Electrical Engineering Department

PhD Course work:

1. **Research Methodology**
2. **Recent topic paper (PEE-101)**
3. **Specialized paper**
    - **A. Power system dynamics & reliability (PEE-201)**
    - **B. Electric drives & their control (PEE-202)**
    - **C. advanced power system protection (PEE-203)**
    - **D. Evolutionary Techniques (PEE-204)**
    - **E. Renewable energy generation sources (PEE-205)**
    - **F. Advanced Control Systems (PEE-206)**

PEE-101 RECENT RESEARCH IN ELECTRICAL ENGINEERING

L T P
3 1 0

Module-I

Clean electricity, micro-turbine generator systems, Voltage sag analysis: Distribution system relaying, Magneto hydrodynamic power generation technology (MHD): Narrow band power line communication, buck boost transformer.

Computer methods for load flow, Optimal power flow, Fault analysis and Stability

Characteristics of Electric Motors: Characteristics of DC motors, 3-Phase induction motors and synchronous motors, Starting and braking of electric motors.

Static Relays: Introduction, merits and demerits of static relays, Numerical relays

Module-II

Condition based maintenance of underground cable systems: on-line detection of shorts in fields of turbine generator rotor, flywheel energy storage system

Modeling of transformers with internal incipient faults: Digital testing of high voltage circuit breakers, surge current protection using super-conductors

Measurement of Power Quality: Introduction, Power quality indices, Power quality measuring instruments, Example calculation of power quality indices, Conclusions

Arc Furnaces and Their Effects on Electric Power Quality: Introduction, General characteristics of arc furnaces, Space charge limitations and furnace operating points, Flicker measurement, Flicker control, Conclusions

Module-III

Energy efficient machine, health monitoring electrical machine

AC and DC drives: Direct torque control, variable frequency control and voltage control.

Distributed power generation and smart grids, EHV-AC and HVDC transmission system**,** Re-generation and hybrid vehicles, Data transmission through distribution system, modified power flow tracing methodology, loss-less transmission through gas insulated transmission system

Restructured Power Systems: Deregulation, Market reforms, Advanced Pricing methods, Integration of IPP & DGs to Grid in India.

PEE-201 POWER SYSTEM DYNAMICS & RELIABILITY

L T P
3 1 0

Module-I

Dynamic models of synchronous machines, Excitation system, Turbines, Governors, Loads. Modeling of single machine infinite bus system, Mathematical Modeling of multi-machine system. Dynamic and transient stability analysis of single machine and multi-machine system. Power system stabilizer design for multi-machine system. Techniques for the improvement of stability

Module-II

Load Forecasting: Classification and characteristics of loads, Approaches to load forecasting, Forecasting methodology, Energy forecasting.

Network modeling and evaluation of simple and complex systems, System reliability evaluation using probability distribution, Frequency and duration methods.

Module-III

Generation System Reliability Evaluation: Concept of LOLP, Evaluation of indices for isolated system, Generation system, Reliability analysis using the frequency and duration methods.

Transmission System Reliability Evaluation: Evaluation of LOLP and indices for an isolated transmission system using frequency and duration method.

Distribution System Reliability Evaluation: Reliability analysis of radial system with perfect and imperfect switching.

Reference Books:-

1. R.Billintan & R.N. Allan, “Reliability Evaluation of Engineering and Systems", Plenum Press.
2. S.K. Sinha & B.K. Kale, “Life Testing and Reliability Estimation", Wiely Eastern Ltd.
3. L. P. Singh; “Advanced Power System Analysis & Dynamics”, New Age International.
4. Kothari & Nagrath, “Modern Power System Analysis” Tata Mc. Graw Hill.

PEE-202 ELECTRIC DRIVES & THEIR CONTROL

L T P
3 1 0

Module-I

Characteristics of Electric Motors: Characteristics of DC motors, 3-Phase induction motors and synchronous motors, Starting and braking of electric motors.

Dynamics of Electric Drives: Mechanical system, Fundamental torque equations, components of load torques, Dynamic conditions of a drive system, Energy loss in transient operations, Steady State Stability, Load equalization.

Module-II

DC Motor Drives: Starting, Braking and Speed Control, Transient analysis of separately excited motor with armature and field control, Energy losses during transient operation, Phase controlled converter fed DC drives, Dual-converter control of DC drive, Supply harmonics, Power factor and ripple in motor current, Chopper Control DC drives, Source current harmonic in Choppers.

Induction Motor Drives: Starting, Braking and transient analysis, Calculation of energy losses, Speed control, Stator voltage control, Variable frequency control from voltage and current sources, Slip power recovery-Static Scherbius and Cramer drives.

Module-III

Synchronous Motor Drives: Starting, Pull in and braking of synchronous motors, Speed control – variable frequency control, Cycloconverter control. Brushless DC Motor, Linear Induction Motor, Stepper Motor and Switched Reduction Motor Drives: Important features and applications.

Energy Conservation in Electrical Drives: Losses in electrical drive system, Measures for energy conservation in electric drives, Use of efficient motor, Energy efficient operation of drives, Improvement of power factor and quality of supply.

Reference Books:-

1. G.K. Dubey, "Fundamentals of Electric Drives", Narosa publishing House.
2. S.K.Pillai, "A First Course on Electric Drives", New Age International
3. V. Subrahmanyam, "Electric Drives: Concepts and Applications", Tata McGraw Hill.
4. M.Chilkin, "Electric Drives", Mir Publishers, Moscow.

PEE-203 ADVANCED POWER SYSTEM PROTECTION

L T P
3 1 0

Module-I

Static Relays: Introduction, merits and demerits of static relays. Comparators: amplitude and phase comparator, duality between amplitude and phase comparators. Circulating current type phase-splitting type and sampling type amplitude comparators. Vector product type and coincidence type phase Comparators.

Static Over Current Relays: Instantaneous over current relay, definite time over current relay, inverse-time over current relay, directional over current relay.

Module-II

Static Differential Relays: Differential relay scheme, single-phase static comparator, polyphase differential protection. Differential protection for generator and transformer.

Static Distance Relays: Impedance relay, reactance relay and mho relay using amplitude and phase comparators. Polarized and offset mho relays.

Carrier Current Protection: Phase Comparison scheme, carrier aided distance protection.

Distance Protection: Effect of resistances, power swings, and line length and source impedance on the performance of distance protection. Out of step tripping and blocking relays. Mho relay with blinders. Quadrilateral and elliptical relays. Selection of distance relays.

Module-III

Induction Motor Protection: Various faults and abnormal operating conditions. Protection against faults, unbalance supply voltage, single phasing, over load and mechanical rotor faults, HRC fuses, over-current, percentage differential and earth fault protection. Negative sequence voltage relays and resistance temperature detector relay.

Digital Protection: Introduction to digital protection, block diagram of digital relay, sampling theorem, correlation with a reference wave, Fourier analysis of analogue and discrete signals, least error squared technique, digital filtering – low pass, high pass, finite impulse response and infinite impulse response fillers. Introduction to digital over-current, transformer differential and transmission line distance protection.

Reference Books:-

1. B. Ram and D. N. Vishwakarma, “Power System Protection and Switchgear”, Tata Mc. Graw Hill.
2. Y. G. Paithankar and S R Bhide, “Fundamentals of Power System Protection”, Prentice Hall of India.
3. T.S.M Rao, “Power System Protection: Static Relays with Microprocessor Applications” Tata Macgraw Hill”.
4. A.R. Van C. Warrington, “Protective Relays- Their Theory and Practice, Vol. I & II” Jhon Willey & Sons.

PEE-204 EVOLUTIONARY TECHNIQUES

L T P
3 1 0

Module-I

Introduction to AI: Definition, Applications, Components of an AI program; production system, Problem characteristics, Overview of searching techniques. Knowledge representation: Turning test, AI agents and architecture, Predicate and propositional logic, Procedural versus declarative knowledge, forward versus backward reasoning.

Module-II

Statistical Reasoning: Probability and Baye's theorem, Certainty factor and rule based systems, Baysian Networks, Dampster Shafer theorem, Examples of knowledge based systems.

Artificial Neural Networks: Biological Neuron, Neural Net, Use of neural nets, Applications, Perceptron Model, Idea of single layer and multiplayer neural nets, Back propagation, Hopfield nets, Supervised and unsupervised learning.

Module-III

Expert Systems: Introduction, Study of some popular expert systems, Expert system building tools and shells, Components of expert systems, Applications to power systems.

Fuzzy Logic: Fuzzy logic concepts, Fuzzy relation and membership functions, Defuzzufication, Fuzzy controllers Genetic algorithm: concepts, coding, reproduction, crossover, mutation, scaling and fitness.

Reference Books:-

1. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India.
2. Fuzzy control –Drianlcov.
3. Weerakorn Ongsakul, Vo Ngoc Dieu "Artificial Intelligence in Power System Optimization" by CRC Press.

PEE-205 RENEWABLE ENERGY GENERATION SOURCES

L T P
3 1 0

Module-I

World energy situation. Indian energy scene. Comparative study of thermal, hydro, nuclear and gas power plants. Selection and location of power plants. Impact of thermal, gas, hydro and nuclear power stations on environment, air and water pollution, green house effect (global warning), impact on land. Renewable and non-renewable energy sources. Conservation of natural resources and sustainable energy sources. Efficiency improvement of thermal and gas power plants- pressurized fluid bed combustion of coal, combined gas steam plant and cogeneration.

Solar Energy: Solar radiation, solar radiation geometry, solar radiation on tilted surface. Solar energy collector. Flat- plate collector, concentrating collector – parabolidal and heliostat. Solar pond. Basic solar power plant. Solar cell, solar cell array, basic photovoltaic power generating system.

Module-II

Geothermal Energy: Geothermal fields, estimates of geothermal power. Basic geothermal steam power plant, binary fluid geothermal power plant and geothermal preheat hybrid power plant. Advantages and disadvantages of geothermal energy. Applications of geothermal energy. Geothermal energy in India.

Nuclear Fusion Energy: Introduction, nuclear fission and nuclear fusion. Requirements for nuclear fusion. Plasma confinement - magnetic confinement and inertial confinement. Basic Tokamak reactor, laser fusion reactor. Advantages of nuclear fusion. Fusion hybrid and cold fusion.

Module-III

Biomass Energy: Introduction, biomass categories, bio-fuels. Introduction to biomass conversion technologies. Biogas generation, basic biogas plants-fixed dome type, floating gasholder type, Deen Bandhu biogas plant, Pragati design biogas plant. Utilization of biogas. Energy plantation. Pyrolysis scheme. Alternative liquid fuels –ethanol and methanol. Ethanol production.

Reference Books:-

1. John Twideu and Tony Weir, “Renewal Energy Resources” BSP Publications, 2006.
2. M.V.R. Koteswara Rao, “ Energy Resources: Conventional & Non-Conventional “ BSP Publications, 2006.
3. D.S. Chauhan,”Non-conventional Energy Resources” New Age International.
4. C.S. Solanki, “Renewal Energy Technologies: A Practical Guide for Beginners” PHI Learning.
5. Peter Auer "Advances in Energy System and Technology". Vol. 1 & II Edited by Academic Press.

PEE-206 ADVANCED CONTROL SYSTEM

L T P
3 1 0

Module-I

State Variable techniques: State variable representation of systems by various methods, Solution of state equations-state transition matrix, Transfer function from state variable model, controllability & observability of state variable model.

Second order systems & state plane: Phase portrait of linear second order systems. Method of isoclines, Phase portrait of second order system with non-linearities, limits cycle, singular points.

Module-II

Non-linear systems: Taylor series, liapunov's 2^{nd} method.

Describing function analysis: Definition, limitations, use of describing function for stability analysis, describing function of ideal relay, relay with hysteresis & dead zone, saturation/coulomb friction & backlash.

Module-III

Sampled Data systems: Sampling process, impulse modulation, mathematical analysis of sampling process, application of Laplace transform, Shannon's theorem, reconstruction of sampled signal zero order & first order hold, Z-transform, definition, evolution of Z-transform, Inverse Z-transform, pulse transfer function, limitations of Z-transform, state variable formulation of discrete time systems. Solution of discrete time state equations, stability, definition, the Schur-Cohn stability criterion, Jury's test of stability of extension of Routh-Hurwitz criterion to discrete time systems, Mapping from s-plane to z-plane, Bilinear transformation.

Reference Books:-

1. Digital Control & state variable Methods: M.Gopal; TMH
2. Modern Control theory: M.Gopal; Wiley International.
3. Discrete time control system: K.Ogate; PHI
4. Digital Control Systems: B.C.Kuo
5. Applied non-linear control: J.E.Slotine & W.P.Li; Prentice Hall, USA.