

ELECTRICAL CIRCUIT ANALYSIS

EEC302

L-T-P=3-1-2

Module 1: Network Theorems (10 Hours)

Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem. Analysis with dependent current and voltage sources. Node and Mesh Analysis. Concept of duality and dual networks.

Module 2: Solution of First and Second order networks (8 Hours)

Solution of first and second order differential equations for Series and parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response.

Module 3: Sinusoidal steady state analysis (8 Hours)

Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer.

Module 4: Electrical Circuit Analysis Using Laplace Transforms (8 Hours)

Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots), series and parallel resonances

Module 5: Two Port Network and Network Functions (6 Hours)

Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

ELECTROMAGNETIC FIELDS

EEC303

L-T-P=3-1-0

Module 1: Review of Vector Calculus (6 hours)

Vector algebra-addition, subtraction, components of vectors, scalar and vector multiplications, triple products, three orthogonal coordinate systems (rectangular, cylindrical and spherical). Vector calculus-differentiation, partial differentiation, integration, vector operator del, gradient, divergence and curl; integral theorems of vectors. Conversion of a vector from one coordinate system to another.

Module 2: Static Electric Field (6 Hours)

Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, Potential difference,

Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density

Module 3: Conductors, Dielectrics and Capacitance (6 Hours)

Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two wire line, Poisson's equation, Laplace's equation, Solution of Laplace and Poisson's equation, Application of Laplace's and Poisson's equations.

Module 4: Static Magnetic Fields (6 Hours)

Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors.

Module 5: Magnetic Forces, Materials and Inductance (6 Hours)

Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.

Module 6: Time Varying Fields and Maxwell's Equations (6 Hours)

Faraday's law for Electromagnetic induction, Displacement current, Point form of Maxwell's equation, Integral form of Maxwell's equations, Motional Electromotive forces. Boundary Conditions.

Module 7: Electromagnetic Waves (6 Hours)

Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.

ELECTRIC MACHINE-I

EEC404

L-T-P=3-0-2

Magnetic fields and magnetic circuits (6 Hours)

Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot-Savart Law; 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.

Module 2: Electromagnetic force and torque (9 Hours)

B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency

Module 3: DC machines (8 Hours)

Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, 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 - Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

Module 4: DC machine - motoring and generation (7 Hours)

Armature circuit equation for motoring and generation, Types of field excitations – separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines

Module 5: Transformers (12 Hours)

Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Autotransformers - construction, principle, applications and comparison with two winding transformer, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.

POWER ELECTRONICS

EEEC405

L-T-P=3-0-2

Module 1: Power switching devices (8 Hours)

Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; Gate drive circuits for MOSFET and IGBT.

Module 2: Thyristor rectifiers (7 Hours)

Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R_{load} and highly inductive load; Three-phase full-bridge thyristor rectifier with R_{load} and highly inductive load; Input current wave shape and power factor.

Module 3: DC-DC buck converter (5 Hours)

Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage, power circuit of a buck converter, analysis and waveforms at steady state, duty ratio control of output voltage.

Module 4: DC-DC boost converter (5 Hours)

Power circuit of a boost converter, analysis and waveforms at steady state, relation between duty ratio and average output voltage.

Module 5: Single-phase voltage source inverter (10 Hours)

Power circuit of single-phase voltage source 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

Module 6: Three-phase voltage source inverter (8 Hours)

Power circuit of a three-phase voltage source inverter, switch states, instantaneous output voltages, average output voltages over a sub-cycle, three-phase sinusoidal modulation.

ELECTRICAL MACHINE-II

EEEC506

L-T-P=3-0-2

Module 1: Fundamentals of AC machine windings (8 Hours)

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, winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding- concentrated and distributed, Sinusoidally distributed winding, winding distribution factor

Module 2: Pulsating and revolving magnetic fields (4 Hours)

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.

Module 3: Induction Machines (12 Hours)

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. Generator operation. Self-excitation. Doubly-Fed Induction Machines.

Module 4: Single-phase induction motors (6 Hours)

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

Module 5: Synchronous machines (10 Hours)

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

POWER SYSTEM-I

EEEC507

L-T-P=3-0-2

Module 1: Basic Concepts (4 hours)

Evolution of Power Systems and Present-Day Scenario. Structure of a power system: Bulk Power Grids and Micro-grids. Generation: Conventional and Renewable Energy Sources. Distributed Energy Resources. Energy Storage. Transmission and Distribution Systems: Line diagrams, transmission and distribution voltage levels and topologies (meshed and radial systems). Synchronous Grids and Asynchronous (DC) interconnections. Review of Three-phase systems. Analysis of simple three-phase circuits. Power Transfer in AC circuits and Reactive Power.

Module 2: Power System Components (15 hours)

Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple configurations. Travelling-wave Equations. Sinusoidal Steady state representation of Lines: Short, medium and long lines. Power Transfer, Voltage profile and Reactive Power. Characteristics of transmission lines. Surge Impedance Loading. Series and Shunt Compensation of transmission lines. Transformers: Three-phase connections and Phase-shifts. Three-winding transformers, autotransformers, Neutral Grounding transformers. Tap-Changing in transformers. Transformer Parameters. Single phase equivalent of three-phase transformers. Synchronous Machines: Steady-state performance characteristics. Operation when connected to infinite bus. Real and Reactive Power Capability Curve of generators. Typical waveform under balanced terminal short circuit conditions – steady state, transient and sub-transient equivalent circuits. Loads: Types, Voltage and Frequency Dependence of Loads. Per-unit System and per-unit calculations.

Module 3: Over-voltages and Insulation Requirements (4 hours)

Generation of Over-voltages: Lightning and Switching Surges. Protection against Over-voltages, Insulation Coordination. Propagation of Surges. Voltages produced by traveling surges. Bewley Diagrams.

Module 4: Fault Analysis and Protection Systems (10 hours)

Method of Symmetrical Components (positive, negative and zero sequences). Balanced and Unbalanced Faults. Representation of generators, lines and transformers in sequence networks. Computation of Fault Currents. Neutral Grounding. Switchgear: Types of Circuit Breakers. Attributes of Protection schemes, Back-up Protection. Protection schemes (Over-current, directional, distance protection, differential protection) and their application.

Module 5: Introduction to DC Transmission & Renewable Energy Systems (9 hours)

DC Transmission Systems: Line-Commutated Converters (LCC) and Voltage Source Converters (VSC). LCC and VSC based dc link, Real Power Flow control in a dc link. Comparison of ac and dc transmission. Solar PV systems: I-V and P-V characteristics of PV panels, power electronic interface of PV to the grid. Wind Energy Systems: Power curve of wind turbine. Fixed and variable speed turbines. Permanent Magnetic Synchronous Generators and Induction Generators. Power Electronics interfaces of wind generators to the grid.

CONTROL SYSTEM

EEEC508

L-T-P=3-0-2

Module 1: Introduction to control problem (4 hours)

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

Module 2: Time Response Analysis (10 hours)

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.

Module 3: Frequency-response analysis (6 hours)

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.

Module 4: Introduction to Controller Design (10 hours)

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.

Module 5: State variable Analysis (6 hours)

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.

Module 6: Introduction to Optimal Control and Nonlinear Control (5 hours)

Performance Indices. Regulator problem, Tracking Problem. Nonlinear system–Basic concepts and analysis.

POWER SYSTEM-II

EEEC609

L-T-P=3-0-2

Module 1: Power Flow Analysis (7 hours)

Review of the structure of a Power System and its components. Analysis of Power Flows: Formation of Bus Admittance Matrix. Real and reactive power balance equations at a node. Load and Generator Specifications. Application of numerical methods for solution of non-linear algebraic equations – Gauss Seidel and Newton-Raphson methods for the solution of the power flow equations. Computational Issues in Large-scale Power Systems.

Module 2: Stability Constraints in synchronous grids (8 hours)

Swing Equations of a synchronous machine connected to an infinite bus. Power angle curve. Description of the phenomena of loss of synchronism in a single-machine infinite bus system following a disturbance like a three-phase fault. Analysis using numerical integration of swing equations (using methods like Forward Euler, Runge-Kutta 4th order methods), as well as the Equal Area Criterion. Impact of stability constraints on Power System Operation. Effect of generation rescheduling and series compensation of transmission lines on stability.

Module 3: Control of Frequency and Voltage (7 hours)

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. Excitation System Control in synchronous generators, Automatic Voltage Regulators. Shunt Compensators, Static VAR compensators and STATCOMs. Tap Changing Transformers. Power flow control using embedded dc links, phase shifters.

Module 4: Monitoring and Control (6 hours)

Overview of Energy Control Centre Functions: SCADA systems. Phasor Measurement Units and Wide-Area Measurement Systems. State-estimation. System Security Assessment. Normal, Alert, Emergency, Extremis states of a Power System. Contingency Analysis. Preventive Control and Emergency Control.

Module 5: Power System Economics and Management (7 hours)

Basic Pricing Principles: Generator Cost Curves, Utility Functions, Power Exchanges, Spot Pricing. Electricity Market Models (Vertically Integrated, Purchasing Agency, Whole-sale competition, Retail Competition), Demand Side-management, Transmission and Distributions charges, Ancillary Services. Regulatory framework.

MEASUREMENT & INSTRUMENTATION

EEEC610

L-T-P=2-0-2

Unit 1: Measurements:

Method of measurement, Measurement system, Classification of instruments, Definition of accuracy, Precision, Resolution, Speed of response, Error in measurement, Classification of errors, loading effect due to shunt and series connected instruments. Analog meters: General features, Construction, Principle of operation and torque equation of Moving coil, Moving iron, Electrodynamometer, Induction instruments Principle of operation of the Electrostatic, Thermoelectric, Rectifier type instruments, Extension of instrument ranges and multipliers.

Unit 2: Instrument transformer: Disadvantage of shunt and multipliers, Advantage of Instrument transformers, Principle of operation of Current & Potential transformer, errors. Measurement of Power:

Principle of operation of Electrodynamic & Induction type wattmeter. Wattmeter errors. Measurement of resistance: Measurement of medium, low and high resistances, Megger.

Unit 3: Measurement of Energy:

Construction, theory and application of AC energy meter, testing of energy meters. Potentiometer: Principle of operation and application of Crompton's DC potentiometer, Polar and Co- ordinate type AC potentiometer. Application. AC Bridges: Measurement of Inductance, Capacitance and frequency by AC bridges.

Unit 4: Cathode ray oscilloscope(CRO):

Measurement of voltage, current, frequency & phase by oscilloscope. Frequency limitation of CRO. Sampling and storage oscilloscope, Double beam CRO. Electronic Instruments: Advantages of digital meter over analog meters, Digital voltmeter, Resolution and sensitivity of digital meters, Digital multimeter, Digital frequency meter, Signal generator. Sensors & Transducers: Introduction to sensors & Transducers, Strain gauge, LVDT, Temperature transducers, Flow measurement using magnetic flow measurement.

HIGH VOLTAGE ENGINEERING

EED601

L-T-P=3-0-0

Module 1: Breakdown in Gases (8 Hours)

Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend's theory, Streamer mechanism, Corona discharge

Module 2: Breakdown in liquid and solid Insulating materials (7 Hours)

Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.

Module 3: Generation of High Voltages (7 Hours)

Generation of high voltages, generation of high D. C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.

Module 4: Measurements of High Voltages and Currents (7 Hours)

Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements.

Module 5: Lightning and Switching Over-voltages (7 Hours)

Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diverters, Surge modifiers.

Module 6: High Voltage Testing of Electrical Apparatus and High Voltage Laboratories (7 Hours)

Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V. Labs.

DIGITAL SIGNAL PROCESSING

EED626

L-T-P=3-0-0

Module 1: Discrete-time signals and systems (6 hours)

Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals - aliasing; Sampling theorem and Nyquist rate.

Module 2: Z-transform (6 hours)

z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z-transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse ztransforms.

Module 2: Discrete Fourier Transform (10 hours)

Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Convolution of signals, Fast Fourier Transform Algorithm, Parseval's Identity, Implementation of Discrete Time Systems.

Module 3: Design of Digital filters (12 hours)

Design of FIR Digital filters: Window method, Park-McClellan's method. Design of IIR Digital Filters: Butterworth, Chebyshev and Elliptic Approximations; Low-pass, Band-pass, Band-stop and Highpass filters. Effect of finite register length in FIR filter design. Parametric and non-parametric spectral estimation. Introduction to multi-rate signal processing.

Module 4: Applications of Digital Signal Processing (6 hours)

Correlation Functions and Power Spectra, Stationary Processes, Optimal filtering using ARMA Model, Linear Mean-Square Estimation, Wiener Filter.

POWER SYSTEM III

EED703

L-T-P=3-0-0

Unit 1: Power Systems in Restructured Environment; Distributed and Dispersed Generation; Environment Aspects of Electric Power Generation.

Unit 2: Generation Cost Curves; Economic Operation of Thermal System; Plant Scheduling, Transmission Loss and Penalty Factor, Hydro-Thermal Scheduling; Concept of Reserves and Constraints; Unit Commitment.

Unit 3: Concept of AVR and ALFC Loops, Significance of Double Loop in ALFC; Exciter and VAR Control; Single Area Load Frequency Control; Two Area Load Frequency Control; Frequency Response.

Unit 4: Reactive Power Sensitivity and Voltage Control; Load Compensation with Capacitor Banks; Line Compensation with Reactors; Shunt and Series Compensation; Fixed Series Capacitors; Thyristor Controlled Series Capacitors; Introduction to SVC and STATCOM.

Unit 5: Types of System Transients; Overvoltage in Transmission Lines; Propagation of Surges and Travelling Waves; Protection against Lightning and Surges.

WIND AND SOLAR ENERGY SYSTEMS

EED706

L-T-P=3-0-0

Module 1: Physics of Wind Power: (5 Hours)

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.

Module 2: Wind generator topologies: (12 Hours)

Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.

Module 3: The Solar Resource: (3 Hours)

Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

Module 4: Solar photovoltaic: (8 Hours)

Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.

Module 5: Network Integration Issues: (8 Hours)

Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.

Module 6: Solar thermal power generation: (3 Hours)

Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.

INDUSRTIAL AUTOMATION AND ROBOTICS

EEC711

L-T-P=3-0-2

Module 1: AC-DC & DC-DC Converters for DC Motor Drives (5 hours)

Review of dc chopper and duty ratio control, AC-DC & DC-DC Converter fed dc motor for speed control, steady state operation of multi-quadrant AC-DC & DC-DC Converter fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper, efficiency of dc drive, smooth starting, regenerative braking.

Module 2: Closed-loop control of DC Drive (6 hours)

Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, for controller design, current controller specification and design, speed controller specification and design.

Module 3: Application of Mechatronic Systems (7 hours)

Definition of robot, classification of robots according to coordinate system and control method, Main components of robots – manipulator, sensors, controller etc, Robot characteristics – payload, reach, repeatability, accuracy, resolution. Homogeneous transformation matrices, Direct and Inverse Kinematics of robots, Trajectory Planning, Mechanical grippers, other types of grippers, Tools as end effecters. Characteristics of actuating systems, Actuating System – Hydraulic devices, pneumatic devices, electric motors, other special actuators.

Module 4: Induction motor characteristics (6 hours)

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation.

Module 5: Scalar control or constant V/f control of induction motor (6 hours)

Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

Module 6: Control of slip ring induction motor (6 hours)

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

ELECTRICAL SYSTEM DESIGN LAB-I

EEC712

L-T-P=0-0-3

Course Contents:

Exercises that must be done in this course are listed below:

Exercise No.1: Study of residential house wiring using switches, fuse, lamps and energy meter.

Exercise No. 2: Study of different types of wiring

Exercise No. 3: Study of fluorescent lamp wiring. Exercise No. 4: Measurement of electrical quantities.

Exercise No. 5: Study of ETAP.

ELECTRICAL ENERGY CONSERVATION AND AUDITING

EED822

L-T-P=3-0-0

Module 1: Energy Scenario (6 Hours)

Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

Module 2: Basics of Energy and its various forms (7 Hours)

Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

Module 3: Energy Management & Audit (6 Hours)

Definition, energy audit, need, types of energy audit. Energy management (audit) approach understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

Module 4: Energy Efficiency in Electrical Systems (7 Hours)

Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

Module 5: Energy Efficiency in Industrial Systems (8 Hours)

Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities in HVAC, Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers.

Module 6: Energy Efficient Technologies in Electrical Systems (8Hours)

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.

SENSORS & TRANSDUCERS

EED813

L-T-P=3-0-0

Unit 1: INTRODUCTION

a) Definition, principles of sensing and transduction, classification

Unit 2: MECHANICAL AND ELECTROMECHANICAL SENSORS

- a) Resistive (potentiometric) type: resolution, accuracy, sensitivity
- b) Strain Gauges: theory, types, sensitivity, gauge factor, variation with temperature
- c) Inductive sensors: common types- reluctance change type, mutual inductance change type, transformer action type, magnetostrictive type
- d) LVDT: Construction, output-input relationship, I/O curve, discussion
- e) Proximity sensor

Unit 3: CAPACITIVE SENSORS

- a) Variable distance- parallel plate type
 - b) Variable area- parallel plate, serrated plate/teeth type and cylindrical type
 - c) variable dielectric constant type
- PIEZOELECTRIC ELEMENTS**
- a) piezoelectric effects, charge and voltage coefficients ultrasonic sensors

Unit 4 THERMAL SENSORS

- a) Material expansion type: solid, liquid, gas and vapour
 - b) Resistance change type: RTD, materials, construction, tip sensitive and stem sensitive type, Thermister materials, shapes, ranges, accuracy specifications
- Thermoemf sensors: types, thermoelectric powers, general consideration

Unit 5: MAGNETIC SENSORS

- a) Sensors based on Thomson effect
 - b) Hall effect and Hall drive, performance characteristics
- RADIATION SENSORS**

- a) LDR, photovoltaic cells, photodiodes, photo emissive cells- types, materials, construction, respons

- b) Geiger counters
- c) Scintillation detectors, Introduction to Smart sensors

Unit 6: VELOCITY, ACCELERATION SENSORS

- a) Electromagnetic velocity sensor; spring-mass-system, measurement of deflection
- b) Principle of accelerometers, sensitivity, noise

Unit 7: FLOW

- a) Pressure gradient technique
- b) Rotameter thermal transport technique
- c) Electromagnetic sensor Ultrasonic sensors