अनुसंधान प्रबंधन और राष्ट्रीय प्रौद्योगिकी संस्थान

RESEARCH MANAGEMENT AND NATIONAL INSTITUTE OF TECHNOLOGY

(An Autonomous institution under Ministry of HRD, Govt. of india)

(A 9001-2008 ISO CERTIFIED INTERNATIONAL B-SCHOOL)

ELECTRICAL ENGINEERING

On

UGC Model Curriculum

SYLLABUS OF MASTER OF ELECTRICAL ENGINEERING

First Semester

Category - Departmental / Specialization Basket

Paper- I

PG / EE / T / 111A Field Computation of Electromagnetic Devices

Magnetic fields in electrical machines and devices. Two dimensional fields in the slotted structure of machines. Method of conformal transformations for two dimensional field problems. Numerical methods for solving Laplace's and Poission's equations : (1)Finite difference Method, (2) Finite Element Method and (3)Boundary Element Method. Eddy Current and Heating as field problems. Solution of these problems by analytical and numerical methods. Simulation methods for the solution of field problems. Inductance calculation for various types of electromagnetic devices.

PG / EE / T / 111B Modelling and Simulation of Dynamic Systems

State variable Modelling of Continuous Dynamic Systems. Solution methods for Nonlinear Differential equations.Bond Graph Techniques.
Simulation Software.
Skeletal Structure of Simulation software.
Packages and Scripting Techniques.
Real-time simulation systems. Case studies. Qualitative Modelling.

PG / EE / T / 111C Advanced Instrumentation Techniques

Measurement standards: voltage, current, resistance, capacitance, inductance, time and frequency.
Advanced measurement and Calibration equipments: inductive voltage dividers, AC and DC comparators, programmable synthetic signal sources and power supplies, Quad bridge, automatic AC bridges, phase sensitive detectors, lock-in-amplifiers, digital phase and frequency measurements. Digital Phase Locked Loop and its application
Intelligent measuring instruments and systems: microprocessor based instruments, PC based instruments and instrumentation systems & instrument networking
Automated test and calibration systems: GPIB based systems, machine computation of errors and uncertainties in measurement. Virtual Instrumentation system.

Paper- II

PG / EE / T/ 112A Special Purpose Electrical Machines

Induction generators: self excitation requirements, steady state analysis, voltage regulation, different methods of voltage control, application to mini and micro hydel systems.
Doubly fed induction machines: control via static converter, power flow, voltage/frequency control (generation mode), application to grid connected wind and mini/micro hydel systems.

Switched Reluctance Motor: Construction, operating performance, control and applications.
Brushless DC Machines: construction operation, performance, control and applications.
Linear Machines: Linear Induction Machines and Linear Synchronous Machines. Construction, operation, performance, control and applications.
Application of permanent magnets in electrical machine: structure, magnetic materials used, types of motors e.g. PMDC and PM Synchronous Machine, control and applications.
Recent developments in electrical machines.

PG / EE / T/ 112B Control System Engineering

Review of classical control theory: Stability margins, correlation of frequency domain and time domain parameters, design specifications, compensation of continuous systems, actuator selection and design.
State variable modelling of linear continuous systems, controllability and observability
Concepts of linear sampled data systems: Discrete equivalents of continuous data systems, reconstruction of sampled signals, sample and zero order holds, stability of linear sampled data systems.
State variable modelling of linear discrete data systems, controllability and observability.

PG / EE / T/ 112C Advanced Power System Principles

Representation of power system components, basic principles of power transmission, Load flow problem and its solution by Gauss-Seidel method. Economic operation, generation scheduling problem. Load frequency, voltage and Var control. HVDC transmission.
Short circuit analysis, formation of bus impedance matrix, solution of symmetrical and unsymmetrical short circuit faults.
Transient stability studies: Concept of Equal Area Criterion, swing equation for multi machine power system and their solution by numerical methods.
Static and numerical relays, Phase and amplitude comparators, derivation of voltage and current values by sampling method.

PG / EE / T/ 112D Lighting Design & Calculation

Review of fundamentals of Illumination Engineering. Lighting field of luminaire- Practical coordinate systems, Transformation of coordinate system from point, line area source, Illuminance calculation- Derivation of luminous flux from luminous intensity, flux transfer and inter-reflection luminance calculations, Discomfort glare. Optical design- reflector system, refractor system. Principal of lighting design- Indoor lighting design by lumen method, by point method, Designing problem and solution and designing documentation. Exterior lighting system- Road lighting system and highway lighting system.

Paper- III

PG / EE / T/ 113A Static Converters in Electric Drives

Basic control techniques for drives (ac as well as dc). Review of major Power Semiconductor Devices and Converter Systems used in electric drives (ac as well as dc) for 1-, 2- and 4-quadrant operation. Interaction with utility supply system, improvement of power factor and reduction of harmonic current. Converters used for slip power recovery and super-synchronous operation of slip-ring induction motors. Converters used for starting and energy saving of induction motors. Electronic protection of drives. Regeneration in drives. Braking in drives. Different feedback techniques and sensors.

PG / EE / T/ 113B Digital Control Theory

Structure of a computer controlled system. Review of Z-transform. Computation of time response of Discrete Data system. Billnear Transformation. W-plane, prewarping, inverse transformation. Design of discrete controllers. Z-domain compensation, w-plane compensation, state variable feed back, deadbeat controlle,r sampled data version of PID controllers. Effect of Data Digitisation. Effect of finite word size, limit cycle determination.

PG / EE / T/ 113C Elements of High Voltage Engineering

High Voltage Generation: High AC, DC and Impulse Voltages. *High Voltage Measurement:* CVT, Peak voltmeters, sphere gaps, impulse recording. *Over-voltage and protection*: Insulation coordination. *High voltage testing methods*. *Partial discharge*: Causes and effects of PD, PD diagnostic techniques, PD patterns and analysis.

Category – Inter - Disciplinary Basket

Paper- IV

PG / EE / T/ 114A Material Technology

The electron. Wave Mechanics. The Simplest Atom. Atoms with many electrons. Molecules and bonding. Crystal structure. Thermal phenomena in materials. Organic polymers. Electrical conduction in metals. Semiconductor. Magnetic materials. Dielectrics .

Paper- V

PG / EE / T/ 115A Active Circuits and Systems

Special operational amplifiers: high voltage/high current, chopper and chopper stabilized amplifiers, instrumentation amplifier, isolation amplifier.
Nonlinear function circuits: limiter, log/anti-log, multiplier/divider, peak detector, comparator, true RMS/DC converter, square wave oscillators.
Timing and counting circuits: digital counters, shift register, analog and digital timers, frequency counters.

Sinusoidal and relaxation oscillators: phase shift, ring, Wien-bridge, tuned, quadrature oscillator, crystal oscillator and clock circuits, voltage controlled oscillators – sine, square and triangle, frequency synthesizers.
Frequency-to-voltage converters: Diode pump integrator, frequency and RPM transducers. Phase and phase /frequency comparators – analog and digital.
Programmable logic devices: PLA, PLD , CPLD, FPGA and its application
Microelectronic fabrication: Optical lithography, Etching, Physical deposition and sputtering, Chemical vapor deposition epitaxial growth, Device isolation, contacts and metallization, CMOS technologies
Optoelectronic devices: photo diode/transistor, LDR, LED and LCD and PLASMA displays, opto-coupler, opto-interrupter, high speed detectors – PIN and avalanche photo diodes
Active filters: types, filter approximations – Butterworth and chebyshev, filter realisations, frequency and impedance scaling, filter transformations, sensitivity, switched capacitor circuit

Paper- VI

PG / EE / T/ 116A Optimization Techniques

Mathematical programming problem, conditions for optimality, Classical optimization techniques.
Linear programming, Simplex algorithm, duality, revised simplex algorithm, sensitivity analysis.
Non linear programming: Unconstrained optimization, gradient based methods, Newton's method, Quasi Newton's method. Constrained optimization. Penalty function methods.
Direct search techniques: univariate methods, pattern search methods, branch and bound method for mixed integer problems, Simulated annealing, Tabu search, Genetic algorithm, particle swarm optimization, ant colony optimization , differential evolution techniques.
Multi objective optimization, pareto solutions.

PG / EE / T/ 116B Solid State Power Supplies

DC Power Supplies: Linear and switching power supplies. Various DC to DC converters and their operating characteristics. Selection of Power Semiconductor Devices. Magnetic component behavior and selection. Control pulse generation and control techniques. Feedback isolation techniques. Auxiliary power supply generation. Parallel operation.
Utility interface: Line current harmonics of rectifiers and their effect. Rectifier circuits with low input current distortion and high power factor.
AC Power Supplies: Linear mode AC power supplies. Switching mode Inverters. Sine wave inverters. Parallel operation. AC voltage regulators. UPS systems.
Special Power Supplies: Power supplies for pulsed gas discharge tubes. High current power supplies. Power supplies for lighting application. Power supplies for other applications.*Other Related topics:* EMI & EMC considerations, Environmental considerations, MTBF & its estimation.

Category – Sessional Courses

Sessional – I

PG / EE / S / 111 Laboratory

Sessional – II

PG / EE / S / 112 Seminar

Second Semester

Category - Departmental / Specialization Basket

Paper – VII

PG / EE / T/ 127A Modelling and Analysis of Electrical Machines & Drives

Thermal modelling and analysis of machines. Thermal equivalent circuit of electrical machines. Thermal monitoring. 3-2 phase transformation and vice-versa. d-q modeling of electrical machines. Space Vector method of transient analysis of induction machines. Finite Element methods for electromagnetic modelling of electrical machines. Modelling and analysis of electrical machines as applicable for drive systems. Application of various software packages. Simulation of electric drive systems using Software tools.

PG / EE / T/ 127B Transducer Technology

Classification of Instrumentation Transducer: Analog/digital, active/passive, force balance.
Variable Inductance and variable capacitance transducers: Application, ac bridge and other interfacing methods.
Special Transducers: Piezoelectric, Magnetostrictive, thermo-electric sensor, semiconductor temperature sensors.
Mechanical Characteristics of transducers: Electrodynamic transducers, eddy current, damping resonance effects, design considerations.
Force balance transducers: Static performance – sensitivity, linearity, threshold, dynamic performance – harmonic response and bandwidth, transient response, phase compensation, velocity feed back, applications.
Vacuum Gauges: Pirani gauge, thermocouple gauge, ionization gauge.
Digital Transducers. Ultrasonic Transducers and Electromagnetic Accoustic Transducers(EMATs). Analog Signal Conditioning techniques.
Bridge amplifier, carrier amplifiers, charge amplifiers and impedance converters, modulation - demodulation, dynamic compensation, linearisation, multiplexing and demultiplexing.
Digital Interfacing techniques: Interfaces, processors, code converters, linearisers.
Single transmission: Cable transmission of analog and digital signal, fibre optic signal transmission, radio, telemetry, pneumatic transmission.
Signal Display/Recording systems: Graphic display systems, storage oscilloscope, recorders-ink, thermal, UV.

Optical Sensors, Smart Sensors, Intoduction to Microelectromechanica Systems(MEMS)
Tomographic Techniques : Capacitance and Impedance

PG / EE / T/ 127C Power System Analysis

Steady state models of power system: Use of component systems in power system analysis, Symmetrical and Koga components, bus admittance matrix and it's modification for changes in the system configuration, the building up algorithm for bus impedance matrix, modification due to network changes.
Fault studies: Analysis of series and shunt faults on digital computer.
Power flow study: Solution of load flow problem using Gauss-Seidel, Newton-Raphson and fast-decoupled approach. Solution of ill conditioned systems. Continuation Power flow.
Optimum Power flow: Formulation of the Optimum power flow problem, Solution of Optimum Power flow problem using Gradient method and linear programming technique.
*Contingency evaluation***:** Necessity of contingency evaluation in power system, contingency ranking for real and reactive contingencies, method of distribution factors for line and generation outages.
Reliability Analysis: Representation of Power system components for reliability analysis, Loss of load expectation and Frequency & Duration approach.
Power system stability: Synchronous machine models, power angle equation, dynamics of synchronous machine, governor and exciter models, swing equation and it's solution for multi-machine systems.

PG / EE / T/ 127D High Voltage Fields

Electric field calculation by Finite Difference Method (FDM): FDM formulations for homogeneous medium in 3-D system with unequal nodal distances, FDM formulations for multi-dielectric media in 2-D system with unequal nodal distances, FDM formulations for multi-dielectric media in axi-symmetric system with equal nodal distances.
Electric Field Calculation by Charge Simulation method (CSM) in single-dielectric and multi-dielectric media, Types of fictitious charges: Point charge, Infinite and finite length line charge, Ring charge, Accuracy Criteria, Factors affecting simulation accuracy, Solution of system of equations, Least Square Error CSM, Optimized CSM, Region oriented CSM, CSM with complex fictitious charges, Application of CSM for lossy dielectric considering volume and surface resistivities, Application of CSM for field calculation under transient voltages for lossy dielectric.
Electric field calculation by Finite Element Method (FEM): Minimum field energy and basic potential equation at nodes for triangular elements considering homogeneous medium and also multi-dielectric media for two-dimensional and axi-symmetric field, Element interpolation, Simplex coordinates, Simplex-Cartesian relation, Interpolation on 1-Simplexes, Interpolation functions on n-Simplexes, Interpolation for curvilinear elements, Local coordinates, Integration by Gauss Quadrature Method.
Hybrid method comprising CSM and FEM, Comparison between CSM and FEM.
Electric field calculation by Direct Boundary Element Method: Basic formulations for 2-D and 3-D systems based on Green's function kernel, Fundamental solution and weighting function for solution, Evaluation of integrals for constant and linear elements, treatment of corners, Multi-boundary problems, Multi-dielectric system.
Electric field calculation by Indirect Boundary Element Method (Surface Charge Simulation Method): Basic formulations for 2-D and axi-symmetric systems considering

ideal homogeneous medium, straight-line and elliptic arc elements, formulations for lossy dielectric including volume and surface resistivities.
Analytical methods of electric field calculation: Solution of field perturbations due to a long conducting/dielectric cylinder in uniform field, Solution of field perturbations due to a conducting/dielectric sphere in uniform field.
Mechanical forces in HV systems: Mechanical pressure on electrode boundary, Mechanical pressure within an insulator, Film pressure on insulator boundary, Total pressure at the insulator-insulator boundary.

PG / EE / T/ 127E Optimal and Robust Control

Optimal Control Systems and Performance Indices. Optimal Control of linear systems with Quadratic Performance Index. Optimal State Regulator Design through Matrix Ricatti equation. Properties and Application of the Optimal Regulator. Linear Quadratic Gaussian (LQG) Control. State Estimator Design. System Design using State Estimators. Loop Transfer Recovery (LTR). Frequency Shaping. Robust Control Systems and System sensitivity. Uncertainty and Robustness. Structured and Unstructured uncertainty. Internal Stability. Kharitnov's methodology. Stability robustness and Performance robustness of Control Systems. Mu-Synthesis. Robust Tracking. H2 and H-infinity Control. H-Infinity Loop Shaping. Gap Metric. Linear Matrix Inequalities (LMI). Quantitative Feedback Theory (QFT).

PG / EE / T/ 127F Computer Control of Industrial Processes

Introduction to computer Control: Brief History, Advantages, different types and application areas, Direct Digital Control and Supervisory Control, SCADA, Embedded Controller.
Example Processes: Satandard SISO process, first order with delay, Standard sensors and actuators. Simple MIMO process. Batch process, which require sequential control.
Architecture of a Computer Control System: Generic architecture. Use of Context diagram and DFD for architectural description. Specific Examples.
Interfacing: Digital data transfer from peripherals, polling, interrupt, DMA. Interfacing considerations for field Input-output.
Programmable Logic Controllers: Features functionalities and Architecture, Examples of programming and applications.
DDC controllers: Features functionalities and Architecture, Examples. DDC algorithms. Digital Implementation of Two term (PI, PD) and three term (PID) controller. Implementation of digital compensators. Model Based Control and their digital implementations.
Distributed Control: Architecture, advantages. Communication for distributed control. Field Bus. Application Examples.

Paper -VIII

PG / EE / T/ 128A Small Machines, Incremental Motion Devices & Actuators

Stepper Motors: Various types, principle of operation, operating characteristics, application. Servo Motors. Servo amplifier and control. Special types of permanent magnet motors for servo application. Various types of specialized actuators.

Micro Machines: principles of operation of various types. Sensors for control, e.g. Position sensor, etc. Recent developments in the area.

PG / EE / T/ 128B Computer Application in Instrumentation

Digital Process Control Systems: Review of discrete-time signals and systems, overview of digital controllers, 3-term controllers, Dahlin and Kalman controllers, control of time-delay systems: Smith predictor.
Random processes: Introduction, stationarity, ergodicity, auto-correlation and cross-correlation: their properties and applications. Power spectral density. Averaging techniques and median filtering.
Modeling of plant dynamics, system identification methodologies, AR model, MA model, ARMA model.
Introduction to discrete-time state-space representation, controllability and observability, state space control, recursive state estimation: Kalman filter.
Adaptive control systems: need for adaptation, gain-scheduling control, self-tuning regulators, model reference adaptive systems.
Introduction to pole placement control and internal model control.
Variable structure control: the switching surface, sliding mode and reaching mode, VSC for linear systems, the chattering phenomenon.
Intelligent instrumentation and control:
Introduction to fuzzy systems: fuzzy sets, membership functions, knowledge base and defuzzification strategies. Mamdani-type and Takagi-Sugeno type fuzzy inferencing.
Introduction to artificial neural networks: perceptrons, multilayered feedforward networks, concepts of supervised and unsupervised learning. Applications.
Intelligent control systems: fuzzy control and neuro-fuzzy control.
Transform based techniques in instrumentation: introduction to short-time Fourier transform and wavelet transform. Applications.

PG / EE / T/ 128C Power System Operation

Generation Scheduling: scheduling problem in thermal system and their solution, derivation of B-coefficients and incremental transmission loss (ITL), ITL from the Jacobian of N-R load flow, hydro thermal scheduling problem and its solutions.
Unit commitment: various constraints in thermal unit commitment problem by dynamic programming.
Automatic Generation Control: Load frequency control of Single and multi area power systems , real time implementation of economic dispatch through load frequency control system .
Megavar voltage control, fundamental characteristics of typical excitation system, automatic voltage regulator (AVR) for generator excitation control. reactive power dispatch and its coordination with active power dispatch.
Energy control center: Computer confuguration in energy control centers, data acquisition and transmission, man-machine interfaces, functions performed in energy control centers.
State estimation: introduction to the problem of state estimation, maximum likelihood estimation and weighted least-estimation, bad data identification, concept of power system monitoring, the line power flow state estimator.
Load forecasting: preliminary survey, some basic concepts in statistics, sources of error, estimation of deterministic part – estimation of average and trend terms, estimation of periodic components, estimation of stochastic component – time series approach.

PG / EE / T/ 128D Dielectric Engineering

Introduction: Properties of dielectric material, electric stress and electric strength, estimation and control of electric stress, brief overview of breakdown mechanisms.
Polarisation: Polarisation mechanism, different types of polarization, effect of polarization on permittivity, electret, electert types, manufacture and applications of electret
Polymers: Thermosetting and thermoplastic materials, polymerization, Cross linking, impregnation process of dielectric material.
Breakdown in gases: Basic ionization process, Townsend current growth equations, Townsend criterion for spark breakdown, streamer mechanisms, breakdown in electronegative gases, time lags of spark breakdown, Paschen's law, breakdown in non uniform fields.
Characteristics of vacuum: Pre-breakdown conduction, factors affecting the breakdown voltage, frequency of applied voltage.
Breakdown in solids: intrinsic breakdown, electromechanical breakdown, thermal breakdown, chemical and electrochemical deterioration, breakdown due to tracking and treeing, partial discharges.
Electrical conduction and Breakdown in liquids: Pure liquids and commercial liquids, purification, natural conduction, induced conduction, process of conduction, breakdown phenomena and electric strength of pure liquids, breakdown of commercial liquids.

PG / EE / T/ 128E Real Time Systems

Overview of Real time systems: Definition, evolution, typology, structure and applications.
Temporal Modelling and specification of real time systems: State diagram, finite automata model, petri-net, state chart and mode chart, Q-model, formal methods.
Sequential and logic control: Ladder diagram, PLC programming, case studies in interlocking and sequence control.
Hardware Components and Configuration of real time system: Interfacing systems for analog and digital I/O, programmable logic control system architecture, computer control system architecture, flight control systems, hardware-in-loop simulation systems, distributed control architecture, reliability enhancement by redundancy.
Real time Operating systems: Features, primary components.
Structured design of real time systems: Data flow oriented method of analysis and design. Mode chart oriented methods.
Development, integration and validation of real time systems. Special consideration for safety critical systems.

PG / EE / T/ 128F Nonlinear and Adaptive Control

Nonlinear Control: State-space representation of non-linear systems. Common non-linearities and their origin. Examples of phase plane analysis for relay based control, Popov's stability criterion. Local linearization, Jacobian and Lyapunov's first theorem. Stability analysis by Lyapunov theory. Describing function method and Limit cycle. Feedback linearization. Sliding Mode Control. Concepts of observability for non-linear systems.

Adaptive Control: Linear parametric model. Adaptive laws. Model reference adaptive control. Robustness in adaptive control. Adaptive control of nonlinear systems. Gain scheduling control

PG / EE / T/ 128G High Voltage Equipment

High Voltage Power Transformer: Transformer insulation requirements, dielectric strength and voltage conditions, winding arrangements, surge behavior, behavior of liquid dielectric, electrode surface phenomena, gas evolution, processing techniques, construction of EHV transformer, short circuit behavior.
Loading and Life of Transformer: Life of transformer, aging of insulation, significance of weighted value of ambient temperature, relationship between weighted ambient, winding temperature rise and hot spot temperature, relationship between weighted ambient and load, transformer loading guide, selection and use of transformer.
Testing of Transformer: Testing of power transformer, impulse testing and partial discharge testing.
High Voltage Bushings: Types, non-condenser bushing, condenser bushing, bushing application for different equipments like, alternator, transformer, switchgear, wall bushing, design of bushing and testings procedures.
High Voltage Circuit Breakers: Air break, SF6 and vacuum circuit breakers.
Gas Insulated Substation (GIS): Advantages of GIS, comparison of GIS and air insulated substations, design and layout of GIS, description of various components of GIS.

Paper - IX

PG / EE / T/ 129A Advanced Electric Drives

Basic structure and principle of dc and ac drive systems. Constant flux and field weakening. Constant torque and constant hp operation. Effect of non-ideal waveform on motor performance. Application of Space Vector to ac machine analysis. Pulse Width Modulation techniques. Multi-level converters and multi-phase motor drives.
Modern methods of motor control: Field Oriented Control, Direct Torque Control, etc. Methods of Sensorless Control.
Space Vector Modulation Techniques. Application of micro-controllers, DSP and FPGA to motor control.

PG / EE / T/ 129B Embedded Systems

Embedded Systems Overview. Design Metrics: Optimization.
Embedded System Technologies: Processor Technologies, IC Technologies, Design Technologies.
Processor Technologies: General-purpose processors, Single-purpose processors, Application-Specific Instruction Set Processors (ASIPs).
Microcontroller and Digital Signal Processor as ASIP, customized ASIPs, processor as Intelligent Property (IP).
IC Technologies: Full-custom/VLSI (SoC), semi-custom ASIC, generic ICs: from PLDs through FPGAs.
Design Technologies: Design process – specification to synthesis, testing. Design process models. Co-design Ladder.

Development Environment: Development processor, target processor.
Software for the target hardware: High level language, Assembly language, Hardware description language.
Software development process: Compilers / Cross-compilers, Assemblers, Linkers, Debuggers, Profilers, Interpreters.
Program execution: Hardware as target, simulator as software model of the target, emulator. Modeling of Processors, Peripherals, Implementation of DSP algorithms
Peripherals: Timers, UARTs, pulse width modulator, keypad controller, LCD controller, ADC, DAC. Sensors and actuators.
Memories: ROMs, RAMs, Advanced RAMs.
Interfacing: Addressing, Interrupts, DMA, Arbitration, Hierarchical buses, Protocols – serial, parallel, wireless.
*Case Studies:*Instrumentation and Signal Processing Systems, Control and Actuation Systems, Power Electronic Drive Systems etc.

PG / EE / T/ 129C Power System Protection

*Two and Multi-input Protective relaying**:*** Generalised theory, characteristics derived by 2-input and multi-input phase and amplitude comparators. Duality concept, multi-input comparator circuitry. Instantaneous amplitude comparators.
Distance relays: principles of operation, zone discrimination, basic measuring elements, different characteristics used – their development through comparators, distance measurement problems, distance relay settings, requirement characteristics for different zones, performance characteristics, VA burden and relay accuracy, conic pick up and quadrilateral characteristic by multi input phase and amplitude comparators.
Polyphase distance relay: basic idea, different phase comparison schemes.
Wire pilot relaying: introduction; summation devices and sequence networks, problems in pilot relaying, pilot wire protection characteristic, pilot supervision, characteristic of pilot circuits, practical design considerations, typical protection schemes.
Carrier pilot relaying: mode of communication, coupling equipment, signaling equipment, mode of signal transmission, carrier aided distance protection, Carrier phase comparison protection.
Numerical relaying: introduction, protection philosophy, basic hardware and protection schemes, protection algorithms, microprocessor application to protective relays.

PG / EE / T/ 129D High Voltage Measurements

Measurement of high direct and alternating voltages, Sphere gaps and uniform field gaps and the influence of external parameters on measurement, Generating voltmeters, Voltmeter and voltage dividers, milli-ammeter and series impedance.
Impulse voltage measurement, Sphere gaps, impulse peak voltmeters, oscillographic measurements, Potential dividers for high voltage measurements, voltage dividers for ac and dc voltage measurements.
Dividers for impulse voltage measurements

a) Resistance dividers.
b) Capacitance dividers.
c) Resistance/capacitance dividers.

Effects of connections to test object, Effect of delay cables and terminations, Effect of connections to measuring instruments.
Impulse current measurements, measuring technique and design of different type of shunt

High-speed oscillographic technique

1) Recurrent surge oscillographs.
2) Sealed off and continuously evacuated oscillographs.

Partial discharge measurements and measuring techniques. Application of optical methods in high voltage measurement.

PG / EE / T/ 129E Mechatronics

Introduction to mechatronics, history and perspective. Essential linear and nonlinear electronic circuit elements for mechatronic design, Servo amplifier, Signal conditioning circuit design, Data acquisition system, Embedded computers, Computer interfacing circuit design. Sensing Position, Speed, Range, Proximity, Touch, Force, Torque, Attitude, etc., Stereovision, SLAM.

Actuators: Servo motors, Stepper motors, Relays etc., Hydraulic actuators, Pneumatic actuators, Artificial muscles. Simple mechanisms like Geared mechanisms, Four bar linkage, Pantograph mechanism, etc. Application of Digital Control in embedded environment.

Machine Vision: Image Segmentation and description, Image segmentation and description of 3D structure, Recognition. Controller Area Network, Piconet.

Industrial Manipulator: Robot arm kinematics and dynamics, Manipulability, Planning of manipulator trajectory, Elementary steps for robot arm design. Robust control of robot arm, Force and Impedance Control.

Walking robots: Mechanisms of Biped, quadruped and Hexapod robot, Walking robot gaits, Walking control of Biped, quadruped and Hexapod robot.

Visual feedback: Vision based autonomous operation of industrial manipulators and walking robots (path and locomotion planning).

Tele-operation: wired, wireless, hydraulic line coupling; master-slave robot manipulation (wired and wireless). Software development for autonomous operation of robot.

PG / EE / T/ 129F Advanced Topics in Electrical Machine Design

Basic considerations. Application of Software Tools in design. Standardization and standard specifications. Recent development of materials used in electrical machines.

Recent trends in design methodology. Optimization techniques as applied to the design of transformers and rotating machines.

Heating and Cooling. Considerations for the temperature of the hottest spot as well as effect of ambient temperature and loading on the life expectancy of machines.

Stall time calculations for induction motors. Failure mode analysis and fault detection.

Design of special static equipment. High frequency equipment design.

Category – Inter - Disciplinary Basket

Paper - X

PG / EE / T/ 1210A Electrical Systems in Vehicular Applications

Conventional cars. Electric vehicle development history. Vehicle specifications. Architecture of Electrical vehicle system (two, three and four wheelers). Grid connected Electric Vehicle system. Hybrid vehicles with drive trains for series, parallel, combination.

Automotive control area protocols. Types of motor used with special duty and constructions. Types of power storage used in Electrical vehicles. Power management system strategy and control strategy. Auxiliary electrical system in vehicles. Automotive steering systems. Automotive semiconductor devices, components and sensors. Automotive motor drives actuators and control. Testing of electric motor, controllers and hybrid electric vehicles. Safety components of Electrical vehicles. Passenger safety system. ARAI regulations.

PG / EE / T/ 1210B Advanced Digital Signal Processing

Review of FIR and IIR filters, DFT and FFT.
Random signals: Correlation functions, and power spectra.
Spectrum estimation and analysis: principles, periodogram method, Blackman – Turkey method, fast correlation method. Autoregressive spectrum estimation.
Homomorphic signal processing: concepts, definitions of the complex cepstrum, homomorphic deconvolution, complex cepstrum of exponential sequences, minimum phase and maximum phase sequences, realization of the characteristic system, example of homomorphic filtering.
Multirate digital signal processing: decimation, interpolation, design of practical sampling rate converters, application example.
Optimal and adaptive filters: Wiener filtering technique, adaptive filters and their applications.
Hardware for digital signal processing: Digital Signal Processors.
Digital image processing.
Two dimensional image representation: Image digitization, image distortion, image transmission encoding and decoding, image restoration. Image display techniques. Tomographic imaging techniques and their applications. Hardware for digital image processing.

PG / EE / T/ 1210C Power Electronics Application in EHV Transmission

HVDC Transmission: Converter operation, protection and control of HVDC link, modeling of HVDC system for power system studies.
Flexible AC Transmission Systems: Series and shunt devices and principle of operation and control, UPFC and IPFC, modeling of FACTS devices for power system studies.
Harmonics in Power System: Sources of harmonics, study of harmonic penetration, harmonic suppression.

PG / EE / T/ 1210D Condition Monitoring of High Voltage Equipment

Preventive Maintenance: How Preventive Maintenance Helps, Purpose of Diagnostic Testing, Why Condition Monitoring, Causes of Insulation Degradation, Oil-Paper composite Insulation System.
Traditional Condition Assessment Techniques for Oil-Paper Composite Insulation: Dissolved Gas Analysis, Furan Analysis, Degree of Polymerization.
Moisture in Oil-Paper Composite Insulation: Moisture Distribution, Moisture Dynamics, Effects of Moisture, Moisture Detection – Crackle Test, Karl Fischer Titration, Equilibrium Curves, Comparison of Equilibrium Curves, ABB and Serena's Equations, Moisture Content in Paper, Moisture Management, Oil Reclamation.

Dielectric Response Measurement: Polarization Mechanisms in Dielectrics, Dielectric Response in Time-Domain.
Polarisation and Depolarisation Current (PDC) Measurement, PDC Measurement – Test Set Up and Typical Results. Recovery Voltage Measurement (RVM), RVM Fundamentals, Polarization Spectrum, Typical RVM Results. Frequency Domain Spectroscopy (FDS), FDS equipment and analysis.
Dielectric Response Function and Insulation Model: Mathematical Model of Dielectric Response, Oil Conductivity, Paper Conductivity, Relating Oil and Paper Conductivities with Insulation Condition, Modeling of Recovery Voltage, Modeling Dielectric Response in Frequency Domain, Dissipation Factor, Circuit Model, Identification of Equivalent Model Parameters, Calculating RV from Equivalent Model, Calculating Dissipation Factor From Equivalent Model, Calculating Complex Capacitance from Equivalent Model.

Category – Sessional Courses

Sessional – I

PG / EE / S / 121 Term Paper Leading to Thesis

Sessional – II

PG / EE / S / 122 Seminar

Third and Fourth Semester

Sessional 1

PG / EE / TH / 21 Thesis Work

Sessional 2

PG / EE / VV/ 22 Viva – Voce