C
External Marks	: 20	0	0	2	1
Total Marks	: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Evaluate and imply basic control hardware models in software based approach.
b. Check the time domain response and obtain performance parameters of a first order and second order systems.
c. Compare linear and nonlinear control characteristics with their applications.
d. Analyze errors of physical system models from an electrical equivalent.
e. Analyze and explore the applications & characteristics of servo motors.
f. Evaluate the concept of stability and able to apply various techniques to find out stability.

LIST OF EXPERIMENTS

1. To verify the control action of P, PI and PID controllers and their applications.
2. To verify the characteristics of potentiometers and to use two potentiometers as an error detector in a control system.
3. To determine the time domain response of a first order and second order system for step input and obtain performance parameters.
4. To verify the characteristics of synchro transmitter-receiver set and to use it as an error detector.
5. To draw the speed-torque characteristics of a DC servo motor and to explore its applications.
6. To draw the speed-torque characteristics of an AC servo motor and explore its applications.
7. To verify the variations of time lag by changing the time constant using control engineering trainer.
8. To obtain the transfer function of a D.C. motor – D.C. generator set using transfer function trainer.
9. To design a Lag compensator and test its performance characteristics.
10. To design a Lead-compensator and test its performance characteristics.
11. To design a Lead-Lag compensator and test its performance characteristics.
12. Design of PID controller using MATLAB/SIMULINK.
13. Application of MATLAB to draw a) Root Locus b) Bode plot c) Nyquist Plots for a given control system and predict its stability.

EE-14408 LABORATORY-V: DIGITAL ELECTRONICS

Internal Marks	: 30	L	T	P	C
External Marks	: 20	0	0	2	1
Total Marks	: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Identify different types of digital IC's, read their specification sheets and the way to handle these.
b. Verify the truth tables of various gates and different laws and rules of Boolean Algebra.
c. Design and test different types of combinational and sequential circuits.
d. Analyze different types of DAC, ADC and memory devices.
e. Create and troubleshoot working projects using digital logic.
f. Evaluate performance of digital specific application based working projects.

LIST OF EXPERIMENTS

1. Verification of the truth tables of TTL gates viz: 7400, 7402, 7404, 7408, 7432, 7486.
2. Design and realization of all gates using NAND/NOR gates.
3. Verification of theorems and laws using gates.
4. Design and verification of the truth tables of Half-Adder using different gates and Full Adder circuit using 7483 IC.
5. Design and verification of the truth table of four bit subtractor using 7483 and 7486 IC's.
6. Design and verification of binary to gray code converter or vice-versa.
7. Verification of truth table of Multiplexer (74150)/Demultiplexer(74154).
8. Design, fabrication and testing of Mon-stable multivibrator of t = 0.1ms approx. using 74121/123IC.Testing for both positive and negative edge triggering, variation in pulse width and retriggering.
9. Design and test S-R flip-flop using NOR/NAND gates.
10. Design, fabricate and test a switch debouncer using 7400.
11. Verify the truth table of a JK flip flop using IC 7476.
12. Verify the truth table of a D flip flop using IC 7474 and study its operation in the toggle and asynchronous mode.
13. Operate the counters 7490, 7493 and 74193(Up/Down counting mode). Verify the frequency division at each stage. Using a frequency clock (say 1 Hz) display the count of LED's.
14. Verify the truth table of decoder driver7447/7448. Hence operate a 7 segment LED display through a counter using a low frequency clock. Repeat the above with the BCD to Decimal decoder 7442.

EE-14409 LABORATORY-VI: OBJECT ORIENTED PROGRAMMING

Internal Marks: 30	L	T	P	C
External Marks: 20	0	0	2	1
Total Marks: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Perform experimentation for comparing features of procedural-programming and object-oriented programming paradigms.
b. Develop C++ programs for simple applications.
c. Explore looping and decision making in C++ programs.
d. Perform matrix operations in C++.
e. Explore alternative and efficient ways to do experimentation with pointers in C++.
f. Explore and incorporate exception and file handling features of C++ programs.

LIST OF EXPERIMENTS

1. Program to find the area and circumference of the circle
2. Program to interchange the values of two numbers.

[Control statements]

3. Program to find all roots of quadratic equations.
4. 2's complement of a number is obtained by scanning it from right to left and complementing all the bits after the first appearance of a 1. Thus 2's complement of 11100 is 00100. Write a C++ program to find the 2's complement of a binary number.
5. Program to reverse an integer number.
6. Write a program that will read the value of x and evaluate the following function: Y= 2 for x>0, Y=0 for x=0 Use nested statements with the conditional control statement.
7. Program to display the different colors using the switch statement.
   [Arrays and Strings]
8. Program to find the minimum and maximum element of an array and to do bubble sorting
9. Program to perform different operations on matrices including – addition, subtraction, multiplication, transpose.

[Classes and Objects]

10. Program to illustrate the concept of classes and object.
11. Program to illustrate the concept of nesting of member functions.
12. Program to illustrate the concept of inline function within a class.
13. Program to show the working of static members in a class.

[Constructors and Destructors]

14. Program to illustrate the concept of default constructor, parameterized constructor and copy constructor.

15. Program to illustrate the concept of destructors.

[Overloading and Type Conversions]

16. Program to overload the unary operator and binary operator.
17. Program to illustrate the concept of type conversions basic to class type, class to basic type, class to class type.

[Inheritance]

18. Program to illustrate the concept of inheritance.
19. Program to illustrate the concept of ambiguity in multiple inheritance.
20. Program to illustrate the concept of virtual base class in inheritance.
21. Program to illustrate the order of execution of constructors and destructors in inheritance.

[Polymorphism]

22. Program to illustrate the concept of overloaded function having different number of arguments in the different overloaded forms.
23. Program to illustrate the concept of virtual functions and pure virtual functions.

[File handling]

24. Program to illustrate the concept of file pointers.
25. Program to perform read and write operations on a file.

EE-14501 SYNCHRONOUS MACHINES

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the principle, construction and analyze the operation of synchronous machine as an alternator, synchronous motor and compensator.
b. Evaluate different methods of voltage regulation and analyze the performance of synchronous machines for drawing the various associated phasor diagrams.
c. Understand parallel operation of alternators with infinite bus with study of load sharing.
d. Identify, formulate and solve synchronous machine related problems.
e. Evaluate the starting methods of synchronous motor.
f. Comprehend industrial problems associated with synchronous machines.

CONTENTS

1. INTRODUCTION

Construction and Working Principle of Synchronous Machines, Excitation Systems, Production of Sinusoidal Electromotive Force (EMF), Flux and Magneto Motive Force (MMF) Phasors in Synchronous Machines, Cylindrical and Salient Pole Rotors, Classification of Windings, Pitch Factor, Distribution Factor, Electromagnetic Force Equation.

2. ALTERNATORS

Construction, Phasor Diagram of Cylindrical Rotor Alternator, Ratings, Nature of Armature Reaction, Determination of Synchronous Reactance, Open-Circuit Characteristics, Short-Circuit Characteristics, Short-Circuit Ratio, Short-Circuit Loss, Effect of Variation of Power Factor on Voltage. Determination of Voltage Regulation: EMF Method, MMF Method, Zero Power Factor (Z.P.F)Method, Alternator on Infinite Bus Bar, Operation at Constant Load and Variable Excitation, Power Flow through Inductive Impedance, Power-Angle Characteristics of Synchronous Machines - Cylindrical and Salient Pole, Two Reaction Theory of Salient Pole Machines, Power Factor Control.

3. PARALLEL OPERATION OF ALTERNATORS

Conditions for Proper Synchronizing for Single Phase and Three Phase Alternators, Conditions for Parallel Operation, Synchronizing Power, Current and Torque, Effect of Increasing Excitation of one of the Alternators, Effect of Change of Speed of one of the Alternators, Effect of unequal Voltages, Load Sharing.

4. TRANSIENTS

Transient Reactance's and Time Constants from Equivalent Circuits, Synchronous Machine Reactance's and their Determination, Short Circuit Oscillogram, Synchronization with the Grid System, Qualitative Introduction to the Transient Stability of the Synchronous Machines.

5. SYNCHRONOUS MOTORS

Operating Characteristics, Power-Angle Characteristics, Conditions for Maximum Power Developed,V-Curves and Inverted V-Curves, Methods of Starting, Synchronous Motors Applications, Synchronous Condensers, Hunting and Damper Windings, Single Phase Synchronous Motors: Reluctance and Hysteresis Motors.

BOOKS RECOMMENDED

1. Bimbhra P.S., *Electrical Machinery,* Khanna Publishers.
2. Fitzgerald A.E., Kingsley C. and Umans S.D., *Electric Machinery*, 6th Edition, McGraw Hill.
3. Langsdorff E.H., *Principles of D.C. machines*, McGraw Hill.
4. Nagrath I.J. and Kothari D.P., *Electrical Machines*, 4th Edition, Tata McGraw Hill.
5. Say M G, *Alternating Current Machines*, 5thEdition, Sir Isaac Pitman and Sons Ltd.

EE-14502 NUMERICAL & STATISTICAL TECHNIQUES

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Apply the knowledge gained from numerical techniques in solving engineering and research problems.
b. Evaluate Linear & Non Linear equations via methods of convergence.
c. Create the suitable numerical and statistical technique for better and faster solutions.
d. Evaluate Differentiation and Integration problems using iteration approach.
e. Apply the gained knowledge for application in probabilistic approach.
f. Create and evaluate Sampling Distribution problems.

CONTENTS

1. FLOATING POINT NUMBERS & CURVE FITTING

Floating-Point Representation, Rounding, Chopping, Error Analysis, Condition and Instability, Method of Least Squares, Fitting of Simple Curves using Least Squares Method, Regression and Correlation(Two Variables Case Only).

2. LINEAR & NON-LINEAR EQUATIONS

Gauss-Elimination Method (using Pivoting Strategies) and Gauss-Seidel Iteration Method, Rayleigh's Power Method for Eigen-Values and Eigen-Vectors, Bisection, Fixed-Point Iteration and Newton-Raphson Methods, Order of Convergence.

3. NUMERICAL DIFFERENTIATION & INTEGRATION

Solution of Initial Value Problem using Taylor Series, Euler's and Runge-Kutta (up to fourth order) Methods, Statistical Methods, Newton-Cote's Quadrature Formula (With Error) and Gauss-Legendre Quadrature Formula, Interpolation: Lagrange's Formula with Error, Divided Difference, Newton's Divided Difference Formula, Finite Difference Time Domain (FDTD), Boundary Element Method (BEM), Methods of Moments, Finite Element Methods (FEM), Applications in electromagnetic field problems.

4. RANDOM VARIABLES, SPECIAL PROBABILITY & SAMPLING DISTRIBUTION

Definition, Probability Distribution, Distribution Functions, Probability Distribution Function and Cumulative Distribution Function, Expectation and Variance, Binomial, Poisson, Geometric and Exponential Distributions, Population and Samples, Concept of Sampling Distributions, Sampling Distribution of Mean, Chi-Square, T and F Distributions ,Tests of Hypotheses: Basic Ideas, Important Tests based on Normal, Chi-Square, T and F Distribution.

BOOKS RECOMMENDED

1. Kendall Atkinson, *An Introduction to Numerical Methods and Analysis*, 2nd edition, Wiley Publishers.
2. Conte, S.D and Carl D. Boor, *Elementry Numerical Analysis: An Algorithmic Approach*, Tata McGraw Hill, New York.
3. Benoîte de Saporta, Francois Dufour, Huilong Zhang, *Numerical Methods for Simulation & Optimization Piecewise Deterministic Processes Markov*, Wiley, 2015.
4. Johnson, R., Miller, I. and Freunds J., *Probability and Statistics for Engineers*, 7thedition, Pearson Education.
5. Mathew, J.H., *Numerical Methods for Mathematics, Science and Engineering*, Prentice Hall Inc.J.
6. Walpole, Ronald E., Myers, Raymond H., Myers, Sharon L. and, Keying Ye, *Probability and Statistics for Engineers and Scientists*, 8thedition, Pearson Education.
7. Sastry S.S., *Introductory Methods of Numerical Analysis*, 3rdedition, Prentice Hall India.

EE-14503 INDUSTRIAL ELECTRONICS

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Acquire knowledge about fundamental concepts of industrial electronics.
b. Analyze various thyristor commutation techniques used in industrial electronics.
c. Comprehend different single phase and three phase power converter circuits.
d. Understand categorization of chopper as per necessity of industrial electronics application.
e. Develop skills to propose cycloconverter circuits for various applications.
f. Foster ability to understand the use of inverters in commercial and industrial applications.

CONTENTS

1. THYRISTORS AND THEIR CHARACTERISTICS

Introduction to Thyristor Family, V-I Characteristics of SCR, SUS, GTO, LASCR, DIAC, TRIAC, Principle of Operation of SCR, Turn on Methods of a Thyristor, Switching Characteristics of Thyristors during Turn-on and Turn-off, Gate Characteristics, Firing of Thyristors, Series and Parallel Operation of SCR, Protection of SCR from Over Voltage and Over Current.

2. THYRISTOR COMMUTATION TECHNIQUES

Load Commutation (Class A), Resonant-Pulse Commutation (Class B), Complementary Commutation (Class C), Impulse Commutation (Class D), External Pulse Commutation (Class E), Line commutation (Class F).

3. PHASE CONTROLLED TECHNIQUES

Introduction to Phase angle Control, Single Phase Half Wave Controlled Rectifiers, Single Phase Half Controlled and Full Controlled Bridge Rectifiers with RL Load, Three Phase Full Controlled Bridge Rectifiers with R and RL Load. Basic Circuit and Principle of Operation of Dual Converter with Circulating and Non-Circulating Current mode of operation, Applications of Rectifiers and Dual Converters to Control the Speed of DC Motors.

4. CHOPPERS

Introduction and Principle of Chopper Operations, Control strategies, Chopper Configurations, Regenerative Chopper, Voltage Commutated Chopper, Current Commutated Chopper, Load Commutated Chopper.

5. CYCLOCONVERTERS

Basic Circuit and Operation of Single Phase Cycloconverter, Single Phase Bridge Cycloconverter, Three Phase to Single Phase Cycloconverter, Advantages and Disadvantages of Cycloconverter.

6. INVERTERS

Introduction, Operating Principle of Single Phase Inverter, Three Phase Bridge Inverter, VSI, CSI, Voltage Control (PWM Control) and Reduction of Harmonics in the Inverter Output Voltage.

BOOKS RECOMMENDED

1. Bimbhra P.S., *Power Electronics*, Khanna Publishers.
2. Singh M.D. and Khanchandani K.B., *Power Electronics*, Tata McGraw Hill Publishing Company Limited.
3. Rashid M.H., *Power Electronics*, PHI.
4. Sen P.C., *Power Electronics*, Tata McGraw Hill Publishing Company Limited.

EE-14504 INSTRUMENTATION ENGINEERING

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Demonstrate different types of electronic instruments and their usages.
b. Identify the use of CRO and DSO.
c. Understand the principle of various digital instruments.
d. Identify different types of transducers.
e. Apply knowledge of transducers for measurement of various parameters.
f. Demonstrate the techniques related to end devices.

CONTENTS

1. ELECTRONIC INSTRUMENTS

Electronic Voltmeter and Current Probes, Tuned Type and Sampling type Voltmeter, Current Probes for D.C. and A.C. Measurements, Electronic Multimeter - Construction, Measurement of D.C. and A.C. Voltage and Current, Measurement of Resistance. CRO- Construction, Synchronization, Measurement of Voltage, Current, Phase and Frequency, DSO- Working and Operation.

2. DIGITAL INSTRUMENTS

Comparison of Analog and Digital Instruments, Digital Voltmeter, Multimeter and Frequency Meter.

3. TRANSDUCERS

Block Diagram Representation of Instrumentation System, Terminology and Definition, Classification, Transducing Principles and Elements, Ultrasonic, Optical and Infrared Sensors, Inductive, Capacitive and Resistive Transducers for Measurements of Length, Thickness, Displacement, Velocity, Torque, Level, Pressure, Temperature, Flow, Humidity, Moisture and pH.

4. END DEVICES

Recorders: X-Y Recorders, Strip-Chart Recorder, Magnetic and Potentiometric Recorder, Digital Displays- LED and LCD, Introduction to Data Acquisition Systems.

BOOKS RECOMMENDED

1. Golding Edward William and Widdis Frederick Charles, *Electrical Measurements and Measuring instruments*, Wheelers India
2. Bell David A., *Electronics Instrumentation and Measurements*, Prentice Hall, India

3. Reissl and Martin V, *Electrical Measurements Fundamentals, Concepts, Applications*, Wiley Eastern Limited, New Delhi.
4. Sawhney A.K., *A course in Electrical & Electronic Instrumentation*, Dhanpat Rai and Sons.
5. Norton H.N., *Handbook of Transducer for Electronic Measuring system,* Prentice Hall.
6. Mani &Sharma , *Instrumentation Devices & Systems*, Rangon, McGraw Hill.

EE-14505 LABORATORY-VII: ASYNCHRONOUS & SYNCHRONOUS MACHINES

Internal Marks : 30	L	T	P	C
External Marks : 20	0	0	2	1
Total Marks : 50				

COURSE OUTCOMES

After studying this course, the students will

a. Construct equivalent circuits for single phase and three phase induction motor by performing no-load and blocked rotor test.
b. Comprehend the requirement of starting and speed control methods of induction motors in the various applications of industry.
c. Construct equivalent circuits of synchronous generator and motor.
d. Apply knowledge to show utility of alternator, synchronous motors and synchronous condenser for various applications in power system.
e. Construct characteristic curves for induction motors and synchronous machines.
f. Compare various methods of parallel operation of three phase alternators.

LIST OF EXPERIMENTS

1. To perform no-load and blocked–rotor test on three-phase induction motor and to obtain equivalent circuit parameters.
2. To perform load-test on three-phase induction motor and to plot torque versus speed characteristics.
3. To perform no-load and blocked–rotor test on single-phase induction motor and to determine the parameters of equivalent circuit.
4. To perform load–test on single-phase induction motor and to plot torque–speed characteristics.
5. To perform the speed control methods of three-phase induction motor by a) Kramer's method b) Cascading method.
6. To start the three-phase induction motor using star- delta and DOL starters.
7. To perform no load and short circuit test on three-phase alternator and to draw open circuit & short circuit characteristics.
8. To analyze the effect of variation of field current on the stator current and power factor with synchronous motor running at no load and to draw V-curves & inverted V-curves.
9. To perform parallel operation of three phase alternators using dark lamp method, two-bright and one dark lamp method.
10. To perform parallel operation of three-phase alternators using synchroscope.
11. Application of MATLAB software for solution of problems regarding induction motors and synchronous machines.

EE-14506 LABORATORY-VIII: INDUSTRIAL ELECTRONICS

Internal Marks	: 30	L	T	P	C
External Marks	: 20	0	0	2	1
Total Marks	: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the properties and characteristics of thyristors.
b. Evaluate and analyze the use of thyristors for different applications like phase control, speed control circuits.
c. Acquire fault finding skills in thyristor based circuits.
d. Develop thyristor based circuits for industrial use like understanding speed control of motors.
e. Understand the different types of waveforms of inverter and chopper circuits
f. Design of power saving variable D.C. sources.

LIST OF EXPERIMENTS

1. To plot V-I characteristics and study the effect of gate triggering on turning on of SCR.
2. To draw V-I characteristics of an UJT and to use UJT as relaxation oscillator.
3. To study the effect of free-wheeling diode on power factor for single phase half-wave rectifier with R-L load.
4. To plot waveforms for output voltage and current, for single phase full-wave, fully controlled bridge rectifier, for resistive and resistive cum inductive loads.
5. To study three phase fully controlled bridge converter and plot waveforms of output voltage, for different firing angles.
6. Study of Jones chopper or any chopper circuit to check the performance.
7. Thyristorised speed control of a D.C. Motor.
8. Speed Control of induction motor using thyristors.
9. Demonstration of series inverter circuit.
10. Demonstration of commutation circuit.
11. Study of a single-phase cycloconverter.

EE-14507 LABORATORY-IX: INSTRUMENTATION & MEASURING DEVICES

Internal Marks : 30	L	T	P	C
External Marks : 20	0	0	2	1
Total Marks : 50				

COURSE OUTCOMES

After studying this course, the students will

a. Evaluate the values of power factor, pH
b. Evaluate the value of frequency
c. Evaluate the effect of displacement on voltage using a transducer.
d. Analyze characteristics of thermistor
e. Evaluate the value of earth resistance
f. Apply various transducers to measure different physical quantities.

LIST OF EXPERIMENTS

1. To analyze the input-output characteristics of a potentiometer and to use a potentiometer as an error detector.
2. Determination of frequency and phase angle using CRO.
3. To measure insulation resistance by Megger.
4. To measure earth resistance by Earth Tester.
5. To observe phase sequence of three phase circuit using rotating type phase sequence indicator measurement of resistance using wheatstone bridge.
6. To measure frequency of A.C. supply using Weston Frequency Meter.
7. To measure power factor of single phase and three phase load by PF Meter and verifying through current, voltage and power measurement.
8. To measure circuit parameters and three phase load by PF Meter and LCR Meter.
9. Measurement of displacement using LVDT.
10. Temperature measurement using temperature sensor (RTD).
11. Light measurement using LDR and photo cell censor.
12. Water level measurement using capacitance transducer.
13. Velocity measurement using air flow transducer.
14. RPM measurement using electromagnetic transducers.
15. Analyze the characteristics of a Thermistor.
16. Study of the characteristics of an Electromagnetic Flow meter.
17. To plot the characteristics of a Photo reflective sensor.

EE-14508 LABORATORY-X: NUMERICAL& STATISTICAL TECHNIQUES

Internal Marks	: 30	L	T	P	C
External Marks	: 20	0	0	2	1
Total Marks	: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Create programs in C/C++/MATLAB software for practical understanding of numerical methods.
b. Evaluate various iterative techniques for finding real roots of an equation.
c. Hypothesize and validate interpolation methods.
d. Design coding for solving simultaneous linear algebraic equations.
e. Analyze the techniques of numerical integration &differentiation.
f. Apply the knowledge gained for evaluating numerical & statistical problems.

LIST OF EXPERIMENTS

To develop algorithms/programs in C/ C++/MATLAB language for the following methods

1. Bisection method for finding a real root of an equation.
2. Newton Raphson method for finding a real root of an equation.
3. Iteration method for finding a real root of an equation.
4. Gauss elimination method for solving simultaneous linear algebraic equations.
5. Gauss Jordan method for solving simultaneous linear algebraic equations.
6. Simpson's 1/3rd rule for numerical integration.
7. Simpson's 3/8th rule for numerical integration.
8. Trapezoidal Rule for numerical integration
9. Newton's forward interpolation formula.
10. Lagrange's method for interpolation.
11. Euler's method for solving ordinary differential equations.
12. Modified Euler's method for solving ordinary differential equations
13. R-K method for solving ordinary differential equations.
14. Electrostatic and Magneto-static problems based on PDE MATLAB.

DEEE-14501RENEWABLE ENERGY RESOURCES

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Judge the importance of renewable sources of energy
b. Evaluate the effect of non judicious use of conventional sources on environment.
c. Analyze the advantages and disadvantages of various schemes for harnessing energy from renewable sources.
d. Analyze to compare economics of harnessing power from renewable sources.
e. Analyze the solar energy prospectus in India.
f. Evaluate the energy harnessing from biomass.

CONTENTS

1. ENERGY RESOURCES

Renewable Energy Sources, Energy and Global Climatic Change and its Effect on Environment, Environmental Consequences on Society and the Political Responses at National and International Levels.

2. SOLAR, WIND AND GEOTHERMAL ENERGY

Solar Radiation and its Measurement, Solar Thermal Energy Collectors, Solar Thermal Energy Conversion Systems, Solar Photovoltaic System. Wind Systems in India, Wind Turbines and Rotors, Estimation of Wind Energy Potential, Wind Energy Conversion Systems (WECS). Geothermal Sites, Geothermal Field, Geothermal Resources, Geothermal Electric Power Plant.

3. FUEL CELLS AND BIOMASS

Principle of Operation of Fuel Cell, Fuel Processor, Fuel Cell Types, Energy Output of a Fuel Cell, Efficiency, and EMF of a Fuel Cell, Operating Characteristics of Fuel Cells, Thermal Efficiency of a Fuel Cell, Introduction to Biomass as Energy Source, Biodiesel.

4. HYBRID ENERGY SYSTEMS

Hybrid Energy Systems and its types, Hybrid Vehicles, Hydrogen-Powered Vehicles.

5. GREEN ENERGY

Introduction to Green Energy, Concept of Green Buildings and Waste Management, Micro-Mini Hydro Power Systems.

BOOKS RECOMMENDED

1. Kothari DP, Singal KC and Ranjan Rakesh, *Renewable energy sources and emerging technologies*, Prentice Hall ,2nd edition.
2. G.D. Rai, *Non-Conventional Sources of Energy*, Khanna Publishers
3. Bansal N.K., M. Kleemann, M. Heliss, *Renewable energy sources and conversion technology*, Tata McGraw Hill.
4. Abbasi SA, Abbasi N, *Renewable energy sources and their environmental impact*, PHI.
5. Mittal KM, *Renewable energy Systems*, Wheelar Publishing, New Delhi.
6. Mukherjee D, *Renewable energy Systems*, New Age International, New Delhi.

DEEE-14502 ELECTRICAL DESIGN & ILLUMINATION ENGINEERING

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Be able to analyze and evaluate the various types of light sources available.
b. Analyze various parameters required for good lighting design.
c. Create a general lighting scheme.
d. Evaluate the various lighting controls and their applications.
e. Understand and apply the various lighting design techniques to create lighting design for various utilities.
f. Evaluate the properties of various light sources and hence recommend their installation.

CONTENTS

1. LIGHTING & ITS IMPORTANCE

Optical Systems of Human Eye, Dependence of Human Activities on Light, Performance Characteristics of Human Visual System, External Factors of Vision-Visual Acuity, Contrast, Sensitivity, Time Illuminance, Color, Visual Perception, Optical Radiation Hazards, Good and Bad Effects of Lighting and Perfect Level of Illumination, Artificial Lighting as substitute to Natural Light, Ability to Control Natural Light, Production of Light, Physics of Generation of Light, Properties of Light, Quantification and Measurement of Light.

2. ILLUMINATION

The Nature of Radiation, Polar Curve, Law of Illumination, Photometry (Photovoltaic Cell, Distribution Photometry, Integrating Sphere, Brightness Measurement), Types of Lamps: Conventional and Energy Efficient, Basic Principle of Light Control, Different Lighting Scheme and their Design Methods, Flood and Street Lighting.

3.LAMP, ACCESSORIES & LUMINARIES

Light Production by Gas Discharge, Fluorescence, Incandescence, Daylight Principle of Operation, Light Efficacy, Color, Electrical Characteristics, Typical Applications, Dimming Condition of GLS Filament, Tungsten Halogen Lamps, Fluorescent Tubes, Compact Fluorescent Lamp (CFL), Low and High Pressure Sodium Lamps, High Pressure Mercury Lamp, Metal Halide Lamp, Functions of Luminaries, Classification, Materials used in Luminaries Manufacturing, Reflection, Refraction, Diffusion, Polarization and Optical Design, Photometric Measurements, LED: Its Use, Ballasts: Types and Applications, Ignitors and their uses.

4. LIGHTING CONTROL

Types of Lighting Controls, Strategy for Selection, Benefits of Lighting Control, Electric Distribution System for Lighting, Maintenance Strategies, Group Replacement Schedule, Techniques of Achieving Energy Efficient Lighting Design, Role of Computers in Lighting Design, Advantages and Limitations of Computer Aided Lighting Design.

5. ILLUMINATION ENGINEERING AND DESIGN

Basics of Lighting Design, Illumination Levels Required as per Standards, Task and Ambient Lighting, Facade Lighting, Lighting Design for a Study Room/Lecture Hall, Introduction to Lighting Design Software's viz. Digilux, Cglux.

BOOKS RECOMMENDED

1. Mamak H.S., *Book on Lighting*, Publisher International lighting Academy.
2. Joseph B. Murdoch, *Illumination Engineering from Edison's Lamp to Lasers,* Visions Communications, 1994.
3. Cayless M.A., A. M. Marsden, *Lamps and Lighting,* Butterworth-Heinemann.

DEEE-14503 ELECTRICAL ENGINEERING MATERIALS

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Analyze the different types of chemical bonds.
b. Analyze qualitatively the bonding scheme and its general physical properties.
c. Analyze the characteristics of different types of materials and calculate its dielectric losses
d. Justify the selection of suitable material for manufacturing of carbon brushes , cores and insulating material
e. Analyze the classification and applications for magnetic and special materials.
f. Create awareness of recent developments in material science and engineering.

CONTENTS

1. INTRODUCTION TO DIELECTRIC MATERIALS

Static Dielectric Constant, Polarization, Atomic Interpretation of the Dielectric Constant of Mono-Atomic and Poly Atomic Gases, Internal Fields in the Solids and Liquids, Static Dielectric Constants of Solids, Ferroelectric Materials and Spontaneous Polarization, Piezo-Electricity, Frequency dependence of Electronic, Ionic and Orientation Polarization, Complex Dielectric Constant and Dielectric Losses.

2. CONDUCTIVITY OF METALS

Ohm Law and Relaxation Time of Electrons, Collision Time and Mean Free Path, Electron Scattering and Resistivity of Metals, Heat developed in Current Carrying Conductor, Thermal Conductivity of Metals.

3. MAGNETIC MATERIALS

Magnetisation from Microscopic view point, Orbital Magnetic Dipole Movement and Angular Momentum Materials, Diamagnetism, Origin of Permanent Magnetic Dipoles in Material, Paramagnetic Spin Systems.

4. PROPERTIES OF FERROMAGNETIC MATERIALS

Spontaneous Magnetisation and the Curie-Weils Law, Ferromagnetic domains and coercive force, Antiferromagnetic and Ferromagnetic Materials, Magnetic materials for electrical devices, Introduction to Permanent Magnets**.**

5. SPECIAL PURPOSE MATERIALS

Superconductivity and Nano Materials, Refractory Materials, Structural Materials, Radioactive Materials, Materials used for the Fuses and Carbon Brushes.

BOOKS RECOMMENDED

1. Dekker A.J., *Electrical Engineering materials,* Prentice-Hall.
2. Chalotra G.P., *Electrical Engineering Materials,* Khanna publishers.
3. Seth S.P. and Gupta P.V.*, Electrical Engineering materials*, Dhanpat Rai & co.

DEEE-14504 ENERGY AUDITING & MANAGEMENT

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the need, comparison and use of various type of electrical energy resources.
b. Understand and compare the basic energy audit report
c. Comprehend various energy management standards and justify its implementation
d. Acquire the knowledge to use various instruments for energy audit
e. Understand the environmental effects and various international protocols
f. Analyze the pollution situation and understand clean development mechanism.

CONTENTS

1. ENERGY SOURCES

Types of Energy, Conventional Sources of Energy, Non-Conventional Sources of Energy, Commercial Energy Production, Current Scenario of Energy in India and World, Need for Energy Conservation.

2. ENERGY AUDIT

Definition, Need, Types of Audit, Preparing an Energy Audit Report, Benchmarking, Sankey Diagram, Calculation of Payback Period.

3. ENERGY MANAGEMENT

Definition, Need, Standards for Energy Management ISO Standards 14001, 50001, Energy Conservation Act 2003, Designated Consumers, Energy Substitution.

4. INSTRUMENTATION

Instruments used for Energy Audit: Power Analyzer, Thermal Analyzer, General Instruments and their use, SCADA, Maximum Demand Controllers, Automatic Power Factor Controllers, Energy Efficient Motors, Soft Starters with Energy Saver, Variable Speed Drives, Energy Efficient Transformers, Electronic Ballast, Occupancy Sensors, Energy Efficient Lighting Controls, Energy Saving Potential of Each Technology.

5. ENERGY AND CLIMATE CHANGE

Energy and Environment, Air Pollution, Climate Change, United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol, Clean Development Mechanism (CDM), CDM Methodology and Procedures, Sustainable Development.

BOOKS RECOMMENDED

1. Beggs Clives, *Energy Management Supply and Conservation*, Butterworth Heinemann.
2. Albert Thumann& Paul Mehta, *Handbook of Energy Engineering*, The Fairmont Press, INC.
3. Albert*, Plant Engineers & Manager Guide to Energy Conservation,* Kindle edition.
4. Wayne C, *Energy Management Handbook*, John Willey and Sons.

DEEE-14505 SOLAR TECHNOLOGIES

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the basics of solar energy conversion and utilization processes.
b. Retrieve knowledge of semiconductors, optical system, energy storage related to photovoltaic system.
c. Comprehend the challenges of sustainable energy, processes, designing of photovoltaic systems
d. Comprehend and justify the different applications of solar technologies in domestic, commercial and industrial sectors.
e. Understand the manufacturing processes involving environmental challenges for gaining carbon credits.
f. Plan and evaluate the standalone and grid connected PV system.

CONTENTS

1. SOLAR RADIATION

Sustainable Sun's Energy in India, advantages and challenges, The Sun-Earth movement and its various angles, Solar Radiation, Measurement of Solar Radiation.

2. EMERGING SOLAR TECHNOLOGIES AND ITS CONCEPTS

Organic Solar Cell, Dye-sensitized Solar Cell (DSC), Thermo-Photovoltaics (TPV) and its material properties and structures.

3. SOLAR PHOTOVOLTAICS MODULES

Solar PV Modules, Series and Parallel Connection of Cells, Design, Structure and Rating of PV Modules, I-V Equation of PV Modules, Effect of Temperature and Solar Irradiation.

4. SOLAR COLLECTORS

Flat-Plate Collectors, Evacuated Tube Collectors, Concentrated photovoltaic collectors (CPC), Parabolic Troughs, Fresnel reflectors, Parabolic and Scheffler dishes, Solar towers.

5. PHOTOVOLTAIC SYSTEM AND APPLICATIONS

Stand-alone PV system configurations, Grid connected PV system, Wire sizing in PV system, Hybrid PV system, Batteries for PV system.

BOOKS RECOMMENDED

1. Solanki C.Singh, *Solar Photovoltaics*, 3rd Edition PHI.
2. Rai, G.D., *Non- Conventional Energy Sources*, Khanna Publishers.
3. Kothari D.P., Singal K.C. and Ranjan R., *Renewable Energy Sources and Emerging Technologies*, Prentice Hall (India).
4. Simon, Christopher A., *Alternate Source of Energy*, Rowman and Little Field Publishers Inc.
5. Rao, S. and Parulekar, B.B., *Energy Technology: Non-Conventional, Renewable and Conventional*, Khanna Publishers.

DEEE-14506 ANALOG INTEGRATED CIRCUITS

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand differential and operational amplifiers.
b. Understand and read specifications sheets of different types of Op-Amps, 555 timer and other analog IC's.
c. Analyze different operations using Op-Amps.
d. Evaluate the performance of different operations using Op-amps, 555 timers.
e. Apply Op-Amps for different applications and understand the implications of different waveform generators and special function IC's.
f. Create and trouble shoot small working projects using Op-amp and other special function IC's.

CONTENTS

1. DIFFERENTIAL AMPLIFIERS

Single Ended Input, Double ended (Differential) Input, Double ended Output, Common-Mode Operation and Common Mode Rejection, Differential Amplifier Circuit, DC Bias, AC Operation of Circuit, Common Mode Operation of Circuit, Use of Constant Current Source, Current Mirror.

2. OPERATIONAL AMPLIFIERS

Block Diagram of a Typical Op-Amp, Schematic Symbol, Integrated Circuits and their types, IC Package Types, Pin Identification and Temperature Range, Interpretation of Data Sheets, Overview of Typical Sets of Data Sheets, Characteristics and Performance Parameters, Ideal Op-Amp, Equivalent Circuit of Op-Amp, Ideal Voltage Transfer Curve.

3. APPLICATIONS OF OP-AMP

Sign Changer, Scale Changer, Phase Shift Circuits, Voltage Follower, V-to-I And I-to-V Converters, Adder, Subtractor, Instrumentation Amplifier, Integrator, Differentiator, Logarithmic Amplifier, Anti-Logarithmic Amplifier, Comparator, Schmitt Trigger, Precision Rectifier, Peak Detector, Clipper and Clamper, Low Pass, High Pass and Band Pass Butterworth Filter.

4. WAVEFORM GENERATORS AND SPECIAL FUNCTION IC'S

Oscillators**,** Phase Shift Oscillators, Wein Bridge Oscillator, Square Wave Generator, Triangular Wave Generator, Saw Tooth Generator, Voltage Controlled Oscillator, Timer IC 555, Fixed and

Adjustable Voltage Regulators, IC 723 General Purpose Regulator, Monolithic Switching Regulator, Switched Capacitor Filter, IC MF10, Frequency-to-Voltage and Voltage-to-Frequency Converters.

BOOKS RECOMMENDED

1. Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, 3rdEdition, Prentice Hall India.
2. Robert L. Boylestad, Nashelsky Louis, *Electronic devices and Circuit Theory*, 9th Edition, Pearson Education.
3. Robert L. Coughlin, *Op-Amps and Linear Integrated Circuits* 5th Edition.

EE-14601 POWER SYSTEM-II (SWITCH GEAR & PROTECTION)

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Analyze the principle of operation of different types of relays.
b. Analyze different types of faults occur in the generator, transformers and transmission line.
c. Demonstrate the knowledge for various components used in the relays.
d. Evaluate the arc quenching mechanism used in different circuit breakers.
e. Design the relay setting for over-current and earth fault relays.
f. Create the basic knowledge of power system protection concepts.

CONTENTS

1. SUB-STATION

Types, Main equipment in substation, substation layout, busbar-arrangements.

2. FUSES

Fuse-types, rating, selection, theory and characteristics, applications.

3. ISOLATOR AND CIRCUIT BREAKERS

Isolating switches functions, types, rating and operation, need for Circuit Breakers, arc phenomenon, theory of Arc Interruption, Recovery Voltage and Restriking Voltage, various types of Circuit Breakers. Principles and constructional details of ACB, Air blast, Minimum Oil, bulk oil , Vacuum Circuit, SF6 Breakers. Different type of operating mechanism and construction of arcing chutes.

4. PROTECTIVE RELAYS

Introduction, classification, constructional features and characteristics of Electromagnetic, Induction, Thermal, Overcurrent, Directional, Distance, Differential, Translay, Negative Sequence. Introduction to Digital and Microprocessor based relays.

5. PROTECTION OF FEEDERS

Time graded protection, Differential and Distance protection of feeders, choice between Impedance, Reactance and Mho relays. Elementary idea about carrier current protection of lines.

6. PROTECTION OF GENERATORS AND TRANSFORMERS

Types of faults on alternator, stator and rotor protection, negative sequence protection, loss of

excitation and overload protection. Types of fault on transformers, percentage differential protection, Gas relays.

7. PROTECTION AGAINST OVER VOLTAGE AND EARTHING

Ground wires, rod gap, impulse gap, valve type and metal oxide arresters, line Arrester/ surge absorber, grounded and ungrounded neutral system, different types of earthing.

BOOKS RECOMMENDED

1. Rao S., *Switchgear and Protection*, Khanna Publishers
2. Chakrabarti A., Soni, M.L. Gupta P.V. and Bhatanagar U.S., *A Textbook on Power System Engineering*, DhanpatRai and Co.
3. Wadhawa C.L,*A Course in Electrical Power*, New Age international Pvt. Ltd
4. Badri Ram and Vishwakarma D.N., *Power system Protection and Switchgear,* Tata McGraw Hill
5. Deshpande M.V., *Switchgears and Protection*, Tata McGraw Hill

EE-14602 ELECTRICAL DRIVES & UTILIZATION

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Analyze different motor applications.
b. Design various illumination systems.
c. Evaluate different heating schemes for a given application.
d. Understand process of electroplating.
e. Understand technology used in refrigeration and air conditioning.
f. Understand different schemes of electric traction and its main components.

CONTENTS

1. ELECTRIC DRIVES

Electrical drives & Mechanical drives, Concept of electrical drives, Basic features of industrial drives, review of operating and starting characteristics of different types of electric motors for various drives (AC and DC motors). Power semiconductor based drives. Estimation of rating and heating of motors, Load equalization (Fly wheel effect), Drives for particular services.

2. ELECTRIC TRACTION

Introduction to Indian railways system , Electric Locomotive Classes, Various types of Traction system, single phase feeding arrangement prevalent in India. Substation Arrangements, Different Types of Catenary construction and line insulation, Span and Dropper design Calculations.

3. ELECTRIC HEATING

Methods of electric heating, types of electric heating, constructional details and performance of resistance heating furnace. Dielectric heating, Induction heating, Infra-red heating and its applications, Microwave heating.

4. ILLUMINATION

Production of light by different methods, terms used, laws of illumination, Different Artificial light sources, their construction and operating principles, Design of lighting schemes and equipment used for indoor, industrial and flood lighting, LED Lighting, Illumination drivers.

5. REFRIGERATION AND AIR CONDITIONING

Refrigeration system, Domestic refrigeration, Air conditioner, Comfort Air-conditioning, Effective temperature, Concept of Heat Ventilation and Air Conditioning System, Inverter Technology Based Air Conditioning.

6. ELECTROLYSIS

Laws of Electrolysis, Process voltage, current, energy, efficiency, Applications of electrolysis, Electroplating on non-conducting materials.

BOOKS RECOMMENDED

1. Partab H., *Modern Electric Traction*, Dhanpat Rai publications
2. De N.K. and Sen P.K., *Electric Drives*, PHI publication.
3. Berde M.S., *Electric Motor Drives*, Khanna Publishers.
4. Gupta J.B., *Utilization of Electric Power and Electric Traction*, S.K. Kataria and Sons
5. Tripathy S. C., *Electric Energy Utilization and Conservation*, Tata McGraw Hill
6. Taylor E.O., *Utilization of Electric Energy*, Orient Blackswan
7. Hughes Austin, *Electric Motors and Drives: Fundamentals, Types and Applications,* Newnes, (2005)

EE-14603 ELECTRICAL GENERATION & ECONOMICS

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Evaluate and compare the performance of conventional and non-conventional energy sources.
b. Analyze the load curves and related factors for determining power generation needs.
c. Carry out economic analysis of different electric energy generation techniques.
d. Evaluate cogeneration plants.
e. Plan optimal method of loading turbo generator.
f. Justify the need of hydro thermal coordination.

CONTENTS

1. CONVENTIONAL RESOURCES OF ELECTRIC ENERGY GENERATION

Thermal, Nuclear, Hydro, Gas and Diesel power plants, their layout and components. Selection of power plants: site, number and capacity of units. Types of turbines, introduction to governor & speed regulation, pumped storage, small scale Hydro-Electric plants (mini and micro), Base and Peak load plants.

2. NON-CONVENTIONAL RESOURCES OF ELECTRIC ENERGY GENERATION AND COGENERATION

Drawbacks of conventional energy resources, need and growth of non-conventional and renewable energy resources. Introduction to Magneto Hydro Dynamic system, photo voltaic effect and solar energy, wind energy, geothermal power plants and biomass based electric energy generation, Cogeneration: Definition and scope, Topping and Bottoming Cycles, Benefits, Cogeneration technologies.

3. LOADS AND LOAD CURVES

Types of loads, connected load, maximum demand, demand factor, group and peak diversity factors, chronological load curve, load duration curve, mass curve, load factor, capacity factor, utilization factor, load forecasting.

4. ECONOMICS OF ELECTRIC ENERGY GENERATION

Capital cost of power plants, annual fixed and operating costs, unit cost of electrical energy, and effect of load factor on unit cost, depreciation, objectives and types of electricity tariff, determination of most economic power factor.

5. ECONOMIC OPERATION OF STEAM POWER PLANTS AND HYDRO-THERMAL SCHEDULING

Methods of loading turbo-generators, Input- output curve, Heat rate curve, Incremental cost curves, Method of Lagrangian multiplier, Effect of transmission losses, Co-ordination equations, Iterative procedure to solve co-ordination equations, Advantages of combined operation of plants, Optimal scheduling of hydro-thermal system.

BOOKS RECOMMENDED

1. Deshpande, M.V., *Power plant engineering*, Tata McGraw Hill.
2. Gupta, B.R., *Generation of electric energy*, S. Chand.
3. Nagrath, I.J. and D.P. Kothari, *Power system engineering*, Tata McGraw-Hill Education.
4. Nag, P.K. *Power plant engineering*, Tata McGraw-Hill Education.
5. Wood, A. J. and B. F. Woolenberg, *Power Generation Operation & Control*, Wiley India.
6. Godfrey Boyle, *Renewable energy-power for a sustainable future*, Oxford UniversityPress.
7. Rai, G.D, *Non-conventional energy sources*, Khanna Publishers.

EE-14604 MICROCONTROLLER & PROGRAMMABLE LOGIC CONTROLLERS

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Comprehend the importance of 8051 microcontroller and understand its internal architecture.
b. Acquire programming skills in assembly and C language.
c. Acquire skill in interfacing peripherals with 8051 microcontroller.
d. Create and troubleshoot the circuits involving interfacing of 8051 with real world.
e. Create and troubleshoot simple controllers employing 8051 microcontroller.
f. Evaluate the performance of 8051 controller and PLC based practical circuits.

CONTENTS

1. INTRODUCTION

Microprocessor, microcontroller and their comparison, The 8051 Architecture: Introduction, 8051 micro-controller hardware, input/output, pins, ports and circuits.

2.8051 ASSEMBLY LANGUAGE PROGRAMMING

The mechanics of programming, assembly language programming process, programming tools and techniques, instruction set (data moving, logical operations, arithmetic operations, jump and call instructions).

3. 8051 PROGRAMMING AND C

Data types and time delay, I/O programming, logic operations, data conversion, accessing code ROM space, data serialization.

4.8051 TIMER AND SERIAL PORT PROGRAMMING

8051 timer, counter and programming Timer 0 &1, introduction to serial communication, connect port RS232 and serial port programming in C.

5.8051 INTERRUPT PROGRAMMING

Programming timer interrupts, external hardware interrupts, serial communication interrupt, interrupt priority.

6**. MICROCONTROLLER APPLICATIONS**

Interfacing keyboards, LCD displays, Digital-to-Analog (D/A) and Analog-to-Digital (A/D), sensor interfacing and signal conditioning.

7. PROGRAMMABLE LOGIC CONTROLLERS (PLC)

Introduction, operation of PLC, difference between PLC and Hardwired system, difference between PLC and Computer, relay logic and ladder logic, ladder commands and examples of PLC ladder diagram realization, PLC timers, PLC counters, PLC classification.

RECOMMENDED BOOKS:

1. Kenneth J Ayala, *The 8051 Micro Controller-Architecture, Programming and Application*, Penram International Publication.
2. Mazidi M.A. and Mazidi J. G., *The 8051 Microcontroller and Embedded Systems*, Pearson Education.
3. Otter, Job Dan, *Programmable Logic Controller*, P.H. International, Inc, USA.
4. Dunning Gary, *Introduction to PLC's*, Tata McGraw Hill.
5. Kumar Rajesh, *Module on PLCs and their Applications*, NITTR Chandigarh.

EE-14605 LABORATORY-XI: POWER SYSTEM

Internal Marks	: 30	L	T	P	C
External Marks	: 20	0	0	2	1
Total Marks	: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Plot characteristics of various transmission lines
b. Understand concept of relays and circuit breakers.
c. Analyze various protection schemes in power system.
d. Plot characteristics of different types of relays.
e. Measure the resistance of earth.
f. Demonstrate the operation of a circuit breaker.

LIST OF EXPERIMENTS

1. To find the ABCD parameters of a Transmission line.
2. To obtain the Characteristics of over current and earth fault protection relay.
3. To find the operating characteristics of fuse. (HRC or open type)
4. To find the earth resistance using three electrodes.
5. To draw the characteristics of over current static relay.
6. To simulate the different types of faults on transmission line using MiPower software.
7. To obtain the characteristics of under voltage and over voltage numeric relay.
8. To find the characteristics of bimetallic Relay.
9. To draw the characteristics of high speed impedance Relay.
10. To find the breakdown strength of transformer oil.
11. To find the resistivity of earth using four electrode method.
12. To demonstrate the operation of a Circuit breaker.

EE-14606 LABORATORY-XII: ELECTRIC DRIVES

Internal Marks	: 30	L	T	P	C
External Marks	: 20	0	0	2	1
Total Marks	: 50				

COURSE OUTCOMES

After studying this course, the students will

a. Analyze speed and direction control of single phase and three phase electric motors using ac and dc drive.
b. Analyze speed control of stepper motor using drives.
c. Evaluate methods of speed control of servo motor using drives.
d. Conduct and analyze PLC based ac/dc motor control operation.
e. Design a set up for microcontroller based speed control of stepper motor and dc motor.
f. Understand regenerative/dynamic braking operation of ac motor and dc motor.

LIST OF EXPERIMENTS

1. To start and stop the single phase and three phase induction motors using single phase and three phase AC drives.
2. To forward and reverse the direction of single phase and three phase induction motors using single phase and three phase AC drives.
3. Speed control of DC motor using PWM.
4. Speed control of BLDC motor.
5. Demonstration of BLDC motor.
6. Speed control of stepper motor using drives
7. Speed control of induction motor using V/F drives.
8. Speed control of servo motor using servo drive.
9. PLC based AC/DC motor control operation.
10. Microcontroller based speed control of stepper motor.
11. Microcontroller based speed control of DC motor.
12. Regenerative/ dynamic braking operation of DC motor.
13. Regenerative/ dynamic braking operation of AC motor.
14. To demonstrate thyristor controlled DC drive.

EE-14607 LABORATORY-XIII: MICROCONTROLLER & PROGRAMMABLE LOGIC CONTROLLERS

Internal Marks : 30	L	T	P	C
External Marks : 20	0	0	2	1
Total Marks : 50				

COURSE OUTCOMES

After studying this course, the students will

a. Comprehend the importance of 8051 microcontroller, PLC and understand their internal architecture.
b. Acquire programming, simulation and testing skills in assembly and C language.
c. Acquire skill in interfacing peripherals, relays, LED, LCD, Keyboard and sensors with 8051 microcontroller.
d. Create and troubleshoot the circuits involving interfacing of 8051and PLC with real world.
e. Create and troubleshoot automatic controllers employing 8051 microcontroller.
f. Evaluate the performance of 8051 controller and PLC based practical circuits.

LIST OF EXPERIMENTS

1. Demonstration of MCS51 family.
2. Write a program to add and multiply two numbers lying at two memory locations and display the result.
3. Write a program of flashing LED connected to port 1 of the micro-controller.
4. Write a program to show the use of INT0 and INT1.
5. Write a program to control the speed of DC motor.
6. Write a program to control a stepper motor in direction, speed and number of steps
7. Write a program to demonstrate jump, loop and call instruction in microcontroller.
8. Write a program to generate a square wave of different duty cycle in microcontroller
9. Write a program to demonstrate different addressing modes in microcontroller
10. Implementation of different gates using PLC.
11. Implementation of DOL and star delta starter using PLC.
12. Implement basic logic operations, motor start and stop operation using
    (i) Timers (ii) Counters
13. Motor forward and reverse direction control using PLC.
14. Make a PLC based control system for conveyor belt.
15. Implement a PLC based traffic light control.
16. PID control using PLC.
17. Temperature and Pressure control using PLC
18. Pneumatic / hydraulic control using PLC

DEEE-14601 POWER SYSTEM OPERATION & CONTROL

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Retrieve characteristic features of power generation in steam units, co-generation plants and hydro-electric units.
b. Understand economic dispatch problem.
c. Evaluate unit commitment problem and apply various solution methods.
d. Understand optimal power flow problem and find its solutions.
e. Understand hydro-thermal co-ordination.
f. Retrieve the techniques of automatic generation control.

CONTENTS

1. CHARACTERISTICS OF POWER GENERATION UNITS

Characteristics of Steam Units, Cogeneration Plants and Hydro-Electric Units.

2. ECONOMIC DISPATCH OF THERMAL UNITS

Economic Dispatch Problem, Thermal Dispatching with Network Losses Considered, Penalty Factor, Lambda Iteration method, Gradient method, Newton's method, Base point and Participation factors. Economic Dispatch v/s Unit Commitment, Constraints in Unit Commitment, MATLAB program for the solution of Economic Dispatch Problem

3. OPTIMAL POWER FLOW

Mathematical formulation of OPF Problem, Solution of Optimal Power Flow by Gradient, Newton, LPOPF and Interior Point Methods, MATLAB program for the solution of OPF

4. HYDRO THERMAL CO-ORDINATION

Introduction to Long Range and Short Range Hydro Scheduling, Types of Short Range Scheduling problem, Scheduling energy, the Short term Hydro-Thermal Scheduling problem and its solution by Lambda-Gamma Iteration method and Gradient method, MATLAB program for the solution of short term hydro-thermal scheduling problem.

5. GENERATION CONTROL

Automatic Load Frequency Control, Load Frequency and Economic Dispatch Control, Automatic Voltage Control, Decentralized Control, SIMULINK model of ALFC

BOOKS RECOMMENDED

1. Wood Allen J. and Brace F. Woollenberg, *Power Generation Operation and Control,* John Willey & Sons.
2. Kothari D.P. and J .S. Dhillon, *Power System Optimization,* Prentice-Hall of India, Pvt. Ltd, New Delhi
3. Kirchmayer L.K., *Economic Operation of Power Systems,* John Willey & Sons, N.Y.
4. Kothari D. P. and I. J. Nagrath, *Modern Power System Analysis*, Tata McGraw- Hill Publishing Company Ltd., New Delhi.
5. Sttephen J. Chapman, *MATLAB® Programming for Engineers,* THOMSON.

DEEE-14602 COMPUTER AIDED ELECTRICAL MACHINE DESIGN

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the general concepts of electrical machine design.
b. Acquire knowledge about various insulating materials used in electrical machine design.
c. Alleviate the problems of electric machine design by using different design techniques.
d. Understand the different ways of cooling and ventilation of electric machine.
e. Calculate the heat losses and efficiency in the electric machines.
f. Analyze, design, model and synthesize of Transformers and Induction motors.

CONTENTS

1. GENERAL CONCEPTS OF ELECTRICAL MACHINE DESIGN

Basic considerations & Limitations in design, specific magnetic and electric loadings, output, real and apparent flux densities, separation of main dimensions for D.C., induction and synchronous machines. Review of different types of insulating materials used in electrical machines.

2. HEATING, COOLING AND VENTILATION

Introduction, Modes of heat transfer, Temperature rise calculation, continuous, short time and intermittent ratings, methods of ventilation and cooling.

3. DESIGN OF TRANSFORMERS

General considerations, output equation, main dimensions, leakage reactance, winding design, tank and cooling tubes, calculation of magnetizing current, losses, efficiency and regulation. Recent advances in design of transformer.

4. DESIGN OF THREE-PHASE INDUCTION MOTORS

General considerations, output equation, choice of specific electric and magnetic loadings, No. of slots in stator and rotor, elimination of harmonic torques, design of stator and rotor windings, leakage reactance, equivalent resistance of squirrel cage rotor, magnetizing current, temperature rise and efficiency. Recent advances in the design of induction motors.

BOOKS RECOMMENDED

1. Sawhney A. K., *A Course in Electrical Machine Design,*DhanpatRai.
2. Aggarwal R. K., *Principles of Electrical Machine Design,* S. K. Kataria& Sons.
3. JuhaPyrhonen, TapaniJokinen and Valeria Hrabovcova,*Design of Rotating Electrical Machines*, Wiley Publication.

4. Fitzgerald A.E., Charles Kingsley, Jr, and Stephan D, Umanx, *Electric Machinery,* Tata McGraw Hill.

DEEE-14603 OPTIMIZATION TECHNIQUES

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOME

After studying this course, the students will

a. Develop mathematical modeling of operation research problems.
b. Solve linear programming problems using graphical, simplex, Big M and two-phase simplex methods.
c. Understand basic concept of duality of linear programming.
d. Perform sensitivity analysis of linear programming problems.
e. Develop mathematical model and solution of transportation and assignment problems.
f. Understand and apply integer programming to the mixed-integer problems

CONTENTS

1. INTRODUCTION

Definition of operation research, models in operation research, general methods for solving O.R. models Elementary theory of convex sets, Linear programming problems, examples of LPPs, mathematical formulation of the mathematical programming problems, Graphical solution of the problem, Simplex method, Big M method, Two Phase method, problem of degeneracy.

2. DUALITY IN LINEAR PROGRAMMING

Concept of duality, fundamental properties of duality, duality theorems, complementary slackness theorem, duality and simplex method, dual simplex method.

3. SENSITIVITY ANALYSIS

Discrete changes in the cost vector, in the requirement vector and in the co-efficient matrix.

4. TRANSPORTATION PROBLEM

Introduction, mathematical formulation of the problem, initial basic feasible solution, optimum solution, degeneracy in transportation problems, transportation algorithm, unbalanced transportation problems.

5. ASSIGNMENT PROBLEMS

Introduction, mathematical formulation of an assignment problem, assignment algorithm, unbalanced assignment problems.

6. INTEGER PROGRAMMING

Introduction, Gomory's all-IPP method, Gomory's mixed-integer method, Branch and Bound method. Games and Strategies : Introduction, Two person zero sum games, Maximum,

Minimum, Principle; Games without saddle points, Mixed Strategies, Graphical solution, Dominance property, Reducing the game problem to a LPP.

RECOMMENDED BOOKS

1. Swarup Kanti, *Operations Research*, Sultan Chand and Sons, New Delhi, P. K. Gupta and Man Mohan
2. Mohan Chander and Kusum Deep, *Optimization Techniques*, New Age International, 2009.
3. G. Hadley, *Linear Programming*, Addison-Wesley

DEEE-14604 ENERGY CONVERSION

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOME

After studying this course, the students will

a. Understand and retrieve fundamentals of electrical engineering.
b. Understand the different energy conversation techniques.
c. Prepare the different techniques of conversion and its application.
d. Evaluate the performance of pumps and flow control strategies.
e. Understand and justify the choices of luminance requirements.
f. Carry out the process of selecting diesel generating system.

CONTENTS

1. BASICS OF ELECTRICAL ENGINEERING

Fundamentals of Electricity: Concepts of different electrical parameters like voltage, current, frequency, D.C and A.C circuits, Electrical power and energy. Transformers, Generators, Alternators, Conversion of Thermal, Chemical, Electromagnetic and Mechanical energy into Electrical energy.

2. ELECTRICAL ENERGY SOURCES

Importance of Electrical energy in modern industrial society, Production of electricity using coal, oil, natural gas, nuclear fuels and hydel-its relative advantages and disadvantages (i.e. conversion of Thermal, Nuclear, hydel energy into electric energy),Electricity generation using Renewable Energy Sources: Basic Principles and Applications. (Conversion of Electromagnetic energy and natural energy sources like solar radiation, Wind, Ocean waves, Solid waste etc. to electricity),Conversion of chemical energy into electrical energy (fuel cell),Thermal power plant, nuclear power plants and hydroelectric power plant, Transmission and distribution of electricity, Villages electrification program and problems in India.

3. ELECTRICAL AND MECHANICAL ENERGY UTILITY SYSTEMS

Conversion of Electrical Energy to Mechanical Energy (Electric Motors).Electric Motors: Types, Losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, Energy efficient motors. Compressed Air System: Types of air compressors, compressors efficiency, efficient compressors operation, Compressed air system components, capacity assessment, and leakage test, factors affecting the performance. Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies. Pumps and Pumping Systems: Types, performance evaluation, efficient system operation, flow control strategies, variable speed drives. Cooling Towers: Types and

performance evaluation, efficient system operations, flow control strategies, assessment of saving opportunities. Illumination / Lighting Systems: Light source, choice of lighting, luminance requirements, electronic ballast, occupancy sensors, energy efficient lighting control. Diesel generating systems: Factors affecting selection, energy performance assessment of diesel conservation avenues.

BOOKS RECOMMENDED

1. Archie W. Culp, *Principles of energy conversion,*McGrawHill,1979.
2. Kettani M. Ali, *Direct energy conversion*, Addison-Wesley Pub. Co., 1970
3. Desai B.V.*, Alternative Liquid fuels*, New Age International.
4. Hogde B.K, *Analysis and design of Energy Systems*, Prentice hall 1988.

DEEE-14605 ROBOTIC CONTROL SYSTEM

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand basic terminologies of Robotics.
b. Implement elements of robotics practically.
c. Understand differential motion planning and robot control system.
d. Paraphrase kinematics and robotic controls.
e. Recognize dynamic modelling.
f. Understand robotics control dynamics.

CONTENTS

1. INTRODUCTION AND TERMINOLOGIES

Definition and Origin of Robotics, Classification of Robotics, Various Generations of Robotics, Degrees of Freedom, Science and Technology of Robotics.

2. ELEMENTS OF ROBOTS -- JOINTS, LINKS, ACTUATORS, AND SENSORS

Position and Orientation of a Rigid Body, Homogeneous Transformations, Representation of Joints, Link Representation using D-H parameters, Examples of D-H parameters and Link Transforms, Different kinds of Actuators – Stepper, DC servo and Brushless Motors, Model of a DC Servo Motor, Types of Transmissions, Purpose of Sensors, Internal and External Sensors, Common Sensors – Encoders, Tachometers, Strain Gauge based Force-Torque Sensors, Proximity and Distance measuring Sensors

3. KINEMATICS OF ROBOTS

Mechanism Matrix representation, Modeling Kinematic chains, Robot joints, Co-ordinates, reference frame-workspace Robots, Direct and Inverse Kinematics problems-solution, Degeneracy and Dexterity

4. DIFFERENTIAL MOTION PLANNING AND ROBOT CONTROL SYSTEM

Joint and Cartesian Space Trajectory Planning and Generation, Classical Control concepts using the example of Control of a Single link, Independent joint PID control, Control of a multi-link manipulator, Non-linear model based control schemes, Simulation and Experimental case studies on Serial and Parallel Manipulators, Control of Constrained Manipulators, Cartesian control, Force control and Hybrid position/force control, Advanced topics in Non-Linear control of Manipulators.

5. DYNAMIC MODELING

Models of Flexible links and joints, Kinematic modeling of multi-link Flexible Robots, Dynamics and Control of Flexible link Manipulators, Introduction to some well-known Wheeled Mobile Robots (WMR), Two and Three Wheeled WMR on flat surfaces, Slip and its modeling

BOOKS RECOMMENDED

1. Mittal R.K and I. J. Nagrath, *Robotics And Control,* Tata Mac Graw Hill.
2. Saeed B. Niku, *Introduction to Robotics,* Pearson Education.
3. Klafter R.D, T.A. Chmielewski and Michael Negin, *Robotic Engineering-An integrated approach,* Prentice Hall of India.
4. Reza N. Jazar, *Theory of Applied Robotics Kinematics, Dynamics and Control,* Springer.

DEEE-14606 PROCESS DYNAMICS AND CONTROL

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Create procedure models of different processes.
b. Analyse the performance of Single Loop Regulatory Control.
c. Evaluate &deconstruct controller tuning.
d. Evaluate Model Based Control Schemes.
e. Create and design controllers for interacting multivariable systems.
f. Interpolate Optimal Control Systems.

CONTENTS

1. PROCESS DYNAMICS AND CONTROL ELEMENTS

Need for Process Control, Mathematical models of various control systems, Continuous and batch processes, Self-regulation, Servo and Regulatory Operations, Lumped and Distributed parameter models, Linearization of non-linear systems. I/P converters, pneumatic and electrical actuators, valve positioner, Selection Criterion, Cavitation and Flashing, Introduction to Multivariable control, multivariable PID controller, Predictive PID control, Control Schemes for Distillation Column, CSTR(Continuous stirred tank reactors).

2. CONTROL ACTIONS AND SINGLE LOOP REGULATORY CONTROL

Characteristics of Proportional Derivative and Integral Controllers, Introduction to Tuning and Evaluation Criteria's, Process Reaction Curve method, Z-N and Cohen Coon methods, Continuous Cycling and Damped Oscillations method

3. MODEL BASED CONTROL SCHEMES

Cascade control, Split Range control, Feed Forward control, Ratio control, Inferential control, Override control, Smith Predictor control scheme, Internal model controller, IMC PID controller, Single Loop Dynamic Matrix Control, Generalized Predictive control.

4. MULTIVARIABLE SYSTEM AND MULTILOOP REGULATORY

Multivariable systems, Transfer Matrix representation, Poles and Zeros of MIMO systems, Multi loop control- introduction, process interaction, Paring of inputs and outputs, Relative Gain Array (RGA)- properties and application, Multi-loop PID Controller, Decoupling Control.

5. OPTIMAL CONTROL SYSTEMS

Parameter optimization, Servo mechanism, Regulators, Optimal Control problems, Transfer Function approach, State Variable approach, State Regulator problem, Infinite Time Regulator

problem, Output Regulator and Tracking problems- LQR(Linear quadratic regulation) & LQG(Linear quadratic gaussian).

BOOKS RECOMMENDED

1. Coughanour D.R., *Process Systems analysis and Control,* 2ndEdition, McGraw-Hill.
2. Smith C.A. and A.B. Corripio, *Principle and Practice of Automatic Process Control*, 3rd ed., John Wiley and Sons, 2005
3. Seborg E., T.F. Edger, and D.A. Millichamp, *Process Dynamics and Control,* 2ndEdition, John Wileyand Sons, 2004.

OEEE-14601 NON-CONVENTIONAL ENERGY SOURCES

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	0	0	3
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Analyze the global and national energy scenario as regards to energy crisis.
b. Evaluate the economic aspects of MHD generation.
c. Analyze the available solar potential in India.
d. Evaluate the various technologies for harnessing solar energy.
e. Evaluate the application of fuel cell in diverse fields.
f. Evaluate the energy harnessing from biomass, wind, geothermal, tidal and other non conventional sources of energy.

CONTENTS

1. INTRODUCTION

Global and National energy scenarios, Limitation of conventional energy sources, need and growth of alternative energy source, Energy-Environment interaction, basic scheme and application of direct energy conservation.

2. MHD GENERATORS

Basic principles, gaseous, conduction and hall effect, generator and motor effect, different types of Magneto-Hydro-Dynamic (MHD) generator, types of MHD material, conversion effectiveness, analysis of constant area MHD generator, practical MHD generator, application and economic aspects.

3. SOLAR ENERGY AND PHOTOVOLTAIC EFFECT

Solar energy in India, Solar radiation analysis, diode equivalent circuit of PV cell , solar collectors, Applications of solar energy viz solar furnace, Photovoltaic effect, different types of photovoltaic cells, cell fabrication, characteristics of photovoltaic cells, conversion efficiency.

4. FUEL CELLS

Principle of Operation of Fuel Cell, Gibb's free energy, general description of fuel cells types, construction, operational characteristics and applications.

5. MISCELLANEOUS SOURCES

Geothermal system, hydro-electric plants, wind power, tidal energy, Bio-mass energy, biodiesel, thermo-electric generator

BOOKS RECOMMENDED

1. Gupta B. R., *Generation of Electrical Energy*, S. Chand.
2. Rai G.D., *Non-Conventional Energy Sources*, Khanna Publishers (2005).
3. Rao, S. and Parulekar, B.B., *Energy Technology: Non-Conventional, Renewable and Conventional*, Khanna Publishers (2005).
4. Wadhwa, C.L., *Generation Distribution and Utilization of Electric Energy*, New Age International (P) Limited, Publishers (2007).
5. Simon, Christopher A., *Alternate Source of Energy*, Rowman and Little Field Publishers Inc.(2007).
6. Venikov, V.A. and Putyain, E.V., *Introduction to Energy Technology*, Mir Publishers (1990).
7. Chakrabarti A., Soni M. L., Gupta P. V. and Bhatnagar U. S., *Power System Engineering*, DhanpatRai and Co.
8. Kothari D.P., Singal K.C. and Ranjan R., *Renewable Energy Sources and Emerging Technologies*, Prentice Hall (India)

OEEE-14602 ENERGY AUDITING AND MANAGEMENT

Internal Marks : 40	L	T	P	C
External Marks : 60	3	0	0	3
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the need, comparison and use of various type of electrical energy resources.
b. Understand and compare the basic energy audit report
c. Comprehend various energy management standards and justify its implementation
d. Acquire the knowledge to use various instruments for energy audit
e. Understand the environmental effects and various international protocols
f. Explain and analyze the pollution situation and understand clean development mechanism.

CONTENTS

1. ENERGY SOURCES

Types of Energy, Conventional Sources of Energy, Non-Conventional Sources of Energy, Commercial energy production, current scenario of energy in India & World, Need for energy conservation

2. ENERGY AUDIT

Definition, Need, Types of Audit, Preparing an energy audit report, benchmarking, Sankey diagram, calculation of payback period.

3. ENERGY MANAGEMENT

Definition, need, Standards for energy management ISO standards 14001, 50001, Energy conservation act 2003, designated consumers, energy substitution.

4. INSTRUMENTATION

Instruments used for energy audit: power analyser, thermal analyser, general instruments and their use, SCADA, Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors , Energy efficient lighting controls, Energy saving potential of each technology

5. ENERGY & CLIMATE CHANGE

Energy and environment, Air pollution, Climate change, United Nations Framework Convention on climate change (UNFCCC), Kyoto Protocol, Clean Development Mechanism (CDM), CDM Methodology and Procedures, Sustainable development

BOOKS RECOMMENDED

1. Dr. Clive Beggs,*Energy Management Supply and Conservation*, Butterworth- Heinemann, 2002 .
2. Thumann Albert & Paul Mehta, *Handbook of Energy Engineering*,The Fairmont Press, INC.
3. Wayne C,*Energy Management Handbook*, John Willey and Sons.

EE-14801 COMPUTER AIDED POWER SYSTEM ANALYSIS

Internal Marks	:40	L	T	P	C
External Marks	:60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Develop per unit system models of synchronous machine, transformer, transmission line and static loads for power system studies.
b. Construct Bus Admittance Matrix and Bus Impedance Matrix for power system studies.
c. Investigate the state of power system by performing load flow analysis.
d. Compare features of Gauss-Siedel, Newton-Raphson and Fast decoupled methods of load flow analysis.
e. Analyze the effect of symmetrical and unsymmetrical faults on power system.
f. Analyze the effect of small and large disturbances on power system stability.

CONTENTS

1. SYSTEM MODELING

System modeling of synchronous machines, transformers, transmission lines and loads, Per Unit (p.u.) representation of power system, Single line diagram of electrical networks, p.u. single phase impedance diagrams corresponding to single line diagram. Formulation of Bus Admittance Matrix and Bus Impedance Matrix for power system studies.

2. LOAD FLOW STUDIES

Data for the load flow studies, Bus types, Formulation of power flow equations, Iterative solutions of load flow equations by the Gauss-Seidel and Newton-Raphson methods, Algorithms and flow charts of these methods, Line flows and line losses calculations. Introduction to Decoupled and Fast Decoupled method.

3. FAULT ANALYSIS

Transients on transmission line, Short circuit of synchronous machine, Selection of circuit breakers, Symmetrical fault analysis using Thevenin's theorem. Symmetrical Component Transformation, Construction of sequence networks of power systems. Analysis of Unsymmetrical LG (line to ground), LL (line to line), LLG (line line ground) faults using symmetrical components, Symmetrical and unsymmetrical faults analysis using Bus Impedance Matrix with algorithm and flow chart.

4. POWER SYSTEM STABILITY

Steady state stability, Dynamics of a synchronous machine, Power angle equation, Transient stability, Equal area criterion, Numerical solution of swing equation, Factors effecting transient stability.

BOOKS RECOMMENDED

1. Elgerd O.I., *Electric Energy Systems Theory*, Tata McGraw-Hill.
2. Stevenson W.D., *Elements of Power System Analysis*, Tata McGraw-Hill.
3. Nagrath I.J. and Kothari D.P., *Power System Engineering*, Tata McGraw-Hill.
4. Arrillaga J. and Arnold C.P*, Computer Aided Power System,* Wiley.
5. Glenn W. Stagg. & El-abiad, *Computer methods in power system analysis,* Tata McGraw-Hill.
6. Kusic*, Computer Aided Power System Analysis*, Taylors and Francis group.
7. Nagsarkar T.K. and Sukhija M.S., *Power System Analysis*, Oxford University Press, 2016.
8. D.P. Kothari & J.S. Dhillon, *Power System Optimization,* Prentice-Hall of India.

EE- 14802 DIGITAL CONTROL SYSTEMS

Internal Marks :40	L	T	P	C
External Marks :60	3	1	0	4
Total Marks :100				

COURSE OUTCOMES

After studying this course, the students will

a. Create the state models of different physical and electrical systems.
b. Analyze the stability of a given control system.
c. Evaluate discrete time signals analytically and visualize them in the time and frequency domain.
d. Analyze sampled data control systems by using z transformation.
e. Analyze the nonlinear system behavior by phase plane and describing function methods and learn about the stability of linear and nonlinear systems by lyapunov method.
f. Design and analyze optimal control schemes.

CONTENTS

1. STATE VARIABLE ANALYSIS

Introduction, concepts of State, State Variables and State Model, State Models for Linear Continuous Time Systems, State Variables and Linear Discrete Time Systems, Diagonalization, Solution of State Equations, Concepts of Controllability and Observability.

2. INTRODUCTION OF DIGITAL CONTROL

Digital control systems: advantages and disadvantages of digital control, Representation of sampled process and quantization, Z Transform, Z transfer function, Inverse Z Transform and response of linear discrete systems, Z Transform analysis of sampled data control systems, Z and s domain relationship, Solution of difference equations, Stability definition, Jury's test of stability, Extension of Routh-Hurwitz criterion to discrete time systems.

3. NON LINEAR SYSTEM ANALYSIS

Types of non linarites, Phenomenon related to nonlinear systems, Analysis of nonlinear systems: Describing function analysis, Phase plane analysis, Lyapunov stability analysis.

4. OPTIMAL CONTROL

Introduction, Formation of optimal control problem, Calculus of variations, Minimization of functions, Constrained Optimization, Linear quadratic problem, Hamilton Jacobi Equation, Riccati equation and its solution.

BOOKS RECOMMENDED

1. Gopal M., *Modern Control System Theory*, 3rd edition, New Age Intl. Pvt. Ltd.
2. Gopal M., *Digital Control and State Variable Methods*, 2012, 4thedition, Tata McGraw-Hill Education Pvt. Ltd.

3. Ogata K., *Modern Control Engineering*, 5th edition, 2010, Pearson.
4. Ogata K., *Discrete Time Control Systems*, 5th edition, 2013, PHI
5. Kuo B.C., *Automatic Control System*, 2000, 7th edition, PHI.
6. https://archive.org/details/AutomaticControlSystems.
7. http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=87.

EE-14803 HIGH VOLTAGE ENGINEERING

Internal Marks	:40	L	T	P	C
External Marks	:60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Elucidate breakdown phenomenon and concept of high voltage power apparatus.
b. Understand applications of various insulating materials.
c. Design, generate and measure high voltage & current circuits.
d. Evaluate corona loss and compensation requirement in EHVAC transmission line.
e. Employ concept of insulation coordination, insulating material and radio interference in power system.
f. Understand the concept of high voltage DC transmission and its merits.

CONTENTS

1. DIELECTRIC BREAKDOWN

Gases: - Ionization process, Townsend's current growth equations, 1st and 2nd ionization coefficients, Townsend's criterion for breakdown, Streamer theory of breakdown, Pashen's law of Gases, Gases used in practice, Partial Discharge measurements.

Liquids: - Conduction and breakdown in pure and commercial liquids, Suspended particle theory, Cavitation and Bubble theory, Stressed oil volume theory, Liquids used in practice.

Solids: - Intrinsic, Electromechanical and Thermal breakdown composite dielectrics, Solid dielectrics used in practice.

2. INSULATING MATERIALS FOR HIGH VOLTAGE

Applications of insulating materials used in power transformers, rotating machines, circuit breakers, cables and power capacitors.

3. GENERATION OF HIGH VOLTAGES

High Voltage Direct Current (HVDC), High Voltage Alternating Current (HVAC), Power frequency and High frequency: Impulse voltage and impulse current generation, Tripping and contact of Impulse Generator, Measurement of voltage and current: High voltage direct current, Alternating current and Impulse voltage and currents.

4. EXTRA HIGH VOLTAGE (EHV) TRANSMISSION AND CORONA LOSS

Need for EHV Transmission, Use of bundled conductors, Corona characteristics of smooth bundled conductors with different configurations, Corona loss, Factors affecting the corona loss, Radio Interference due to corona, Shunt and series compensation in EHV lines, Tuned power lines, Insulation Co-ordination.

5. HIGH VOLTAGE DIRECT CURRENT (HVDC) TRANSMISSION

Advantages, disadvantages and economics of HVDC Transmission system, Types of Direct Current (DC) links, Converter station equipment and their characteristics.

BOOKS RECOMMENDED

1. Bagamudre R.D., *Extra High Voltage A.C. Transmission Engineering*, New Age International Publishers.
2. Kimbark E.W., *High Voltage Direct Current Transmission*, Wiley-Interscience.
3. Kamaraju V. and Naidu M.S., *High Voltage Engineering,* Tata McGraw-Hill Education.
4. Kuffel, E. and Abdullah, M., *High Voltage Engineering*, Pergamon Press.
5. Wadhwa C. L., *High Voltage Engineering,* New Age Publications.
6. Padiyar, K.R., *HVDC Power Transmission Systems: Technology and System Interactions*, New Age International.
7. www.cpri.in.
8. https:// onlinecourses.nptel.ac.in.

EE-14804 LABORATORY-XIV Computer Aided Power System Analysis

Internal Marks	:30	L	T	P	C
External Marks	:20	0	0	2	1
Total Marks	:50				

COURSE OUTCOMES

After studying this course, the students will

a. Acquire the skill of using computer packages with the help of high level programming language and software tools in power system studies.
b. Acquire the skill of using power system related tools for power system studies.
c. Develop computer program for load flow analysis.
d. Understand the procedure and steps needed to perform short circuit analysis.
e. Carry out stability studies of power system.
f. Simulate load frequency control of single area system.

LIST OF EXPERIMENTS

1. Introduction to mathematical/programming/software tools for power system studies like Mi Power and high level programming language (MATLAB, C++ etc).
2. To develop a program for formation of Bus Admittance Matrices.
3. To develop a program for formation of Bus Impedance Matrix using building algorithm method.
4. To develop a program for load flow analysis using Gauss-Seidel Method.
5. To develop a program for load flow analysis using Newton-Rapson.
6. Use of software tools for load flow analysis.
7. Fault analysis using software tools.
8. Use of software tools for Load Frequency Control without and with PI Controller.
9. Program for Economic Load Dispatching of power systems.
10. Use of Software tools for stability studies.

EE-14805 LABORATORY-XV High Voltage Engineering

Internal Marks :30	L	T	P	C
External Marks :20	0	0	2	1
Total Marks :50				

COURSE OUTCOMES

After studying this course, the students will

a. Develop ability to estimate and analyze over voltages in power system.
b. Comprehend basic gaseous dielectrics, their properties and behavior under high voltage-stresses.
c. Inculcate skill to conduct dielectric tests as per standards.
d. Identify high voltage testing equipment and testing procedures as per standards.
e. Aware of high voltage application in power system and industry.
f. Acquire knowledge to inspect high voltage equipment and to detect potential risks from malfunction of dielectric materials.

LIST OF EXPERIMENTS

1. Study of high voltage equipment installed in the laboratory.
2. Determine the flashover voltage of a pin type insulator.
3. Determine the flashover voltage of suspension type insulator and to observe the corona effects.
4. To find the dielectric strength of the given transformer oil sample.
5. To find impulse spark over voltage of a) Needle-Plane gap, b) Rod-Rod gap.
6. Determine the flashover voltage of Sphere-Sphere gap.
7. To find cable insulation fault by using Cable Tester.
8. Compare the flashover voltages wet and dry for a typical outdoor insulator.
9. To measure Capacitance and Dielectric Loss of an insulating material by using High Voltage Schering Bridge.
10. To capture Thermal Image of Corona Discharge by using Thermal Imager.
11. To measure breakdown strength of solid insulating materials and strength of liquid insulating materials.
12. To find out the viscosity of liquid insulating materials.

EE-14806 SEMINAR

Internal Marks :100	L	T	P	C	
External Marks : -		0	0	2	2
Total Marks :100					

COURSE OUTCOME

After studying this course, the students will

a. Explore and analyze new areas of research related to electrical engineering
b. Evaluate the effect of newer technologies to our lives.
c. Create power point presentations.
d. Acquire ability for public speaking and giving lecture/presentation.
e. Analyze various new technologies with existing technologies.
f. Evaluate the environmental effects of introducing new technologies.

CONTENTS

Students have to study from National/International Journals, Internet and books etc. related to latest topics and developments in the area of Electrical Engineering and deliver a seminar individually for 25-30 minutes along with Seminar Report.

PREE-14701 MAJOR PROJECT

Internal Marks	:120	L	T	P	C
External Marks	:80	0	0	3	3
Total Marks	:200				

COURSE OUTCOMES

After studying this course, the students will

a. Acquire ability to work in team.
b. Evaluate application of a particular tool/ component for specific application.
c. Acquire ability to apply thinking and problem solving skills.
d. Develop habit of responsibility sharing.
e. Apply knowledge gained for analysis and design of circuits.
f. Learn about their social responsibility.

CONTENTS

The students are required to work in team and to formulate software/hardware based projects showing applications of the knowledge gained during the course work. The students should be able to find out the ratings/ suitability of various components/software in their project work.

DEEE-14801 FUZZY LOGICS AND SYSTEMS

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Represent the various forms of fuzzy system.
b. Perform fuzzification and defuzzification of a given situation/process.
c. Develop fuzzy rules for a fuzzy system.
d. Understand basic steps involved to design a Fuzzy-Logic controller.
e. Use software tool for designing fuzzy logic based controllers.
f. Apply fuzzy logics for simple managerial and engineering applications.

CONTENTS

1. INTRODUCTION

Crisp and Fuzzy Sets- Definition, Representation, Operations and Properties; Classical Relations and Fuzzy Relations-Cardinality, Operations and Properties; Fuzzy Cartesian Product and Composition.

2. FUZZIFICATION AND DEFUZZIFICATION

Fuzzy Membership Function-Features and Forms; Fuzzification-Definition, Need and Method; Fuzzy Linguistic Variables and Defuzzification-Definition, Need and Methods; Lambda Cut for Fuzzy Sets and Relations.

3. FUZZY RULE BASED SYSTEM

Formation of Fuzzy Rules, Approximate Reasoning, Canonical Rule Forms, Decomposition Of Compound Rules, Aggregation and Properties of Fuzzy Rules, Fuzzy Inference System, Graphical Techniques of Inference.

4. FUZZY LOGIC APPLICATIONS

Review of Conventional Control Systems Theory, Fuzzy Logic Control-Need, Design Steps and Models, Design of a Fuzzy Controller for Automatic Generation Control by using software tools, Applications of Fuzzy Logics in the Fields of Managerial Decision Making, Optimization and Pattern Recognition.

BOOKS RECOMMENDED

1. Timothy J. Ross, *Fuzzy logic with Engineering Applications*, McGraw Hill, 1995
2. Klir. G, Yuan B.B., *Fuzzy sets and Fuzzy Logic*, Prentice Hall of India Private Limited, 1997.
3. Yen John, Langari Reza, *Fuzzy Logic: Intelligence, Control, and Information*, PHI, 1998.

4. Padhy N.P., *Artificial Intelligence and Intelligent Systems*, Oxford University Press, 2005.
5. Bojadziev George and Bojadziev Maria, *Advances in Fuzzy Systems —Applications and Theory: Volume 5(Fuzzy Sets, Fuzzy Logic, Applications)*, world scientific.

DEEE-14802 POWER SYSTEM PLANNING

Internal Marks	:40	L	T	P	C
External Marks	:60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand the objectives of national and regional planning strategies of electric power.
b. Acquire knowledge about the concept of load forecasting.
c. Apply the concept of generation, transmission and distribution planning in power system.
d. Evaluate loss of energy indices.
e. Calculate voltage and power loss.
f. Make selection of sizes and location of generating stations and substations.

CONTENTS

1. INTRODUCTION OF POWER SYSTEM PLANNING

Objectives, National and Regional Planning, Long and Short Term Planning, Structure of Power System, Planning Methods, Electricity Regulation, Load Forecasting: Characteristics of Loads, Methodology of Forecasting, Energy Forecasting, Peak Demand Forecasting, Total Forecasting, Annual and Monthly Peak Demand Forecasting.

2. GENERATION SYSTEM PLANNING

Probabilistic Generation and Load Models- Determination of Loss of Load Probability and Expected Value of Demand not Served, Outage Performance and System Evaluation of Loss of Load and Loss of Energy Indices, Power Supply Availability Assessment.

3. TRANSMISSION SYSTEM PLANNING

Overview of Transmission Planning, Necessity of Probabilistic Transmission Planning, Probabilistic Planning Criteria, Procedure of Probabilistic Planning, Network Reconfiguration.

4. DISTRIBUTION SYSTEM PLANNING

Design of Sub Transmission Lines and Distribution Substations, Design Considerations of' Primary and Secondary Distribution Systems, Voltage Drop and Power Loss Calculations.

BOOKS RECOMMENDED

1. Wallach Y., *Power System Planning*, McGraw Hill International.
2. Sullivan P., *Power System Planning*, McGraw Hill International.
3. Dasari, S., *Electric Power System Planning*, IBT Publishers, New Delhi.
4. McDonald J.R., *Modern Power System Planning*, McGraw Hill International.
5. *http://nrldc.in/.*

6. http://ieeexplore.ieee.org/document/194918/.
7. www.theiet.org/sectors/energy/documents/modelling-5.cfm?type=pdf
8. Central Electricity Regulatory Commission, Regulations and Orders - www.cercind.org.
9. Electricity Act 2003 and National Policies – *www.powermin.nic.*

DEEE-14803 POWER SYSTEM RESTRUCTURING & DEREGULATION

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand present scenarios of national and international power sector regimes.
b. Investigate the challenges of competitive electricity markets.
c. Perform modeling of power system operation in deregulated environment.
d. Apply congestion management methodologies in deregulated power system networks.
e. Evaluate available transfer capability of transmission system.
f. Apply internet technology for power system monitoring and trading.

CONTENTS

1. INTRODUCTION

Basic Concept and Definitions, Privatization, Restructuring, Transmission Open Access, Wheeling, Components of Deregulated Power System, Advantages of Competitive Environment in Power System, Power System Restructuring: Overview of Restructured Power System, Difference between Vertically Integrated and Restructured Power Systems, Explanations with Suitable Practical Examples.

2. DEREGULATION MODELS

Pool Model, Pool and Bilateral/ Multilateral Trade Model, Competitive Electricity Market, Independent System Operator Activities in Pool Model, Wholesale Electricity Market Characteristics, Central Auction, Single Auction Power Pool, Double Auction Power Pool, Market Clearing and Pricing, Market Power And Its Mitigation Techniques, Ancillary Services, Transmission Pricing.

3. CONGESTION MANAGEMENT

Transmission Congestion and its Management in Normal Operation, Explanation with Suitable Example, Total Transfer Capability (TTC), Available Transfer Capability (ATC), Transmission Reliability Margin (TRM), Capacity Benefit Margin (CBM), Existing Transmission Commitments (ETC).

4. INTERNET APPLICATIONS

Working of Internet, Usability of Internet, Internet Technology and Programming Languages, Web Pages, XML, Internet Applications for Power System Monitoring and Trading.

BOOKS RECOMMENDED

1. Loi Lei Lai, *Power system restructuring and deregulation*, John Wiley & Sons Ltd.
2. Shahidehpour M. and Alomoush M., *Restructured Electrical Power Systems: Operation, Trading and Volatility,* Marcel Dekker, New York
3. Khaparde S.A. and Abhyankar A. R, *Restructured Power Systems,* Alpha Science, India
4. Venkatesh P., Manikandan B.V., Charles Raja S., and Srinivasan A., *Electric Power Systems, Analysis, Security and Deregulation*, PHI Learning Pvt. Ltd., New Delhi.
5. Philipson Lorrin and Willis H. Lee, Marcel Dekker, *Understanding Electric Utilities and Deregulation*, New York, CRC Press, 2005.
6. Ilic Marija, Galiana Francisco and Fink Lestor, *Power System Restructuring Engineering & Economics*, Kulwer Academic Publisher, USA-2000.
7. Surya Santoso, Wayne Beaty H., Dugan Roger C., Mc Granaghan Mark F., *Electric Power System Quality*, McGraw Hills, 2002.

DEEE-14804 SYSTEM ENGINEERING AND RELIABILITY

Internal Marks : 40	L	T	P	C
External Marks : 60	3	1	0	4
Total Marks : 100				

COURSE OUTCOMES

After studying this course, the students will

a. Retrieve basic concept of system engineering and reliability.
b. Comprehend different reliability functions.
c. Analyze the failure data and component reliability.
d. Evaluate the reliability of engineering systems using different techniques.
e. Understand the qualitative concept of availability and maintainability.
f. Analyze improvement of availability and reliability of any system.

CONTENTS

1. BASIC CONCEPTS OF SYSTEM ENGINEERING AND RELIABILITY

Introduction to System Engineering, Reliability and Quality, History of Reliability, Failure Modes, Causes of Failure (Unreliable Systems)

2. RELIABILTY DESIGN AND ANALYSIS

Reliability and Cost, Failure Data Analysis, Failure Density, Failure Rate, Component Reliability, Mean Time to Failure(MTTF), Mean Time Between Failure(MTBF), Markov's Model of Reliability Function.

3. SYSTEM RELIABILTY MODELS

Introduction, System with Series and Parallel Components, k out of m Systems, Fault Tree Analysis (FTA), Reliability evaluation from Fault Tree.

4. MAINTAINABILTY AND AVAILABILTY CONCEPTS

Concept of Maintainability, Qualitative aspect of Availability, Availability Function, Concept of Preventive Maintenance.

5. RELIABILTY MANAGEMENT

Economic Issues Manufacture and Customer Cost, Reliability Achievement Cost Model, Reliability Management Policies, Objectives, Reliability Data Acquisition, Managing People for Reliability.

BOOKS RECOMMENDED

1. Shooman M.L., *Probabilistic Reliability: An Engineering Approach*, Mc-Graw-Hill.
2. Balaguruswamy E., *Reliability Engineering*, Mc-GrawHill International
3. Srinath. L.S., *Reliability Engineering*, East-West Press Private Ltd.

4. Ramakumar R., *Engineering Reliability*, Prentice Hall, NJ.
5. Billinton R., *Power System Reliability Calculation*, MIT Press, USA
6. Endreyni, *Reliability Modeling in Electric Power System*, John Wiley, New York
7. https:// en.m.wikipedia.org/reliability engineering.
8. https://onlinecourses.nptel.ac.in

DEEE-14805 ADVANCED MICROPROCESSOR

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	: 100				

COURSE OUTCOMES

After studying this course, the students will

a. Retrieve the basic concepts of 8086/8088 microprocessor architectures, pin diagram and assembly language programming.
b. Develop assembly level programs and understanding the basics of the processors.
c. Analyze interfacing of external devices to the processor or according to the user requirements to create novel products and solutions for the real time problems.
d. Understand RISC based microcontroller and different communication modes
e. Apply embedded systems utilizing microprocessors.
f. Test and evaluate the performance of microprocessor based applications.

CONTENTS

1. MICROPROCESSOR 8086/8088 AND ITS ARCHITECTURE

Internal 8086/8088 Microprocessor Architecture, Real Mode Memory Addressing, Addressing Modes. Data Movement Instructions, Arithmetic and Logic Instructions, Program Control Instructions, String Instruction, Assembly Language Programming, Assembler Directives, Program Development Tools.

2. 8086 HARDWARE SPECIFICATIONS AND BASIC INTERRUPT PROCESSING

8086 Pin-Outs And Pin Functions, Clock Generator, Bus Buffering and Latching, Bus Timings, Ready and Wait State, Minimum/Maximum Mode Operation, Memory Interfacing with 8086, Address Decoding, Introduction to Basic I/O Interface, I/O Port Address Decoding, The Purpose of Interrupts, Interrupts, Interrupt Instructions, The Operation of a Real Mode Interrupt, Interrupt Flag Bits, Storing an Interrupt Vector in the Vector Table. Hardware Interrupts: INTR and INTA.

3. INTERFACING WITH ADVANCED DEVICES

Memory Interfacing to 8086, Interrupt Structure of 8086, Vector Interrupt Table, Interrupt Service Routine, Introduction to DOS and BIOS Interrupts, Interfacing Interrupt Controller 8259 DMA Controller 8257 to 8086.

4. COMMUNICATION INTERFACE

Serial Communication Standards, Serial Data Transfer Schemes, 8251 USART Architecture and Interfacing, RS-232, IEEE-488, Prototyping and Trouble Shooting.

BOOKS RECOMMENDED

1. Ray, K. and Bhurchandani, K.M., *Advanced Microprocessors And Peripherals*, Tata McGraw Hill, 2nd edition,2006.
2. Barry B. Brey, *The Intel Microprocessors*, PHI/Pearson Ed. Asia.
3. Hall, Douglas V., *Microprocessor and Interfacing*, 3e.
4. http://computer.howstuffworks.com/microprocessor.html
5. www.nptel.iitm.ac.in

DEEE-14806 DIGITAL SIGNAL PROCESSING

Internal Marks	:40	L	T	P	C
External Marks	:60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Analyze discrete signals and systems.
b. Evaluate discrete Fourier transform using fast Fourier transform algorithms.
c. Create describing equation for digital filter structure.
d. Design and analyze digital filters.
e. Design and analyze filters using pole-zero combination.
f. Design and analyze DSP processor.

CONTENTS

1. INTRODUCTION

Representations of Discrete Signals and Systems and Basic Operators, Z–Transforms, Causality and Stability in terms of Z–Transform, Bilateral Z–Transform, Computation of Z–Transform.

2. DISCRETE FOURIER TRANSFORM (DFT) & FAST FOURIER TRANSFORM (FFT)

Discrete Fourier Series, Discrete Fourier Transform and its Properties, Efficient Computation of DFT Using FFT Algorithms, Linear Filtering approach to Computation of DFT.

3. DIGITAL FILTER STRUCTURE

Describing Equation, Structures for Finite Impulse Response Systems and Structure for Infinite Impulse Response Systems, Representation of Structures using Signal Flow Graph.

4. DESIGN OF DIGITAL FILTERS

Introduction, Difference Between Analog Filters and Digital Filters, Implementation of Digital Filter, Types of Filters, Linear Time Invariant Systems as Filters, Design of Infinite Impulse Response Filters from Analog Filters, Infinite Impulse Response Filter Design using Butterworth Approximation, Frequency Transformation, Finite Impulse Response Filters Design, Least Square Filter Design, Designing Digital Filter From Pole–Zero Placement, Butterworth Filter Design using Bilinear Transformation, Finite Impulse Response Filter Design using Windows, Design of Filters using Pole–Zero Combination.

5. HARDWARE ARCHITECTURE OF DSP PROCESSOR

Introduction, Desirable Features of DSP Processors, Types of Architectures, Internal Architecture of ADSP–21xx Family, Features of ADSP–21xx Family Processors, System

Interface, Instruction Set of ADSP–21xx, ADSP–21xx Development Tools, ADSP–210x Processors, Time Multiplier System DSP Processor.

BOOKS RECOMMENDED

1. Helmut, U. and Willibald, W., *Protection Techniques in Electrical Engg. Systems*, Marcel Dekker Inc. (2001).
2. Proakis, J.G. and Manolakis, D.G., *Digital Signal Processing*, Prentice–Hall of India Private Limited (1996).
3. Rabiner, C.R. and Gold, B., *Theory and Applications of Digital Signal Processing*, Prentice–Hall of India Private Limited (2000).
4. Antonion, A., *Digital Filters: Analysis Design and Application*, Prentice–Hall of India Private Limited (1999).
5. Oppenhein, A.V. and Schafer, R.W., *Digital Signal Processing*, Prentice–Hall of India Private Limited (1998).
6. http://nptel.ac.in/courses/117102060/
7. https://www.tutorialspoint.com/digital_signal_processing/index.htm

DEEE 14807 SIGNALS AND SYSTEMS

Internal Marks	:40	L	T	P	C
External Marks	:60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Evaluate continuous and discrete signals.
b. Be able to analyze the response of a system to various test signals.
c. Evaluate the Laplace transform of various signals.
d. Create signals from samples.
e. Create system models based on equations.
f. Evaluate region of convergence.

CONTENTS

1. INTRODUCTION TO SIGNALS AND SYSTEMS

The Black-Box Approach, Physical Instances and their Adaptation in the Framework, Formal Definition of 'Signal' And 'System', The Domain and Range Variables, Continuous and Discrete Signals and Continuous and Discrete Systems, Continuous/Discrete vs. Analog/Digital, Periodic and Aperiodic Signals, Even and Odd Signals, Deterministic and Random Signals, Complex Exponential and Sinusoidal Signals, Unit Step, Unit Ramp, Unit Impulse, Domain and Range Operations and Transformations, and their Effects upon Signals, Characterization of Systems: Memory, Linearity, Causality, Time-Invariance, Stability, Examples and Counterexamples, Classification of Systems: Continuous Time Systems and Discrete Time Systems, Linear System, Time Invariant System, Causal System, Bounded Input Bounded Output System, Systems With and Without Memory, Linear Time Invariant System.

2. CONTINOUS TIME SIGNALS

Laplace Transform: Recapitulation, Analysis and Characterization of Linear Time Invariant Systems using Laplace Transform, Computation of Impulse Response and Transfer Function using Laplace Transform, Fourier Transform: Representation of Continuous Time Signals, Properties of Continuous Time Fourier Transform, Energy Density Spectrum.

3. SAMPLING THEOREM

Representation of Continuous Time Signals by its Sample, Types of Sampling, Sampling Theorem, Reconstruction of a Signal from its Samples, Aliasing, Sampling of Band Pass Signals.

4. LINEAR TIME INVARIANT CONTINOUS TIME SYSTEM

System Modeling: Differential Equation, Impulse Response, Frequency Response, Convolution, Analysis and Characterization of Linear Time Invariant System using Fourier Methods and Laplace Transform.

5. Z-TRANSFORMS

Basic Principles of Z-Transform, Z-Transform Definition, Relationship between Z-Transform and Fourier Transform, Region of Convergence, Properties of Z-Transform, Poles and Zeros, Inverse Z-Transform using Contour Integration, Residue Theorem, Power Series Expansion and Partial Fraction Expansion.

BOOKS RECOMMENDED

1. Oppenheim, Alan V., and A. S. Willsk, *Signals and Systems*, Prentice Hall, 1982.
2. Smith W.A., *The Scientists and Engineers Guide to Digital Signal Processing*, California Technical Publication.
3. Rawat T., *Signals and Systems*, Oxford University Press.
4. Nagoorkani A., *Signals and Systems*, TMH publications.
5. www.nptel.ac.in/courses/117104074.

DEEE-14808 FLEXIBLE AC TRANSMISSION SYSTEMS

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Retrieve the basics of Power Transmission System.
b. Understand the need and principle of operation of FACTS devices in Power System.
c. Understand the need of Series and Shunt Compensation.
d. Apply FACTS devices for Power System Transmission capability enhancement.
e. Design of AC and DC filters for harmonics mitigation.
f. Understand modeling and control of FACTS controllers.

CONTENTS

1. INTRODUCTION

Basic Issues in Bulk Power Transmission, Review of Basics of Power Transmission System, Lossless Transmission Lines, Maximum Power Flow, Line Load Ability, Control of Power Flow in AC Transmission Line, Conventional Control Mechanisms, FACTS – Introduction, Need and Application in Emerging Transmission Networks.

2. STATIC SHUNT COMPENSATORS: SVC AND STATCOM THEIR APPLICATION

Principle, Configuration and Control of Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM), Applications- Enhancement of Steady-State, Transient and Voltage Stability, Controlling of Power System Damping.

3. STATIC SERIES COMPENSATORS AND THEIR APPLICATION

Objective of Series Compensation, Variable Impedance type Series Compensators, Switching Converter type Series Compensators, Different Modes of Operation and Modeling of Thyristor Controlled Switch Capacitor for Stability Studies.

4. STATIC PHASE SHIFTER AND EMERGING FACTS CONTROLLER Principle of Operation, Steady State Model of Static Phase Shifter (SPS), Operating Characteristics of SPS, Unified Power Flow Controllers (UPFC): Basic Operating Principles and Characteristics, UPFC Model for Power Flow Studies.

5. APPLICATION OF FACTS CONTROLLER AND HARMONICS FILTERS

Reactive Power Control by FACTS Controller, Congestion Management on Transmission Lines using FACT Controller, Principle of Transmission System Compensation, Comparison between Series and Shunt Compensation, Generation of Harmonics, Carrier Frequency and Radio Interference Noise, Design of AC and DC Filters.

BOOKS RECOMMENDED

1. Mohan Mathur, R., Rajiv. K. Varma, *Thyristor Based Facts Controllers for Electrical Transmission Systems*, IEEE press and John Wiley & Sons, Inc.
2. Hingorani, N.G. and Gyragyi, L., *Understanding FACTS: Concepts and Technology of Flexible AC Transmission System*, Standard Publishers and Distributors, 2005.
3. Sang, Y.H. and John, A.T., *Flexible AC Transmission Systems*, IEEE Press, 2006.
4. K.R. Padiyar, *FACTS Controllers in Power Transmission and Distribution*, New Age International Publisher, 2007.
5. Ghosh,A. and Ledwich, G., *Power Quality Enhancement Using Custom Power Devices*, Kluwer Academic Publishers, 2005.
6. Miller T.J.E., *Reactive Power Control in Electric Systems*, John Wiley.

DEEE-14809 NEURAL NETWORKS

Internal Marks	:40	L	T	P	C
External Marks	:60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Acquire a thorough knowledge on biological neurons and artificial neurons, comparative analysis between human and computer, artificial neural network models, characteristics of ANN's.
b. Learn different types of activation functions, learning strategies, learning rules, perceptron models, single and multi-layer feed-forward and feed-back Neural Networks.
c. Learn various algorithms including back propagation algorithm, Kolmogorov Theorem.
d. Learn different types of associative memories and basics of Fuzzy Logic.
e. Apply concept of classical and Fuzzy Sets, Fuzzy Logic System components fuzzification and defuzzification.
f. Apply the neural network conceptual knowledge to real-world electrical problems and applications.

CONTENTS

1. INTRODUCTION & ESSENTIALS TO NEURAL NETWORKS

Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate and Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, Historical Developments, Potential Applications of ANN. Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application.

2. SINGLE & MULTI-LAYER FEED FORWARD NEURAL NETWORKS Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence Theorem, Limitations of the Perceptron Model, Applications, Credit Assignment Problem, Generalized Delta Rule and Derivation of Back-Propagation (BP) Training, Summary of Back-Propagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements.

3. ASSOCIATIVE MEMORIES-I

Paradigms of Associative Memory, Pattern Mathematics, Hebbian Learning, General Concepts of Associative Memory ,Associative Matrix, Association Rules, Hamming Distance, The Linear Associator, Matrix Memories, Content Addressable Memory.

4. ASSOCIATIVE MEMORIES-II

Bidirectional Associative Memory (BAM) Architecture, BAM Training Algorithms, Storage And Recall Algorithm, BAM Energy Function, Proof of BAM Stability Theorem, Architecture of Hopfield, Network: Discrete and Continuous Versions, Storage and Recall Algorithm, Stability Analysis, Capacity of the Hopfield Network Summary and Discussion of Instance/Memory Based Learning Algorithms, Applications.

5. FUZZY LOGIC

Classical and Fuzzy Sets, Introduction to Classical Sets – Properties, Operations And Relations, Fuzzy Sets, Membership, Uncertainty, Operations, Properties, Fuzzy Relations, Cardinalities, Membership Functions, Fuzzy Logic System Components: Fuzzification, Membership Value Assignment, Development of Rule Base and Decision Making System, De-Fuzzification to Crisp Sets, De-Fuzzification Methods.

BOOKS RECOMMENDED

1. Rajasekharan and Pal, *Neural Networks, Fuzzy logic*, *Genetic algorithms: synthesis and applications*, Prentice Hall India.
2. Naga Bhaskar C., Vijay Kumar G., *Neural Networks and Fuzzy Logics,* B S Publication.
3. Philip D. Wasserman*, Neural Computing & Practice,* scholarly articles.
4. Yegnanarayana B., *Artificial Neural Networks*, Prentice Hall India.
5. Zaruda, *Artificial Neural Networks*, Prentice Hall India.
6. Kosko B., *Neural Networks and Fuzzy Logic System,* Prentice Hall India.
7. Amirthavalli M., *Fuzzy Logic and Neural Networks*, Scitech Publications India Pvt. Ltd.
8. Freeman J.A., Skapura D.*, Neural Networks*, Pearson Education.
9. Kumar S., *Neural Networks*, CIVIC, 2004.
10. Simon Hakins, *Neural Networks*, Pearson Education.
11. Eliasmith C. and Anderson C,H., *Neural Engineering*, Prentice Hall India.
12. Web sources: IEEE explore, IET.

DEEE-14810 ENERGY EFFICIENT MACHINES

Internal Marks	: 40	L	T	P	C
External Marks	: 60	3	1	0	4
Total Marks	:100				

COURSE OUTCOMES

After studying this course, the students will

a. Understand importance of energy management and audit.
b. Apply energy conservation measures in industrial and agriculture sector.
c. Understand the concept of maximum demand control.
d. Understand concept of harmonics and performance assessment of capacitors.
e. Evaluate motor efficiency and selection of drive for industrial use.
f. Analyze the payback period of energy efficient motors.

CONTENTS

1. ENERGY MANAGEMENT AND AUDIT

Introduction to Energy Management, Energy Audit and its Need, Types of Energy Audit, Energy Conservation: Industrial and Agricultural Sector, Bench Marking, Energy Audit Instruments.

2. ENERGY EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS

Electricity Billing, Electrical Load Management and Maximum Demand Control, Methods of Power Factor Improvement and its Benefits, Selection and Location of Capacitors, Performance Assessment of Power Factor Correction Capacitors, Power Factor with Non-Linear Loads, Harmonics and the Power Factor.

3. ENERGY EFFICIENT MOTORS AND DRIVES

Difference Between Standard Motors and Energy Efficient Motors, NEMA Design A, B, C, D, Wound Rotor, Multispeed Motors, Motor Efficiency Determination Methods: Direct Measurement Method, Loss Segregation Method, Motor Efficiency Labeling, Factors for Selection of Energy Efficient Motors, Over-Motoring, Eddy Current Adjustable Speed Drives, AC Variable Frequency Drives, Wound Rotor Motor Drives with Slip Loss Recovery (Static Kramer Drives).

4. ECONOMICS OF ENERGY EFFICIENT MOTORS AND SYSTEMS

Motor Life Cycle Cost, Direct Saving and Payback Analysis, Present Worth Method with Constant Power Costs, Present Worth Method with Increasing Power Costs, Net Present Worth Method.

BOOKS RECOMMENDED:

1. Andreas John C., *Energy Efficient Electric Motors*, Marcel Dekker Inc. 1992.
2. Albert T., *Introduction to Efficient Electric System Design*, The Fairmount Press Prentice Hall.
3. Tripathi S.C., *Electric Energy Utilization and Conservation*, Tata McGraw Hill 1991.
4. Charles B., *Handbook of Modem Electronics and Electrical Engineering*, John Wiley & Sons.
5. NEMA https*://www.nema.org*.
6. BEE web-link https://www.beeindia.gov.in.