Fundamental of Electrical Engineering

Course Code: EEL 1006 **L-T-P: 3 - 0 - 2**

Course Outcomes:

1. To solve the electrical circuits (DC & AC).
2. Solve and analyze the electrical circuits using network theorems and understand the behavior of AC electrical circuits and resonance.
3. To understand the three phase electrical systems and apply the concepts of measurements in measuring electrical quantities.
4. Solve and analyze the behavior of magnetic circuits and understand the concept of transformers and their applications.
5. To study the working principles of basic electrical machines including DC as well as AC machines.

Unit I

Introduction and Electrical Circuit Analysis: Concepts of network, Active and passive elements, Voltage and current sources, Concept of linearity and linear network, Unilateral and bilateral elements, Source transformation, Kirchhoff's laws, Loop and nodal methods of analysis, Star-delta transformation,

AC fundamentals: Sinusoidal, square and triangular waveforms – Average and effective values, Form and peak factors, Concept of phasors, Phasor representation of sinusoidally varying voltage and current

Unit II

Steady- State Analysis of Single Phase AC Circuits: Analysis of series and parallel RLC Circuits, Concept of Resonance in series & parallel circuits, bandwidth and quality factor; Apparent, active & reactive powers, Power factor, Concept of power factor improvement and its improvement (Simple numerical problems)

Network theorems: Superposition theorem, Thevenin's theorem, Norton's theorem, Maximum Power Transfer theorem (Simple numerical problems).

Unit III

Three Phase AC Circuits: Three phase system-its necessity and advantages, Star and delta connections, Balanced supply and balanced load, Line and phase voltage/current relations, Three-phase power and its measurement (simple numerical problems).

Measuring Instruments: Types of instruments, Construction and working principles of PMMC and moving iron type voltmeters & ammeters, Single phase dynamometer wattmeter, Use of shunts and multipliers (Simple numerical problems on shunts and multipliers).

Unit IV

Magnetic Circuit: Magnetic circuit concepts, analogy between electric & magnetic circuits, B-H curve, Hysteresis and eddy current losses, Magnetic circuit calculations (Series & Parallel).

Single Phase Transformer: Principle of operation, Construction, EMF equation, Equivalent circuit, Power losses, Efficiency (Simple numerical problems), Introduction to auto transformer.

Unit V

DC Machines: Principle & Construction, Types, EMF equation of generator and torque equation of motor, applications of DC motors (simple numerical problems)

Three Phase Induction Motor: Principle & Construction, Types, Slip-torque characteristics, Applications (Numerical problems related to slip only)

Single Phase Induction motor: Principle of operation and introduction to methods of starting, applications.

Three Phase Synchronous Machines: Principle of operation of alternator and synchronous motor and their applications.

Text/ Reference Books:

1. D.P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
2. L.S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
3. E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
4. V.D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.
5. B Dwivedi and A Tripathi, "Fundamentals of Electrical Engineering", Wiley India.
6. Kuldeep Sahay, "Basic Electrical Engineering", New Age International Publishers.
7. J. B. Gupta, "Electrical Engineering", Kataria and Sons.
8. C L Wadhwa, "Basic Electrical Engineering", New Age International.
9. W.H. Hayt and J.E. Kimerly, "Engineering Circuit Analysis", Mc Graw Hill.

Electrical Circuit Analysis

Course Code: EEL 1007 **L-T-P: 3 - 0 - 0**

Course Outcomes:

1. Understand the graph theory and its application in Electrical Network
2. Obtain the transient and steady-state response of electrical circuits.
3. Analyse two port circuit behavior.
4. Familiarization with network synthesis and stability of system.
5. Understand the basics and analysis for filters.

Unit I

Network Graph Theory: Concept of network graph terminology used in network graph, Relationship between twigs and links, planar and non planar graph, Tree, Property of a tree in a graph, Co-tree, Link, Basic loop and basic cut-set, Formation of incidence matrix, Cut-set matrix, Tie set matrix, Duality, Network Theorems: Reciprocity theorem, Millman's theorem, Compensation theorem, Tellegen's Theorem.

Unit II

Laplace Transformation: Definition, Inverse LT, Properties of LT, Solution of linear differential equations, Transformed circuit components representation, Independent source, Resistance, inductance and capacitance parameters, Transfer functions.

Transient Circuit Analysis: Initial conditions, Natural response and forced response, Transient response and steady state response for arbitrary inputs, Transient response of RL, RC and RLC networks.

Unit III

Two Port Networks: Transform impedances network functions of one port and two port networks, Concept of poles and zeros, Characterization of LTI two port networks; Z, Y, ABCD, g and h parameters, Reciprocity and symmetry, Inter-connections of two port networks, Analysis of ladder networks.

Unit IV

Network Synthesis- Causality and stability, Hurwitz polynomial, Positive real function, Frequency response of reactive one ports, Synthesis of LC, RC and RL driving point immittance functions using Foster's and Cauer's methods.

Unit V

Filters- Passive and active filter fundamentals, Determination of pass and attenuation bands constant, Low pass filters, High pass filters, constant K-type filters, Band pass filters, Band stop filters, M-derived filters, lattice filters.

Text/ Reference Books:

1. M. E. Van Valkenburg, "Network Analysis", Prentice Hall.
2. C. K. Alexander and M. N. O. Sadiku, "Fundamentals of Electric Circuits", McGraw Hill Education.
3. A. Chakrabarti, "Circuit Theory", Dhanpat Rai & Co.
4. D. Roy Choudhary, "Networks and Systems", Wiley Eastern Ltd.
5. W. H. Hayt and J. E. Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education.

ELECTRICAL MACHINES-I

Course Code: EEL 2321 **L-T-P: 3 - 0 - 2**

Course Outcomes:

6. Understand the concepts of magnetic circuits.
7. Understand how a transformer is manufactured and how does it work.
8. Analyse three phase transformer and phase conversion.
9. Understand the construction and principle of operation of DC machines.
10. Analyse the differences in operation of different dc machine configurations.

Unit I

Basics of Magnetic Circuits: Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; linear and nonlinear magnetic circuits, B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; Statically and Dynamically induced EMF, Torque, Hysteresis, Core losses, Faraday's law of EMI Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

Unit II

Transformer Basics: Principle construction and operation of single phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency, **Transformer Tests:** Open & Short circuit tests, Polarity test, Sumpners test, Separation of hysteresis and eddy current losses, **Parallel operation:** Parallel operation of single phase transformer, **Auto Transformers:** Construction, Principle, Applications, Comparison with two winding transformers.

Unit III

Three Phase Transformers: Construction, various types of connection and their comparative features**, Parallel operation:** Parallel operation of three phase transformers, **Performance of Transformers:** Excitation phenomenon in transformers, Three phase to six phase conversion, No load and on load tap changing of transformers, Three winding transformers, Cooling methods of transformers.

Unit IV

Basic Concepts of the Rotating Electrical Machines: Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, commutator, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil, Armature winding and commutation, lap and wave windings, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

Unit V

D.C. Generators & Motors: EMF equation, Working principle, Construction, Methods of excitation, voltage build-up in a shunt generator, critical field resistance and critical speed, Armature reaction, Effect of brush shift, Compensating winding, Characteristics of various types of generators, Applications D.C. Motors: Torque equation, Characteristics of various types of motors, Applications, Direct testing,

Regenerative Testing, 4-point starter, 3-point starter, Speed control of series motors, Speed control of shunt motors.

Text/ Reference Books:

6. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
7. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.
8. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
9. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
10. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

Electrical Measurement and Instrumentation

Course Code: EEL 2311 **L-T-P: 3 - 0 - 2**

Course Outcomes:

1. To introduce the basic principles of all measuring instruments.
2. Measurement of R, L and C using different measuring instruments and understand their operation and characteristics.
3. Identify and effective use of potentiometer and instrument transformers.
4. Understand the different types of electrical and electronics measuring instruments.
5. Understand the basic concepts of smart and digital metering and measurement of other entities.

Unit I

Measurement system, Characteristics of instruments, Methods of measurement, Errors in measurement & measurement standards, Review of indicating and integrating instruments: Voltmeter, Ammeter (PMMC, moving iron and attracted disc type), Extension of range using shunt and series resistance.

Unit II

Measurement of Resistance, Inductance and Capacitance: Measurement of low, Medium and high resistances, Insulation resistance measurement (Wheat-stone's, Kelvin's, Carey Foster's bridge), AC bridges for inductance (Maxwell's, Hey's, Anderson's, Owen's Bridge) and capacitance measurement (Desaunty's, Wien's, Schering Bridge).

Unit III

Potentiometers and Instrument Transformers: Principle and operation of D.C. Crompton's potentiometer, Current and Potential transformer, Design considerations and testing.

Unit IV

Electrical and Electronics Measurements: Multi-meter, Wattmeter & energy meter, Three-phase Wattmeter, Time, Frequency and phase angle measurements using CRO, Electronic voltmeter, Digital counters, Frequency meter, Digital counters, Frequency meter, Spectrum and wave analyzer, Storage oscilloscope.

Unit V

Instrumentation: Definition, classification and selection of transducers, Strain gauges, Thermistors, Thermocouples, LVDT, Inductive & capacitive transducers, Piezoelectric and Hall-effect transducers, Measurement of motion, force, pressure, temperature, flow and liquid level.

Smart Metering: Basic concepts of smart sensors and application, Data acquisition systems, True RMS meter, Clamp meter, Digital multi-meter.

Text/ Reference Books:

11. A K Sawhney, "Electrical & Electronic Measurement & Instrument", Dhanpat Rai & Sons, India
12. BC Nakra & K. Chaudhary, "Instrumentation, Measurement and Analysis," Tata McGraw Hill 2nd Edition
13. Purkait, "Electrical & Electronics Measurement & Instrumentation", TMH
14. Forest K. Harris, "Electrical Measurement", Willey Eastern Pvt. Ltd. India
15. M. Stout , "Basic Electrical Measurement", Prentice Hall of India
16. WD Cooper, "Electronic Instrument & Measurement Technique", Prentice Hall International
17. EW Golding and F.C. Widdis, "Electrical Measurement &Measuring Instrument", AW Wheeler & Co. Pvt. Ltd. India

Electrical Measurement and Instrumentation Lab

Course Code: EEL 2311 **L-T-P: 0 - 0 - 2**

Note: Minimum ten experiments are to be performed from the following list:

1. Measurement of low resistance using Kevin's Double bridge.
2. Measurement of self-inductance by Maxwell's Bridge.
3. Measurement of self-inductance by Hay's Bridge.
4. Measurement of capacitance by Schering Bridge.
5. Measurement of frequency by Wein's Bridge.
6. Measurement of temperature using Resistance Temperature Detector (RTD).
7. Study and plot of LDR characteristics.
8. Extend the range of an Ammeter/Voltmeter.
9. Measurement of power using CT & PT.
10. Measurement of power in a three phase system by two wattmeter method and determination of its power factor.
11. Measurement of power and power factor of single phase using three ammeters and three voltmeter method.
12. Measurement of temperature using thermocouple.
13. Displacement measurement using LVDT.
14. Measurement of phase difference and frequency of AC signal using CRO.
15. Study the working principle of single phase energy meter.

ELECTRICAL WORKSHOP

Course Code: EEP 231 **L-T-P: 0 - 0 - 2**

1. Introduction of Electrical Safety precautions, Electrical Symbols, abbreviations commonly used in Electrical Engg. and familiarization with tools used in Electrical Works.
2. Name of Appliance use in daily life and their power rating.
3. Making of a circuit in which bulb is getting ON/OFF by two way switch.
4. Making of circuit in which intensity of bulb gets controlled by the use of Fan Regulator.
5. Making the extension board with the help of
    i. One switch and two socket
    ii. Two socket and their individual switch

6. Making switch board that directs electricity from one or more sources of supply to several smaller region.
7. To fabricate half wave rectifiers with filters on PCB.
8. To fabricate full wave rectifiers with filters on PCB.
9. To study wire up a circuit used for Godown wiring
    i. By using two switches
    ii. By using three switches

10. Working, Maintenance and Repair of Electrical equipment i,e Electric Iron , Electric Toaster ,Water heater, Air coolers and Electric Fans etc.
11. To study and demonstrate Vp(peak voltage),Vpp(peak to peak voltage), Time, frequency and phase using CRO.
12. To study different types of earthing and protection devices e.g. MCBs, ELCBs and fuses.
13. To make the connection of fan regulator with lamp to study the effect of increasing and decreasing resistance in steps on the lamp.

Analog Electronic

Course Code: EEL 2412 **L-T-P: 3 - 0 - 2**

Course Outcomes:

6. To learn the basic concept and the characteristics of transistors.
7. Understand the design of OP-AMP and OP-AMP based circuits.
8. A thorough understanding, functioning of OP-AMP.
9. Design sinusoidal and non-sinusoidal oscillators.
10. Know the principle of converter and PLL.

Unit I

Overview of BJT: Structure and I-V characteristics of a BJT; BJT as a switch, Small signal equivalent circuits, high-frequency equivalent circuits.

MOSFET: MOSFET structure and I-V characteristics. MOSFET as a switch. MOSFET as an amplifier: small-signal model and biasing circuits small signal equivalent circuits - gain, input and output impedances, trans-conductance, high frequency equivalent circuit.

Unit II

Operational Amplifiers: Direct coupled and RC Coupled multi-stage amplifier; Differential amplifier; Internal structure of an operational amplifier, Ideal op-amp, non-idealities in an op-amp (offset voltage and current, input bias current, slew rate, gain bandwidth product), Frequency response of an operational amplifier, Power amplifier: Class A, B and C.

Unit III

Linear and Nonlinear applications of op-amp: Inverting and non-inverting amplifier, Instrumentation amplifier, Integrator, Differentiator, Active filter, Voltage regulator.

Hysteretic Comparator, Zero Crossing Detector, Square-wave and triangular-wave generators, Precision rectifier, peak detector, Monoshot.

Unit IV

Feedback Amplifiers: Different feedback amplifiers, Effect of Feedback on Amplifier characteristics, Feedback configuration: Voltage series and shunt, Current series and shunt feedback configurations.

Oscillators: Condition for Oscillations, RC type Oscillators, LC type Oscillators, Generalized analysis of LC Oscillators, Hartley, Colpitts, Wein Bridge and Crystal oscillator.

Unit V

Converter: Voltage to frequency and frequency to voltage converter, D-A and A-D Converter, Clipper and clamper, ADC/DAC specification.

Phase locked loop: Principle**,** Phase detector/comparator, Voltage controlled oscillator, Application of PLL.

Text/ Reference Books:

18. A. S. Sedra and K. C. Smith, *"Microelectronic Circuits,"* New York, Oxford University Press, 1998.
19. J. V. Wait, L. P. Huelsman and G. A. Korn, *"Introduction to Operational Amplifier theory and applications,"* McGraw Hill U. S., 1992.
20. Ramakant A. Gayakwad, *"OP-AMP and Linear IC's,"* Prentice Hall
21. D. Roy Choudhury, *"Linear Integrated Circuits,"* New Age International Pvt Ltd.
22. P.R. Gray, R.G. Meyer and S. Lewis, *"Analysis and Design of Analog Integrated Circuits,"* John Wiley & Sons.

ELECTRICAL MACHINES-II

Course Code: EEL 2422 **L-T-P: 3 - 0 - 2**

Course Outcomes:

1. Understand the concepts of rotating magnetic fields.
2. Understand the operation of induction machines
3. Analyse different types of single phase induction motor.
4. Understand the construction and operation of Synchronous machines.
5. Analyse the special types of electric motors.

Unit I

Fundamentals of AC machines windings: Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single- turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding,

Pulsating and revolving magnetic fields: Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current, Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field.

Unit II

Three Phase Induction Machines: Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque. Equivalent circuit. Phasor Diagram, Losses and Efficiency. Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency). Methods of starting, braking and speed control for induction motors. Cogging and crawling of induction motor**,** Generator operation: Self-excitation. Doubly-Fed Induction Machines.

Unit III

Single-phase induction motors: Constructional features, double revolving field theory, equivalent circuit, determination of parameters, Split-phase starting methods and applications.

Unit IV:

Synchronous machines

Synchronous Generator: Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance method, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, power angle characteristics. Parallel operation of alternators - synchronization and load division.

Synchronous Motor: Principle of operation, effect of load on a synchronous motor, equivalent circuit and phasor diagram, power developed in synchronous motor, synchronous motor with different excitation, different torques in synchronous motor, effect of varying excitation on armature current and power factor, V-curves, Hunting, Starting methods of synchronous motor.

Unit V

Special Electric Motors: Stepper motor, Reluctance motor, hysteresis motor, Schrage motor, AC series motor, Universal Motor, etc.

Text/ Reference Books:

1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.
3. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
4. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
5. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.

Electric Materials

Course Code: EEL 2413 **L-T-P: 3 - 0 - 0**

Course Outcomes:

11. To introduce the basic principles atoms, energies and dielectric materials.
12. Understand the magnetic properties of materials.
13. Understand the mechanism of conduction in semiconductor.
14. Recognize the various material used in electrical application.
15. Identify and effective special purpose material in electrical industry and testing of transformer oil.

Unit I

Atomic Structure and Interatomic Bonding: Electrons in Atoms, Bonding Forces and Energies, Bonding Type of bonds.

Dielectric Materials: Dielectric properties in static field, Permittivity, Dipole moment, Polarization and dielectric constant, Electric conductivity in solid, liquid and gaseous dielectrics, Piezoelectric materials, Ferroelectric material, Pyroelectric materials, Anti-ferromagnetic materials.

Dielectric in alternating field, Leakage currents, Dielectric loss, Dielectric strength, Breakdown voltage.

Unit II

Magnetic Properties of Materials: Magnetic field, Lenz's law and induced dipole moments, Classification of magnetic materials, Special purpose materials, Feebly magnetic materials, Hysteresis loops for different ferromagnetic materials, Factor effecting hysteresis, Soft and hard magnetic materials, Ferrites, Permanent magnets

Unit III

Semiconductor Materials: Classification of material as semiconductor, Intrinsic and extrinsic semiconductors, Working application of semiconductors, Photovoltaic cell, Varistors, LCD, LDR, Advantages of semiconductor materials used in electrical industries.

Unit IV

Materials for Electrical Applications: Materials used for resistors, rheostats, heaters, Conductor materials used for overhead transmission line, underground cables, electrical machine winding, Electrical, Mechanical, Thermal and Visual properties of insulating material, Effect of moisture on insulation.

Unit V

Special Purpose Materials and Processes: Thermocouple material, Soldering materials, Fuse and contact material, Structural Materials, Refractory Materials, Radioactive Materials, Galvanization and Impregnation processes, Processing of electronic materials, Properties and applications of mineral oils, Testing of transformer oil.

Text/ Reference Books:

23. T. K. Basak, *"A course in Electrical Engineering Materials,"* New Age Science Publications.
24. A. J. Dekker, *"Electrical Engineering Materials,"* Prentice-hall, Inc.
25. C. S. Indulkar and S. Thiruvengadam, *"Electrical Engineering Material,"* S. Chand & Company Ltd.
26. N. Alagappan and N. Kumar, *"Electrical Engineering Materials,"* TTTI Madras, McGraw Hill Education.

Signal and Systems

Course Code: EEL 2414 **L-T-P: 3 - 1 - 0**

Course Outcomes:

11. Understand the concepts of continuous time and discrete time systems.
12. Analyse systems in complex frequency domain.
13. Understand sampling theorem and its implications.

Unit I

Introduction to Signals and Systems: Signals and systems as seen in everyday life, and in various branches of engineering and science. Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability, Examples.

Unit II

Behavior of continuous and discrete-time LTI systems: Impulse response and step response, convolution, input-output behavior with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space Representation of systems. State-Space Analysis, Multi-input, multi-output representation. State Transition Matrix and its Role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.

Unit III

Fourier Series and Transform: Fourier series representation of periodic signals, Waveform Symmetries, Calculation of FourierCoefficients. Fourier Transform, convolution/multiplication and their effect in the frequency domain,magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform(DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem.

Unit IV

Laplace and z- Transforms: Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior. The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis.

Unit V

Sampling and Reconstruction: The Sampling Theorem and its implications. Spectra of sampled signals. Reconstruction: ideal interpolator, zero-order hold, first-order hold. Aliasing and its effects. Relation between continuous and discrete time systems. Introduction to the applications of signal and system theory: modulation for communication, filtering, feedback control systems.

Text/ Reference Books:

27. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, “Signals and systems”, Prentice Hall India, 1997.
28. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing: Principles, Algorithms, and

Applications", Pearson, 2006.
29. H. P. Hsu, "Signals and systems", Schaum's series, McGraw Hill Education, 2010.
30. S. Haykin and B. V. Veen, "Signals and Systems", John Wiley and Sons, 2007.
31. A. V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing", Prentice Hall, 2009.
32. M. J. Robert "Fundamentals of Signals and Systems", McGraw Hill Education, 2007.
33. B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2009.

Control System in Electrical Application

Course Code: EEL 3511 **L-T-P: 3 - 0 - 0**

Course Outcomes:

6. Understand the modelling of linear-time-invariant systems using transfer function and state space representations.
7. Understand the concept of stability and its assessment for linear-time invariant systems.
8. Design simple feedback controllers...

Unit I

Introduction to control problem: Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Block diagram algebra.

Unit II:

Time Response Analysis: Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Unit III

Frequency-response analysis: Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. Closed-loop frequency response.

Unit IV

Introduction to Controller Design: Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs. Analog and Digital implementation of controllers.

Unit V

State variable Analysis : Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability. Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

Introduction to Optimal Control and Nonlinear Control: Performance Indices. Regulator problem, Tracking Problem. Nonlinear system–Basic concepts and analysis.

Text/References:

1. M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education, 1997.
2. B. C. Kuo, "Automatic Control System", Prentice Hall, 1995.
3. K. Ogata, "Modern Control Engineering", Prentice Hall, 1991.
4. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009.

POWER ELECTRONICS

Course Code: EEL 3541 **L-T-P: 3 - 0 - 0**

Course Outcomes:

14. Understand the differences between signal level and power level devices.
15. Analyse controlled rectifier circuits.
16. Analyse the operation of DC-DC choppers.
17. Analyse the operation of voltage source inverters.
18. Analyse the working and operation of cycloconverter.

Unit I

Power switching devices: Diode, Thyristor, MOSFET, IGBT: I-V Characteristics, Firing circuit for thyristor, Gate drive circuits for MOSFET and IGBT, Working and Characteristics of GTO, Working and Characteristics of DIAC, Working and Characteristics of TRIAC.

Unit II

AC-DC Converters (Thyristor rectifiers): Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load, Operation and analysis of Single phase uncontrolled and controlled rectifiers with RLE load, Three-phase full-bridge uncontrolled and controlled rectifiers with R-load and highly inductive load; Estimation of RMS load voltage, RMS load current and input power factor, power factor improvement methods for phase controlled rectifiers, effect of source inductance Input current wave shape.

Unit III

DC-DC converters: Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, Principle of step up and step down operation, Time ratio control for Chopper, Single quadrant DC chopper, Two quadrant and four quadrant DC choppers, analysis and waveforms at steady state.

Unit IV

DC-AC Converters (Inverter): Power circuit of single-phase voltage source inverter, Single phase half-bridge inverter, Single phase full-bridge inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, bipolar sinusoidal modulation and unipolar sinusoidal modulation, modulation index and output voltage, Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages.

Unit V

AC-AC Converters : AC Voltage regulator, Single phase half wave AC voltage controller with R load, Single phase full wave AC voltage controller with R load, Single phase full wave AC voltage controller with R-L load, Single phase to single phase (circuit step-up and step-down) cycloconverter, Three-phase to single-phase (halfwave) Cycloconverter, Three-phase to three-phase (half-wave) Cycloconverter.

Text/References:

1. M. H. Rashid, “Power electronics: circuits, devices, and applications”, Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland, “Power Electronics: Converters, Applications and Design”, John Wiley & Sons, 2007.
3. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007.
4. L. Umanand, “Power Electronics: Essentials and Applications”, Wiley India, 2009.

5. PS Bhimbra, “Power Electronics”, Khanna Publishers, 2019.

Power System-I (Power Transmission & Distribution)

Course Code: EEL 3531 **L-T-P: 3 - 1 - 2**

Course Outcomes:

16. Understand the concepts of power systems and various power system components.
17. Understand the electrical circuit parameters of transmission lines.
18. Understand Concept of corona and Insulators
19. Understand the mechanical design of transmission line and cables.
20. Understand concepts of distribution system.

Unit I

Evolution of Power Systems: Single line diagram of Power system, Brief description of power system Elements: Synchronous machine, transformer, transmission line, bus bar, circuit breaker and isolator.
Generation of Electric Power: Conventional and Renewable Energy Sources, Distributed Energy Resources, Energy Storage.
Supply System: Different kinds of supply system and their comparison, choice of transmission voltage.
Transmission Lines: Configurations, types of conductors, resistance of line, skin effect, Kelvin's law, Proximity effect.

Unit II

Over Head Transmission Lines: Calculation of parameters of single phase, three phase, single circuit and double circuit transmission lines, Representation and performance of short, medium and long transmission lines, Ferranti effect, Surge impedance loading.

Unit III

Corona and Interference: Phenomenon of corona, corona formation, calculation of potential gradient, corona loss, factors affecting corona, methods of reducing corona and interference
Electrostatic and electromagnetic interference with communication lines.
Overhead line Insulators: Type of insulators and their applications, potential distribution over a string of insulators, methods of equalizing the potential, string efficiency.

Unit IV

Mechanical Design of transmission line: Catenary curve, calculation of sag & tension, effects of wind and ice loading, sag template, vibration dampers.
Insulated cables: Type of cables and their construction, dielectric stress, grading of cables, insulation resistance, capacitance of single phase and three phase cables, dielectric loss, heating of cables.

Unit V

Distribution Systems:
Distribution system layout, Introduction of Distribution System, Primary & Secondary distribution, Design consideration, distribution system losses, Classification of Distributed system- Radial Ring interconnected systems, Stepped distribution.
Introduction to DC Transmission and Distribution.

Text/ Reference Books:

34. J. Grainger and W. D. Stevenson, "Power System Analysis", McGraw Hill Education, 1994
35. C.L. Wadhwa, "Electrical Power System", New age international Ltd. Third Edition

36. B. R. Gupta, “Power System Analysis and Design”, Third Edition, S. Chand & Co.
37. S. Sivanagaraju & S. Satyanarayana, “Electric Power Transmission and Distribution”, Pearson Education
38. W. D. Stevenson, “Element of Power System Analysis”, McGraw Hill.
39. T.A. Short, “Electric Power Distribution Handbook”, CRC

Power System-I Lab

Course Code: EEL 3531 **L-T-P: 0 - 0 - 2**

Note: Minimum ten experiments are to be performed from the following list:

16. Calculate the parameters of single phase transmission line.
17. Calculate the parameters of three phase single circuit transmission line.
18. Calculate the parameters of three phase double circuit transmission line.
19. Determine the ABCD constant for transmission line.
20. Simulate the Ferranti effect in transmission line.
21. Calculate the corona loss of transmission line.
22. Calculation of sag & tension of transmission line.
23. Calculation of string efficiency of insulator of transmission line.
24. Calculation for grading of underground cables.
25. Simulate the skin effect in the transmission line.
26. Calculation of ground clearance of transmission line.
27. Calculate the parameters for underground cable.

Electric System Design

Course Code: EEL 3612 **L-T-P: 3 - 0 - 0**

Course Outcomes:

9. Understand the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.
10. Understand various components of industrial electrical systems.
11. Analyze and selectthe proper size of various electrical system components.

Unit I

Electrical System Components: LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices

Unit II

Residential and Commercial Electrical Systems: Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

Unit III

Industrial Electrical Systems I: HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

Unit IV

Industrial Electrical Systems II: DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.

Unit V

Industrial Electrical System Automation: Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.

Text/ Reference Books:

10. S.L. Uppal and G.C. Garg, “Electrical Wiring, Estimating & Costing”, Khanna publishers, 2008.
11. K. B. Raina, “Electrical Design, Estimating & Costing”, New age International, 2007.
12. S. Singh and R. D. Singh, “Electrical estimating and costing”, Dhanpat Rai and Co., 1997.
13. Web site for IS Standards.
14. H. Joshi, “Residential Commercial and Industrial Systems”, McGraw Hill Education, 2008.

Power Plant Engineering

Course Code: EEL 3613 **L-T-P: 3 - 0 - 0**

Course Outcomes:

12. Understand the principles of operation for different power plants and their economics.

Unit I

Coal based thermal power plants, basic Rankine cycle and its modifications, layout of modern coal power plant, super critical boilers, FBC boilers, turbines, condensers, steam and heating rates subsystems of thermal power plants, fuel and ash handling, draught system, feed water treatment, binary cycles and cogeneration systems.

Unit II

Gas turbine and combined cycle power plants, Brayton cycle analysis and optimization, components of gas turbine power plants, combined cycle power plants, Integrated Gasifier based Combined Cycle (IGCC) systems.

Unit III

Basics of nuclear energy conversion, Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.

Unit IV

Hydroelectric power plants, classification, typical layout and components, principles of wind, tidal, solar PV and solar thermal, geothermal, biogas and fuel cell power systems.

Unit V

Energy, economic and environmental issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies including waste disposal options for coal and nuclear plants.

Text/ Reference Books:

15. Nag P.K., Power Plant Engineering, 3rd ed., Tata McGraw Hill, 2008.
16. El Wakil M.M., Power Plant Technology, Tata McGraw Hill, 2010.
17. Elliot T.C., Chen K and Swanekamp R.C., Power Plant Engineering, 2nd ed., McGraw Hill, 1998.

Power System-II (Power System Analysis)

Course Code: EEL 3632 **L-T-P: 3 - 1 - 2**

Course Outcomes:

21. Use numerical methods to analyses a power system in steady state
22. Evaluate fault currents for different types of faults.
23. Understand methods to control the voltage, frequency and power flow.
24. Understand the stability of synchronous grid.
25. Understand the monitoring and control of a power system.

Unit I

Representation of Power System Components: Synchronous machines, Transformers, Transmission lines, One-line diagram, Impedance and reactance diagram, Per unit system.

Symmetrical Components: Symmetrical Components of unbalanced phasors, Power in terms of symmetrical components, Sequence impedances and sequence networks (positive, negative and zero sequences).

Unit II

Symmetrical Fault Analysis: Transient if R-L series circuit, Calculation of 3-phase short circuit current and reactance of Synchronous machine, Internal voltage of loaded machines under transient conditions.

Unsymmetrical Faults: Analysis of single line to ground fault, Line-to-line fault and Double Line to ground fault on a generators and power system network.

Formation of Zbus using singular transformation and algorithm, Computer method for short circuit calculations.

Unit III

Load Flows: Introduction, Bus classifications, Bus admittance matrix (Y_{BUS}), Load flow equations, Load flow solution using Gauss Siedel, Newton-Raphson method, Approximation to N-R method, Fast decoupled method.

Unit IV

Power System Stability: Stability and Stability limit, Steady state stability study, Swing equation, Transient stability studies by equal area criterion and step-by-step method, Factors affecting steady state and transient stability, Stability improvement methods, Continuation power flow analysis.

Unit V

Control of Frequency and Voltage: Turbines and Speed-Governors, Frequency dependence of loads, Droop Control and Power Sharing, Automatic Generation Control, Generation and absorption of reactive power by various components of a Power System.

Monitoring and Control: Overview of Energy Control Centre Functions: SCADA systems, Phasor Measurement Units and Wide-Area Measurement Systems, State-estimation, Contingency Analysis.

Text/ Reference Books:

40. J. Grainger and W. D. Stevenson, “Power System Analysis”, McGraw Hill Education.
41. T. K. Nagsarkar & M. S. Sukhija, “Power System Analysis,” Oxford University Press.
42. Hadi Sadat, “Power System Analysis,” Tata McGraw Hill.
43. A. J. Wood and B.F. Wollenberg, “Power Generation, Operation and Control,” John Wiley & Sons.

44. O. I. Elgerd, “Electric Energy Systems Theory,” McGraw Hill Education.
45. D. P. Kothari and I. J. Nagrath, “Modern Power System Analysis,” McGraw Hill Education.

Power System-II Lab

Course Code: EEL 3632 **L-T-P: 0 - 0 - 2**

Note: Minimum ten experiments are to be performed from the following list:

28. Symmetrical fault analysis.
29. Unsymmetrical fault analysis.
30. Formation of bus admittance matrix.
31. Gauss Seidel power flow analysis.
32. Newton-Raphson power flow analysis.
33. Fast decoupled load flow analysis.
34. Stability analysis of power system using continuation power flow.
35. Determination of power angle curve.
36. Program for swing curve when the fault is cleared.
37. Swing curve for sustained fault and critical clearing angle & time.
38. Study of Automatic Generation Control using Simulink model.

Power Quality and FACTS

Course Code: EEL 4711 **L-T-P: 3 - 0 - 0**

Course Outcomes:

13. Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.
14. Understand the working principles of FACTS devices and their operating characteristics.
15. Understand the basic concepts of power quality.
16. Understand the working principles of devices to improve power quality.

Unit I

Transmission Lines and Series/Shunt Reactive Power Compensation: Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation.

Unit II

Thyristor-based Flexible AC Transmission Controllers: Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.

Unit III

Voltage Source Converter based (FACTS) controllers: Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation.

STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.

Unit IV

Power Quality Problems in Distribution Systems: Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. DSTATCOM.

Unit V

Dynamic Voltage Restorer and Unified Power Quality Conditioner: Voltage Sag/Swell mitigation: Dynamic Voltage Restorer – Working Principle and Control Strategies. Series Active Filtering. Unified Power Quality Conditioner (UPQC): Working Principle. Capabilities and Control Strategies.

Text/ Reference Books:

18. N. G. Hingorani and L. Gyugyi, “Understanding FACTS: Concepts and Technology of FACTS Systems”, Wiley-IEEE Press, 1999.
19. K. R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Ltd. 2007.
20. T. J. E. Miller, “Reactive Power Control in Electric Systems”, John Wiley and Sons, New York, 1983.

21. R. C. Dugan, “Electrical Power Systems Quality”, McGraw Hill Education, 2012.
22. G. T. Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1991.