UTTARAKHAND TECHNICAL UNIVERSITY, DEHRADUN

STUDY AND EVALUATION SCHEME

SEQUENTIAL M-TECH. YEAR 1st SEMESTER-I

Power System Operation

S.No	Course No.	Subject	Contact Hours / Week	Credits
1.	PGEE-101	Advanced Power System Analysis	6	4
2.	PGEE-102	Energy Conversion Systems	6	4
3.	PGEE-103	Power System Modeling	6	4
4.	PGEE-201	Programme Elective – I	6	4

UTTARAKHAND TECHNICAL UNIVERSITY, DEHRADUN

STUDY AND EVALUATION SCHEME

SEQUENTIAL M-TECH. YEAR 2nd SEMESTER-II

Power System Operation

S.No	Course No.	Subject	Contact Hours / Week	Credits
1.	PGEE-104	Power System Stability	6	4
2.	PGEE-105	Power Quality	6	4
3.	PGEE-106	Advanced Power System Protection	6	4
4.	PGEE-202	Programme Elective – II	6	4

UTTARAKHAND TECHNICAL UNIVERSITY, DEHRADUN

STUDY AND EVALUATION SCHEME

SEQUENTIAL M-TECH. YEAR 3rd SEMESTER-III

Power System Operation

S.No	Course No.	Subject	Contact Hours / Week	Credits
1.	PGEE-107	Energy Management & Energy Audit	6	4
2.	PGEE-108	Modern Control Theory	6	4
3.	PGEE-203	Programme Elective – III	6	4
4.	PGEE-204	Programme Elective – IV	6	4

UTTARAKHAND TECHNICAL UNIVERSITY, DEHRADUN

STUDY AND EVALUATION SCHEME

SEQUENTIAL M-TECH. YEAR 4th SEMESTER-IV

Power System Operation

S.No	Course No.	Subject	Contact Hours / Week	Credits
1.	PGEE-301	Comprehensive Viva Voce / GATE Score	-	10
2.	PGEE-302	Lab Documentation	-	8
3	PGEE-303	Thesis	-	15

ELECTIVE COURSES

Programme Elective I	**Programme Elective II**
▪ Power System Dynamics ▪ Analysis of Power Electronic Converters ▪ Economic Operation of Power Systems ▪ Optimal Operation and Control of Power Systems	▪ HVDC Transmission ▪ EHV AC Transmission ▪ Flexible AC Transmission Systems ▪ Power System Planning and Reliability
Programme Electives III & IV	
▪ Distribution Automation ▪ AI Techniques ▪ Power Sector Economics and Deregulation ▪ Voltage Stability	

DETAILS OF SYLLABUS

1. ADVANCED POWER SYSTEM ANALYSIS

Load Flow - Network modeling – Conditioning of Y Matrix – Newton Raphson method- Decoupled – Fast decoupled Load flow -three-phase load flow. Sequential Solution Techniques – Extension to Multiple and Multi-terminal DC systems.

Fault Studies -Analysis of balanced and unbalanced three phase faults – fault calculations – Short circuit faults – open circuit faults.

System optimization - strategy for two generator systems – generalized strategies – effect of transmission losses - Formulation of optimal power flow-solution by Gradient method-Newton's method. Power system state estimation.

2. ENERGY CONVERSION SYSTEMS

Photo voltaic power generation ,spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current, practical solar cell performance, commercial photo voltaic systems. Principles of MHD power generation, ideal MHD generator performance, practical MHD generator, MHD technology. Wind Energy conversion: Power from wind, properties of air and wind, types of wind Turbines, operating characteristics. Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation. Wave energy conversion: properties of waves and power content, vertex motion of Waves, device applications.

Co-generation and energy storage, combined cycle co-generation, energy storage. Global energy position and environmental effects: energy units, global energy position.

3. POWER SYSTEM MODELING

Synchronous Machines: Park's transformation, Derivation of two-axis equation, Torque equation, Field and damper windings, Equivalent circuits, Operational impedances and frequency response loci. Governors for hydraulic and steam turbines, Transient droop, speed governing system. Synchronous Generator short circuit and system faults, Sudden load changes, Synchronous Machine Transients

Excitation systems: Modeling of excitation system components, exciter (D.C and A.C), Amplifier, Stabilizing circuit

Induction machines: Generator equation, Short circuit and fault current due to the induction motor, fault calculation.

4. POWER SYSTEM STABILITY

Steady State and Dynamic Stabilities: Development of swing equation, linearisation of swing equation. Steady state stability of single machine connected to an infinite bus system and two machine systems. Coherent and non-coherent machines. Introduction to Dynamic Stability.

Transient Stability: Equal area criterion and its application to transient stability studies under common disturbances including short circuits. Critical clearing angle and critical clearing time. Numerical solution of swing equation by step-by-step method. Multi machine Transient Stability: Numerical methods for solution of differential equations: Modified Euler Method, Runge – Kutta fourth order method.

Methods of improving steady state, dynamic and transient stabilities, series capacitor compensation of lines, excitation control, power stabilizing signals, High speed circuit breaker, auto – recolsing circuits breaker, single pole and selective pole operation, by pass valving and Dynamic braking.

5. POWER QUALITY

Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruptions

Long & Short Interruptions, Definition – causes – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption

Voltage sag – characterization – Single phase and three phase– equipment behaviour of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation.

Overview of mitigation methods – , reducing the fault clearing time , installing mitigation equipment, improving equipment immunity, system equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

6. ADVANCED POWER SYSTEM PROTECTION

Primary and back up protection, current transformers for protection, potential transformer, review of electromagnetic relays and static relays.

Distance protection : impedance, reactance, mho, angle impedance relays. effect of arc resistance quadrilateral relay, elliptical relay. Swiveling characteristics. Compensation for correct distance measurement, Pilot relaying schemes. Wire pilot protection, circulating current scheme, balanced voltage scheme, transley scheme, carrier aided distance protection.

Digital relaying algorithms, differential equation technique, discrete fourier transform technique, walsh-hadamard transform technique, rationalized harr transform technique, Introduction to Microprocessors: Microprocessor based protective relays: over current, directional, impedance, reactance relays. Microprocessor implementation of digital distance relaying algorithms.

7. ENERGY MANAGEMENT AND ENERGY AUDIT

Energy Scenario: Primary energy resources, Commercial and Non-commercial energy, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment.

Energy management : principles, sectors of supply side management , electricity tariff, load management and maximum demand control, power factor improvement, selection and location of capacitors ,optimizing the input energy requirements, fuel and energy substitution, Energy strategies and energy planning, roles and responsibilities of energy manager,

Energy Audit: Definition, need of energy audit, types of energy audit, intermediate and comprehensive energy audit, procedure of energy auditing, site testing and measurement. Energy security

Energy Conservation and Recycling: Energy conservation and its importance, energy conservation opportunities (ECOs),Electrical ECOs, ECOs in process industry, small industries building and shopping complexes , waste management , Recycling of discarded materials and energy recycling, Energy Conservation Act-2001

8. MODERN CONTROL THEORY

Mathematical Preliminaries : Fields, Vectors and Vector Spaces – Linear Transformations and Matrices – Eigenvalues, Eigen Vectors and a Canonical form representation of Linear operators

The concept of state – State Equations for Dynamic systems – Time invariance and Linearity – uniqueness of state model – State diagrams for Continuous-Time State models . Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties. Controllability and Observability . State feedback controller design through Pole Assignment – State observers: Full order and Reduced order, Introduction to optimal control, boundary conditions – constrained minimization – formulation using Hamiltonian method – Linear Quadratic regulator

Non Linear Systems - Types of Non-Linearities – Singular Points – Linearization of nonlinear systems, Describing function– Stability analysis through describing functions, phase-plane analysis, Lyapunov's stability for linear and non linear systems

9. POWER SYSTEM DYNAMICS

Basic concepts: Power system stability, states of operation , system security, simplified representation of Excitation control. Dynamics of a synchronous generator connected to infinite bus: stator equations, rotor equations, Synchronous machine model with field circuit and one equivalent damper winding on q axis (model 1.1), calculation of Initial conditions.

Analysis of single machine system: small signal analysis with block diagram Representation characteristic equation and application of routh hurwitz criterion, Synchronizing and damping torque analysis, small signal model State equations.

Application of power system stabilizers: basic concepts in applying PSS, Control signals, structure and tuning of PSS, washout circuit, dynamic compensator analysis of single machine infinite bus system with and without PSS.

10. ANALYSIS OF POWER ELECTRONIC CONVERTERS

Single & Three Phase AC Voltage Controllers.Resistive, Resistive-inductive and Resistive-inductive-induced e.m.f. loads – PWM Control – Effects of source and load inductances - Synchronous tap changers- Applications - numerical problems. Cycloconverters.

Single & Three Phase Converters. – Half controlled and Fully controlled – Evaluation of input power factor and harmonic factor – dual converters – power factor Improvements – Extinction angle control – symmetrical angle control, D.C. to D.C. Converters. with resistive and Resistive-inductive loads – Switched mode regulators – Analysis of Buck Regulators - Boost regulators – Cuk regulators –Condition for continuous inductor current and capacitor voltage

Pulse Width Modulated Inverters – single phase bridge inverter - inductive and Capacitive loads – Voltage control - single PWM – Multiple PWM – sinusoidal PWM – modified PWM –three phase inverters – analysis of 180 degree condition for output voltage, resistive, inductive loads – analysis of 120 degree Conduction – voltage control of three phase inverters – sinusoidal PWM – Third Harmonic PWM – 60 degree PWM – space vector modulation

11. ECONOMIC OPERATION OF POWER SYSTEM

Economical Operations of Thermal Power Plants: Generator operating cost, input, output curves, heat rate and incremental rate curves of generating units, system constraints, economic dispatch using Newton Raphson method, classical method, Generalised Generation shift Distribution (GGSD) Factors. Effects of transmission losses, economic dispatch using exact loss formula which is function of real and reactive power,

Economical Operations of Hydrothermal Power Plants: Classification of hydro plants, long-range problem, short-range problem. Hydro Plant performance Model, Glimn- Kirchmayer Model, Hamilton-Lamonts Model, Newton Raphson method for short range fixed head hydrothermal scheduling, Interconnected System: Merits and demerits, parallel operation of alternators, load sharing and power limit of interconnected stations, voltage, frequency& load control of interconnected stations.

12. OPTIMAL POWER PLANT OPERATION AND CONTROL

Unit commitment problem : Introductions, thermal & Hydel constraints in Unit commitment, unit commitment problem solution by priority list scheme method, Dynamic programming Approach. Backward , forward DP approach algorithm and their flow charts

Load Frequency Control : Necessity of keeping frequency constant. single area control, Block diagram representation of an isolated Power System, Steady State analysis, Dynamic response-Uncontrolled case. Proportional plus Integral control of single area , Load frequency control of 2-area system : uncontrolled case and controlled case, tie-time bias control. Optimal LF control-steady state representation.

Generation with limited Energy supply : Take-or-pay fuel supply contract, composite generation production cost function. Solution by gradient search techniques, Hard limits and slack variables, Fuel scheduling by linear programming.

13. H.V.D.C. TRANSMISSION

H.V.D.C. Transmission : General considerations, Power Handling Capabilities , converter configurations, 3-pulse, 6-pulse and 12-pulse converters, Terminal equipment, equivalent circuits, Harmonics in HVDC Systems, Harmonic elimination, AC and DC filters.

Control of HVDC Converters and systems : constant current, constant extinction angle and constant Ignition angle control. Individual phase control and equidistant firing angle control, DC power flow control. Interaction between HV AC and DC systems – Voltage interaction, Harmonic instability problems and DC power modulation. Multi-terminal DC links and systems; series, parallel and series parallel systems, their operation and control.

Transient over voltages in HVDC systems : Over voltages due to disturbances on DC side, over voltages due to DC and AC side line faults, Converter faults and protection in HVDC Systems.

14. EXTRA HIGH VOLTAGE TRANSMISSION

Calculation of line resistance and inductances, bundled conductors, two conductor lines and multi – conductor lines, Maxwell's coefficient matrix. Line capacitance calculations, sequence inductances and capacitances and diagonalization.

Surface voltage Gradient on conductors, surface gradient on 2 conductor bundle and consine law, Maximum surface voltage gradient of bundle with more than 3 sub conductors, Mangolt formula. Corona : Corona in EHV lines – corona loss formulae – attenuation of traveling waves due to corona – Audio noise due to corona,

Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous conductor, Static reactive compensatiog systems , Harmonics injected in to network by TCR, design of filters for suppressing harmonics injected in to the system.

15. FLEXIBLE AC. TRANSMISSION SYSTEMS

FACTS Concepts: Transmission interconnections, power flow in an AC system, loading capability limits, Dynamic stability considerations, importance of controllable parameters, basic types of FACTS controllers, benefits from FACTS controllers.

Static Shunt Compensation: Objectives of shunt compensation, mid point voltage regulation voltage instability prevention, improvement of transient stability, Power oscillation damping, controllable var generation, variable impedance type static var generators,

Static Series Compensators: concept of series capacitive compensation, improvement of transient stabillity, power oscillation damping, GTO thyristor controlled series capacitor(GSC) , thyristor switched series capacitor(TSSC), and thrystor controlled series capacitor (TCSC) , UPFC

16. POWER SYSTEM PLANNING & RELIABILITY

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

Basic Probability Theory: Review of probability concepts, Probability distribution and it's use in reliability evaluation, Network modeling and reliability evaluation of simple and complex systems, Frequency and duration methods.

Generation System Reliability Evaluation: Evaluation of LOLP and indices for isolated system using frequency and duration methods. Transmission System Reliability Evaluation, Distribution System Reliability Evaluation: Reliability analysis of radial system with perfect and imperfect switching.

17. DISTRIBUTION AUTOMATION

Introduction to Distribution Automation (DA), control system interfaces, control and data requirements, centralized (Vs) decentralized control, DA Hardware, DA software. Distribution Automation Functions : Information management, system reliability management, system efficiency management, voltage management, Load management.

Communication Systems for DA : requirements, reliability, effectiveness, data rate, Two way capability, Ability to communicate during outages and faults, Ease of operation and maintenance, Communication systems used in DA : Distribution line carrier (Power line carrier), telephone, cable TV, Radio, AM broadcast, FM SCA, VHF Radio, UHF Radio, Microwave. fiber optics

DA benefits, Capital deferred savings, Operation and Maintenance savings, Interruption related savings, Customer related savings, Economic Evaluation Methods : Development and evaluation of alternate plans, Select study area, Select study period, Project load growth, Develop Alternatives, Calculate operating and maintenance costs, Evaluate alternatives., Break even analysis, Sensitivity analysis computational aids.

18. AI TECHNIQUES

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

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. 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.

19. POWER SECTOR ECONOMICS AND DEREGULATION

Power Sector Economics: depreciation, fixed & variable cost, profitability indices, net present value, financing of power sector. Different techniques for project evaluation (capital cost, life cycle cost), various aspects of capital costs, Tariff setting principles, Demand side management(DSM) & Integrated resource planning(IRP): Different techniques &objectives of DSM,

Power Sector In India: Evaluation of integrated, monopoly, state owned electricity boards. Introduction to various institutions in Indian power sector & their role. Challenges before the Indian power sector, Planning commission CEA,NT,PFC, ministry of power SEBS.

Power sector restructuring : Structural models (single buyer model wholesale competition Retail competition) Ownership model (Public sector state owned and municipal utilities , joint sector , cooperatives and private sector). Review of International experience of Restructuring :- Rational for restructuring , structural and ownership changes , outcomes , technological aspects of restructuring , Impact of Power Sector restructuring on DSM , IRP , and Regulation.

20. VOLTAGE STABILITY

Introduction to Voltage Stability, Voltage Collapse, Voltage Security; Factors affecting Voltage collapse and instability; Previous cases of voltage collapse incidences, Graphical Analysis of Voltage Stability, Comparison of Voltage and angular stability of the system; P-V and Q-V curves.

Analysis of voltage stability on SMLB system: Analytical treatment and analysis. Voltage Stability Indices, Voltage collapse proximity indicator; Determinant of Jacobin as proximity indicators; Voltage stability margin, Power System Loads that influences voltage stability: Discharge lights, Induction Motor, Air-conditioning, heat pumps, electronic power supplies, OH lines and cables.

Reactive Power Compensation: Generation and Absorption of reactive power; Series and Shunt compensation; Synchronous condensers, SVC s; Booster Transformers. Voltage security.