Course-Detail

Semester	Core	Elective	Project	Thesis	Total (Credits)
I	16 credits	0-4 credits			16 – 20
II	8 credits	4-12 credits			12 – 20
III*		0-8 credits	4 credits		4 – 12
IV				16	16
TOTAL					**60**

FIRST YEAR FIRST PART

OPTIMIZATION TECHNIQUE **EG 801 EE**

Optimization Techniques: Linear programming, Non-linear programming, Quadratic programming;
Differential equations: Non-linear differential equations, partial differential equation;
Simultaneous equation: Matrix and determinants, Eigen values and Eigen vectors;
Probability and statistical analysis.

DIGITAL SIMULATION AND ANALYSIS OF POWER SYSTEM EG 802 EE

Static Modeling of Power System and its Components: Modeling of lines, transformers, generators & loads, Z_{bus} and Y_{bus} formation;
Load flow Methods: Gauss-Seidel method, N-R method, fast decoupled methods, D.C. load flow, Sparcity of network admittance matrices & triangular decomposition;
Power system security: Short circuit studies for large power system networks, static security assessment contingencies screening & analysis;
Network reduction & static equivalents;
Transient in Power systems: Surge characteristics of transmission lines, Electromagnetic transient calculations, Over voltage on sudden loss of load, Voltage dips, control strategies;
Application of power system software packages.

DISTRIBUTION SYSTEM PLANNING AND MANAGEMENT EG 803EE

Rural & urban distribution: Major characteristic differences, load density, load patterns, load forecasting & load management; Assumptions & input data required for load forecast, load forecast methodology, optimal load management criterion & constraints
Distribution system load flow techniques: Various load flow criterion for radial distribution networks, considerations of looped networks;
Distribution system planing: Primary and secondary distribution route alignment, area substation selection, technical & non-technical losses, technical & financial constraints, economical analysis;
Voltage Control: Voltage drops due to real and reactive component of load, optimal VAR control, voltage regulators;
Distribution system protection :Over-current protection devices for distribution system, fault current calculation, coordination of protective devices;
Distribution system automation :

EG 804EE

POWER SYSTEM DYNAMICS AND STABILITY

Dynamic modeling of power system components: Generators (Non-linear and linear, excitation system (IEEE standard models), turbine and speed governing system, loads, flexible AC transmission system (FACTS) devices;

Transient stability analysis: Single machine-infinite bus system, multi-machine stability, network reduction and numerical integration methods;

Small signal stability analysis: Eigen value and participation factor analysis, single machine-infinite bus and multi-machine simulation, effect of excitation system and AVR, power system stabilizer and SVS supplementary controls;

Voltage stability: P-V and Q-V curves, impact of load and tap-changer dynamics, static analysis, sensitivity and continuation methods.

FIRST YEAR SECOND PART

POWER SYSTEM PLANING AND ECONOMICS **EG 851 EE**

Introduction to power system planning; Characteristics of electricity demand and its representation; Electricity demand forecast; Demand side management: end-use efficiency improvement, techno-economic analysis; Characteristics of electricity generating technologies; Dynamic programming and unit commitment based on dynamic programming; Levelized busbar cost analysis; Screening curve analysis Generation system reliability; Insvesment planning model ; WASP IV - generation planning program; Transmission planning and pricing; Electricity pricing : Peak load pricing, Marginal cost pricing, Avoided cost pricing; Environmental considerations in power

POWER SYSTEM OPERATION AND CONTROL **EG 852EE**

Economic Operation: Economic load dispatch, Use of loss formulae, Linear programming to E.L.D, Economic emission dispatch, Water discharge characteristic of hydro units, Hydro thermal scheduling, Unit commitment; Power system security: System security, Optimal power flow considering security constraints; Reactive Power Generation Control: Control strategy of reactive power generation, Methods of supplying reactive power, Reactive power capability of alternator, Basic concept of reactive power dispatch; State Estimation: State estimation fundamental, DC state estimation, Least-squares estimation, AC state estimation, Advanced topics in state estimation, Application of power system state estimation; Load Frequency Control/AGC Control: Block diagram and transfer function representation of turbine model, Modeling of governing system, Generator and load modeling, Static and dynamic response, Secondary ALFC, Control area, Multi-area system, Tie-line model, PID controllers.

POWER ELECTRONICS AND DRIVES (ELECTIVE) **EG 873EE / EG923EE**

Review of Power Electronic Devices and Firing circuits; Rectifiers: Single phase and three phase rectifier, Semi controlled and fully controlled rectifiers , 6 pulse and 12 pulse operation, PWM controlled rectifier; Inverters : Single phase and three phase inverter, Effect of harmonics in torque production, PWM inverter, Current source inverter; DC Chopper : Step down chopper, Step up chopper, Four quadrant operation of chopper; AC voltage controller: Single phase and three phase ac voltage controller, Cylco-converter, AC voltage controller with PWM control; Applications in dc and ac drives; Applications in Power System: HVDC transmission system, VAR compensation, Transformer tap changer, Phase shifting transformer.

POWER SYSTEM RELIABILITY (ELECTIVE) EG 876 EE / EG927EE

Basic probability theory; Engineering applications of binomial distribution; Network modeling and evaluation of simple systems and complex systems; Probability distribution in reliability evaluation; System reliability evaluation using probability distributions; Discrete markov chains and Continuos markov process; Frequency and duration techniques; Approximate system reliability evaluation; generating capacity.

FLEXIBLE AC TRANSMISSION SYSTEMS(ELECTIVE) G 872EE / EG922EE

Introduction : Need and Concepts of FACTS Controllers; Reactive Power Control in Power Systems: Uncompensated Transmission Lines, Lines with Passive Compensation-Shunt Compensation and Series Compensation; Conventional Reactive Power Compensators: Synchronous Condensers, Thyristor Controller Reactor (TCR) , Thyristor Switched Capacitor (TSC), Fixed Capacitor – TCR, Comparison of different controllers; SVC Control : Basic Control System Components, Modelling of SVCs, Concepts of SVC Voltage Control, Design of Voltage Controller; Applications of Static Var Compensators : Load Compensation, Increase in Steady State Power Transfer Capacity, Enhancement of Transient Stability, Improvement of System Damping, Suppression of Sub-synchronous Resonance, Prevention of Voltage Instability, Improvement of HVDC Link Performance; Thyristor Controlled Series Capacitor (TCSC) : Principle of Operation, Control of TCSC, Modelling of TCSC; Applications of TCSC : Improvement of System Stability, Enhancement of System Damping, Suppression of SSR, Prevention of Voltage Instability; Emerging FACTS Controllers: Static Synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC), Unified Power Flow Controller (UPFC)

EXTRA HIGH VOLTAGE AC TRANSMISSION (ELECTIVE) EG 878EE / EG928EE

EHV Transmission Line Trends : Standard Voltage, Power handling Capability, HVAC & HVDC, Electric Fields and their estimation, Types of Fields; Electrical Aspects of EHV lines : Over voltages on EHV Lines, power frequency, switching & Lightning over voltages, over voltage protection schemes & Insulation co-ordination; Partial Discharge(PD) & Corona : Types of PD & Coronas (Glow, streamer & Leader), Corona Power loss, EMI & AN due to corona, Selection of conductors based on corona performance; HV power cables & Gas insulated systems: their development; design and performance Series & Shunt compensations: Sources & sinks of reactive power, sub synchronous Resonance & Ferro Resonance, Fixed and static VAR compensation; EHV Testing & Laboratory Equipment : Standard wave shapes of lightning and switching Impulse Voltages, Generation & measurement of high AC, DC and Impulse Voltages, Non-destructive testing.

ELECTRIC UTILITY MANAGEMENT (ELECTIVE) EG 879EE / EG929EE

Organization of Electric Utilities; Regulation of Electric Utilities; Deregulation of Electric Utilities; Restructuring and Privatization of Electric Power Industries; Financing of Power Sector Investment, Traditional Financing, Project Financing and Risk Analysis; Electric utility Financial Statement Analysis, Income Statement, balance Sheet, Funds Flow Statement; Projection of Financial Statement; Corporate Financial Simulation Model

PROJECT APPRAISAL TECHNIQUE (ELECTIVE) EG881EE/EG931EE

Economic Concept: Difference between financial and economic analysis, Shadow pricing, Inflation and escalation, Discount rate; Cost and Benefits of Project: Cost Concepts, Component

of project cost, Assessment of Benefits; Externalities; Preparation of Project Cash flow: Depreciation Concepts, Effect of taxation, incremental cash flow, cash flow statements; Project Evaluation Criteria: Present worth criteria, yield criteria, Payback criteria; Capital Budgeting Decision: Method of financing, Cost of capital, choice of minimum attractive rate of return, Capital Budgeting; Project Risk and Uncertainty: Origin of Project risk, method of describing project risk, probability concepts for investment decision, probability distribution of NPV; Decision Tree Analysis: Structuring a decision tree diagram, sequential decision process, worth of obtaining additional information, decision tree and risk; Case Study 1: Hydropower Project; Case Study 2: Transmission Line Project; Case Study3: Rural Electrification Project.

ARTIFICIAL INTELLIGENCES (ELECTIVE) EG880EE/EG930EE

Introduction to Artificial Intelligence(AI): Definitions, Branches of AI; Data Mining and Knowledge Discovery: Data processing and Normalization, Multivariate data analysis tools(PCA, PLS); Inference Methods: Rule base reasoning & Expert systems, Case base reasoning, Model base reasoning, Causal reasoning, Genetic Algorithms, Application concept of the above approaches; Fuzzy Set Theory and Fuzzy Logic Control: Fuzzy set theory and operations, fuzzy rules, approximate reasoning, defuzzification methods, fuzzy logic expert systems, fuzzy logic control systems; Artificial Neural Networks: Structures and Learning paradigms, simple and multilayer perceptrons, adaline and delta rule, back propagation learning, radial basis function networks, unsupervised neural networks, competitive learning, Kohonen's self organizing maps, Hopfield network; Integration of fuzzy logic and neural networks; Neuro-fuzzy applications: system identification, fault diagnosis and control, pattern recognition and Clustering, AI applications in Power System.

SECOND YEAR FIRST PART

Distributed Generation Technology

(EG883EE/EG933 EE)

Credit: 4

1. **Introduction**
   - 1.1. Energy demand trends in world, Depletion of fossil fuel
   - 1.2. Electrical grid introduction; vertically control grid
   - 1.3. Needs for distributed generation
     - Distributed generation, distributed energy resources (DER), storage technologies
     - Domain of DERs
   - 1.4. Integration and interconnection of distributed energy resources
     - Issues
     - Power electronics control technology
     - Protection
     - Penetration level
   - 1.5. Microgrid
2. **Electrical System Modeling and Simulation**
   - 2.1. Modeling scope and assumptions
   - 2.2. Power system simulation
     - Tools; PSCAD, Matlab, EMTP etc
     - Time frame of interest; short-term, mid-term and long-term
     - Instantaneous, average and phasor simulation
     - Steady state simulation; load flow studies, short-circuit analysis
     - Dynamic simulation
   - 2.3. Modeling of Wind turbine generator system
     - Wind Energy capture, Weibull and Reilygh distribution function
     - Turbines and generators
   - 2.4. Photo voltaic model
   - 2.5. Storage technologies
     - Short, mid and long-term storage
     - Batteries,
     - Hydrogen technology (Fuel cell, Electrolyzer and storage)
     - Supercapacitor and Superconducting magnetic energy storage
   - 2.6. Model development using simulation tools
3. **Control and Interconnecting Schemes for DERs**
   - 3.1. Interconnection and intregation
   - 3.2. Relevant standards; IEEE P1547 and others
   - 3.3. Ac vs. dc interconnection
   - 3.4. Power electronic interfaces for DERs
     - Wind power ,PV, Storage
   - 3.5. Operation of DERs (grid-connected and isolated mode)
   - 3.6. Model development using simulation tools
4. **Microgrid**

4.1. Needs, benefits and issues
4.2. Resource evaluation
4.3. Optimizing integrated system
4.4. Microgrid control, operation and management
4.5. Islanded operation
4.6. Model developments using simulation tools

References

[1] Microgrid and Active distribution Network, S. Chowdury, S. P. Chowdury and P. Crosslay, The Institution of Engineering and Technology, London, 2009
[2] Integration Of Alternative Sources Of Energy, Felix A. Farret, M. Godoy Simos, John Wiley & Sons, Inc., Publication, 2006
[3] POWER ELECTRONICS FOR MODERN WIND TURBINES, Frede Blaabjerg and Zhe Chen, Institute of Energy Technology Aalborg University, Morgan & Claypool Publishers' series 2008.
[4] Renewable and Efficient Electric Power Systems, Gilbert M. Masters Stanford University, A JOHN WILEY & SONS, INC., PUBLICATION

Risk Assessment of Power Systems

MSc in Power Systems Engineering

Credit : 4 (EG884EE/EG934 EE)

Objectives:

- To familiarize with different types of risks in power systems; introduce quantitative risk evaluations techniques, measures of risk reduction and acceptable limits;
- To give broad overview of generating system risk evaluation techniques, transmission system risk evaluation techniques
- To give broad overview of RCM and its application to transmission system maintenance scheduling; analysis of probabilistic spare equipment analysis
- To update recent developments in transmission system pricing- reliability based transmission pricing.

General outline of the course:

1. Introduction to power system risk: Risk in power system, Basic concept of power system risk assessment
2. Outage models of system components: Models of outages, In dependent outages, dependent outages
3. Parameter estimation in outage models: Point estimation of mean and variance of failure data; Interval estimation of mean and variance failure data; Failure frequency of individual components; Failure probability estimation from Binomial distribution; Experimental distribution of failure data; Parameter estimation in aging failure modes
4. Elements of risk evaluation methods: Methods for simple system; methods for complex system

5. Risk evaluation techniques for power systems: Techniques used in Generation-Demand systems; Techniques used in distribution system; techniques used in substation configurations; techniques used in composite generation-transmission systems
6. Risk evaluation in transmission system planning: Concept of probabilistic planning; risk evaluation approach; selection of lowest cost planning alternative; comparison of application of different planning criteria.
7. Risk evaluation of transmission system operation planning: concept risk evaluation in operation planning; risk evaluation methods; determination of lowest risk operation mode; case studies
8. Risk evaluation in generating system planning: concept of reliability based generating systems planning; Generation risk cost; selection of lowest cost generation alternatives; decommission of old generating unit.
9. Selection of substation configuration: Load curtailment models; risk evaluation approach; selection of lowest cost substation configuration
10. Reliability centered maintenance: Basic tasks in RCM; transmission system maintenance scheduling; workforce planning in maintenance; case studies

11. Probabilistic spare equipment analysis: spare equipment analysis based on reliability criteria; spare equipment analysis using probabilistic cost method; determination no. of spare transformer units; determination of spare EHV reactors
12. Reliability based transmission pricing: Basic concept; calculation methods; rate design; applications.

References:

1. Wenyuan Li, “Risk assessment of power systems”, Wliey-Interscience, 2005.
2. Billinton R and Allan R, “Reliability evaluation of power systems”, Plenum Press, 1992
3. Billinton R and Li Wenyuan, “ Power System Reliability evaluation using Monte Carlo Methods”, Plenum Press, 1994

SECOND YEAR SECOND PART

Credit :16

1. Thesis