M.Tech. (Electrical Engineering) with specialization in Power Systems

(Effective from the session 2013-2014)

Course Structure & Scheme of Evaluation

I Semester

Subject Code	**Subject Name**	**L**	**T**	**P**	**Credits**				**Total Marks**
						TA	MSE	ESE	
EE2105	Advanced Power System Operation & Control	3	1	0	4	20	20	60	**100**
EE2106	Advanced Power System Protection	3	1	0	4	20	20	60	**100**
EE21xx	Elective I	3	1	0	4	20	20	60	**100**
EE21xx	Elective II	3	1	0	4	20	20	60	**100**
EE21xx	Elective III	0	0	6	4	50	-	50	**100**

Total Credits = 20

II Semester

Subject Code	**Subject Name**	**L**	**T**	**P**	**Credits**				**Total Marks**
						TA	MSE	ESE	
EE2205	Economic Operation of Power System	3	1	0	4	20	20	60	**100**
EE2206	EHV Transmission Technologies	3	1	0	4	20	20	60	**100**
EE22xx	Elective IV	3	1	0	4	20	20	60	**100**
EE22xx	Elective V	3	1	0	4	20	20	60	**100**
EE22xx	Elective VI	0	0	0	6	50	-	50	**100**

Total Credits = 20

III Semester

Subject Code	**Subject Name**	**Credits**	**Eval (100)**
EE 2395	State of Art Seminar	4	Marks
EE 2396	Thesis	16	Marks

IV Semester

Subject Code	**Subject Name**	**Credits**	**Eval (100)**
EE 2493	Thesis	20	Marks

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component 60%
2. Oral Board evaluation component 40%

M. Tech. (Electrical Engineering) Power Systems

First Semester

EE 2105 Advanced Power System Operation & Control

1) **Introduction:** Modern Power System, Structure of a bulk power system network, concept of synchronous grid, interconnected power system and its elements, concept of reliability, Operational Objectives of a Power System, Hierarchical Control in power systems, ownership and co-ordination, definition of various operating states, nature of various control actions and their significance
2) **Equipment and Stability Constraint in System Operation:** Nature of constraints faced in power system operation, equipment constraints, Generator Constraints, Transmission Line Constraints, Stability Problems in Power Systems, Numerical Solution of Differential Equations, Large disturbance Angle stability, Feedback control systems, Voltage instability
3) **Frequency Control in Power System:** Definition of frequency, load frequency variation, Load characteristics, Solution of non-linear algebraic equations, Calculation of system frequency, Frequency Control, Speed Governer, Automatic Generation Control (AGC)
4) **Voltage and Power Flow Control:** Reactive Power and Voltage Control, Reactive Power Characteristics of special devices, HVDC Converter, Power Flow Control, Controllable Devices,
5) **Real and Reactive Power Scheduling:** Scheduling, control variables and constraints, Real Power Scheduling, Optimization, Real and Reactive Power Scheduling
6) **Preventive, Emergency and Restorative Control:** Control actions, power system state estimation, Normal and alert state in a power system, emergency control, blackout, power system restoration
7) **Power System Structures:** Utility Integration, Deregulation, Indian scenario

.**References:**

1. Prabha Kundur, *Power system stability and control*, Tata McGraw Hill Edition
2. K R Padiyar, *Power System Dynamics stability and control*,
3. Stagg and El-Abiad, *Computer Methods in Power System Analysis,* McGraw Hill Publications
4. R.N Dhar, *Computer Aided Power System Operation and Analysis*, McGraw Hill Publications
5. George L. Kusic , *Computer Aided Power System Analysis* - Prentice Hall Publication.

EE2106 Advanced Power System Protection

1. Evolution of relays from electromechanical relays. Comparators and Level Detectors: Static Relay Functional circuits, Amplitude and Phase comparators, level detectors. Performance and operational characteristics of digital protection. Digital Relays, Microprocessor based protective relays. Mathematical background to protection algorithms:

Finite difference techniques, Interpolation formulas: forward, backward and central difference interpolation. Numerical differentiation, Curve fitting and smoothing, Least squares method, Fourier analysis, Fourier series and Fourier transform, Walsh function analysis.

2. Basic elements of digital protection: Signal conditioning : transducers , surge protection , analogue filtering , analogue multiplexers , Conversion subsystem : the sampling theorem , signal aliasing error, sample and hold circuits, multiplexers , analogue to digital conversion , digital filtering concepts , the digital relay as a unit consisting of hardware and software.
3. Protection algorithms: Sinusoidal wave based algorithms: Sample and first derivative (Mann and Morrison algorithm) Fourier and Walsh based algorithms: Fourier algorithm: Full cycle window algorithm, fractional cycle window algorithm. Walsh function based algorithm.
4. Other algorithms: Least squares based algorithms. Differential equation based algorithms. Travelling wave based techniques.
5. Digital differential protection of Electrical Power system: Digital transformer protection. Digital line differential and distance protection. Digital protection of motors
6. Recent advances in digital protection of power systems. new technology in grids

References:

1. A.T. Johns and S.K. Salman , *Digital Protection for Power Systems*, Peter Peregrinus Ltd. on behalf of the IEE London U.K.
2. Badri Ram and D.N. Vishvakarma, *Power System Protection and Switchgear*, TMH , New Delhi
3. Y.G. Paithankar, *Transmission Network Protection Theory and Practice*, Marcel Dekker, USA
4. Arun G. Phadke and J.S. Thorp, *Computer Relaying for Power Systems,* John Wiley and Sons Ltd. England and Research Studies Press Ltd.
5. Y.G. Paithankar and S.R. ,Bhide: *Fundamentals of Power System Protection*, 2nd Edition PHI Learning Pvt. Ltd , New Delhi India , July 2010
6. J.L. Blackburn, *Protective Relaying: Principles and Applications*, Marcel Dekker, New York, 1987.
7. Areva, *Network Protection Application Guide*

<u>Second Semester</u>

EE 2205 Economic Operation of Power System

System operational concept, optimum operating strategies, optimum dispatch neglecting losses, development of loss formulae, optimal load flow including real and reactive power control, Generation rescheduling, Modelling concept of AGC, Automatic generation and control including single and multiple area cases, Real time control and system security, contingency evaluation and state estimation, Advance concept of energy control centres, , multi area economic dispatch, supervisory control and data acquisition systems (SCADA) and WAMs. Future aspects: Generation participation in grids.

References:

1. L. K. Kirchmayr, *Economic Control of Interconnected Systems*, J. Wiley Publications
2. Robert H. Miller, *Power System Operation*, TMH Publications & James H. Malinowski
3. D.P. Kothari, I.J. Nagrath, *Modern Power System Analysis*, TMH

EE 2206 EHV transmission Technologies

Necessity of EHV AC transmission – advantages and problems–power handling capacity and line losses, mechanical considerations– ground return-Voltage gradients of conductors: Corona effects-Power loss and audible noise (AN) – corona loss formulae, Radio interference (RI) – corona pulses generation, properties, limits – frequency spectrum , modes of propagation , excitation function – measurement of RI, RIV and excitation functions. Electrostatic induction in un-energised circuit of double-circuit lines- electromagnetic interference.

Traveling wave theory-Traveling wave expression and solution, source of excitation, terminal conditions, open circuited and short-circuited end- reflection and refraction coefficients-Lumped parameters of distributed lines generalized constants-No load voltage conditions and charging current.

EHV Transmission levels, Design considerations, various components of EHV Transmission systems,

References:

1. R. D. Begamudre, *EHVAC Transmission Engineering*, New Age International (P) Ltd.
2. S. Rao, *HVAC and DC Transmission,*

List of Professional Electives for Power System

List of Professional Elective I

1. EE 2131 Flexible AC Transmission Systems
2. EE 2132 Advanced Energy Management System
3. EE 2111 Optimization Techniques

List of Professional Elective II

1. EE 2133 Power Quality and mitigation
2. EE2134 Computer Aided Power System Analysis
3. EE 2135 Renewable Energy & Grid Integration
4. EE 2125 Virtual Instrumentation

List of Professional Elective III

1. EE 2151 Advanced Control Lab
2. EE 2153 Power Electronics Lab
3. EE 2152 Power System Lab
4. EE 2161 Mini Project / Term Project

List of Professional Elective IV

1. EE 2231 Distribution Automation
2. EE 2232 Reliability Engineering
3. EE 2233 HVDC Transmission

List of Professional Elective V

1. EE 2234 Power System Planning
2. EE 2235 Power System Communication
3. EE 2236 Power System Dynamics

List of Professional Elective VI

1. EE 2251 Instrumentation Lab
2. EE 2252 Advanced Power Electronics & Drives Lab
3. EE 2253 Advanced Power System Protection Lab
4. EE 2261 Mini Project / Term Project

EE 2131 Flexible AC Transmission Systems

Introduction to FACTS, challenges and needs, Power Flow in AC transmission line, Power flow control, Description and definition of FACTS controllers, Static power converter structures, Voltage-sourced and current-sourced converters, Converter output and harmonic control, power converter control issues, Shunt Compensation: SVC, STATCOM, Operation and control, Configurations and applications, Series Compensation: TCSC, mitigation of sub-synchronous resonance, SSSC, Combination of shunt-series compensation: UPFC, Power flow studies with FACTS controllers, operational constraints, IPFC, UPQC, other FACTS Controllers: TCPAR, TCBR etc.

References:

1. N.G.Hingorani, *FACTS*
2. K.R. Padiyar, *FACTS Controllers in Transmission & Distribution*
3. V. K. Sood, *HVDC and FACTS Controllers: Applications of Static Converters in Power Systems*
4. Enrique Acha, C.R. Feurte, Esquivel and others, *Modelling and Simulation in Power Networks,* Wiley.

EE2132 Advanced Energy management systems

Energy Scenario - Energy Resources - Energy Sector Reforms & Restructuring - Energy Security -Energy Conservation Act and its features - Energy Conservation - Energy Audit - Energy Bench Marking - Maximizing System Efficiencies - Energy Audit Instruments - Duties and Responsibilities of Energy Managers and Auditors - Thermal Energy Efficiency & Audits - Electrical Energy Efficiency - Audits –Energy audit in power distribution system – Loss estimation- Application of Non Conventional and Renewable Energy Systems - Use of Energy Efficient Technologies - Energy Economics - Investment Need and Criteria - Discount rate - Simple Payback - ROI, NPV, IRR, LCC, Overview of PMUs and SCADA

Supervisory control and data acquisition systems (SCADA), Distributed Control System used in real time power systems, SCADA and operating systems. Data loggers and data display system. Remote control instrumentation .Disturbance recorders. Area and Central Control station instrumentation. Frontiers of future power system instrumentation including microprocessor based systems, sequence of events recording (SOE), Dynamic Data Exchange (DDE) module, ETAP (Electrical Transients Analyser Program), energy management system (EMS), substation RTU, RTDS system, Introduction to load forecasting, importance, classification-(span-wise), electricity load profiles, application of load forecasting, accurate load forecasting, deregulation, standards, performance measures, types of electricity load forecasting: Daily load profile, peak load forecasting

Quality data requirement, Data processing techniques, bad data removal, data redundancy, Factors affecting forecasting accuracy: Temperature, pressure, rain fall, humidity, etc. and demographic factors; socio-economic models

Statistical models: Straight line fit, curve fitting methods, univariate and multivariate models, holt-winter model, Time series models/ regression models

Artificial intelligence based models: Fuzzy logic based models, Artificial neural network models, hybrid models; other advance models

Economic aspects, demand side load management, energy conversion, fuel switching and load smoothing by peak clipping, valley filling, load shifting and load shading, etc. role of utility planning, motivating tariff, peak time and off-peak time. Marketing of power, Strategies for Electricity Bill Reduction

References:

1. Albert, *Plant Engineers & Managers Guide to Energy Conservation*.
2. Wayne C. Turner, *Energy management handbook*, John Wiley and Sons.
3. NPC energy audit manual and reports.
4. Cape Hart, Turner and Kennedy, *Guide to Energy Management*,
5. Cleaner Production **–** *Energy Efficiency Manual for GERIAP, UNEP, Bangkok* prepared by National Productivity Council
6. M. K. Lahiri, *Saving of Electricity by System Management*, Lahiri Publication.
7. Box & Jenkins, *Time Series analysis forecasting and control*, Holden-Day Publication.
8. Kalyanmoy Deb, *Optimization for Engineering Design: Algorithms and Examples*, PHI Publication
9. S. A. Soliman and A. M. Al-Kandari, *Electrical load forecasting modeling and model construction*
10. Handschin, E: *Real Time Control of Electric Power Systems*, Elsevier, 1972
11. John D Mc Donald, *Electric Power Substation Engineering*, CRC press, 2001.
12. Wood, A. J and Wollenberg, B. F: *Power Generation Operation and Control*, 2nd Edition John Wiley and Sons, 2003.
13. Green, J. N, Wilson, R: *Control and Automation of Electric Power Distribution Systems*, Taylor and Francis, 2007.
14. Turner, W. C: *Energy Management Handbook*, 5th Edition, 2004
15. M.K. Khedkar, G.M. Dhole, *Electric Power Distribution Automation*, University Science Press

EE 2133 Power Quality and mitigation

Genesis of power quality problem, effects on power system, remedies, harmonics and their mitigation, Over view of Power quality and Power Quality Standards, Long Interruption and Power Quality Evaluation, Short Interruption, Voltage Sag (Characterization, Equipment Behaviour, Stochastic Assessment), Mitigation of Interruptions and Voltage sags, Signals, Origin of Power Quality Variations, Processing of Stationary signals, Processing of Non Stationary Signals, Statics and Variables, Origin of Power Quality events, Triggering and segmentations, Characterization of Power quality Events, Event classification, Event statics, passive filters, capacitor banks and power electronics based solutions.

References:

1. M. H. J. Bollen, *Understanding Power Quality Problems Voltage sags and Interruptions*
2. M. H. J. Bollen, Irene, Yu.HuaGu, *Signal Processing of Power Quality Disturbances*
3. C. Sankaran, *Power Quality,* CRC Press

EE2134 Computer Aided Power System Analysis

Unit –I
Network Modelling and Power Flow I: System graph, loop, cutest and incidence matrices, y-bus formation, sparsity and optimal ordering, power flow analysis, Newton Rap son method.

Unit –II
Network Modelling and Power Flow II: Decoupled and fast decoupled method, formulation of three phase load flow, dc load flow, formulation of AC-DC load flow, sequential solution technique.

Unit –III
Analysis of three phase symmetrical and unsymmetrical faults in phase and sequence domain, Phase shift in sequence quantities due to transformer, open circuit faults.

Unit –IV
Stability Studies: Transient stability analysis, swing equation, stability of multimachine system using modified Euler method and Runge-Kutta method

Unit –V
Power System Security: Factors affecting security, State transition diagram, contingency analysis using network sensitivity method.

Unit –VI
AC power flow method, introduction to state

References:

1. D. P. Kothari and I. J. Nagrath, *Modern Power System Analysis*, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
2. Hadi Saadat, *Power System Analysis*, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2002.
3. George L. Kusic, *Computer Aided Power System Analysis,*. Prentice Hall of India (P) Ltd., New Delhi, 1989.
4.J. Arrilaga, C. P. Arnold, B. J. Harker, Computer *Modelling of Electric Power System*, John Wiley & Sons.K.

5 Mahailnaos, D. P. Kothari, S. I. Ahson, *Computer Aided Power System Analysis & Control*, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1988.
6. G. T. Heydt, *Computer Analysis Methods for Power Systems*, Macmillan Publishing Company, New York.
7. L. P. Singh, *Advanced Power. System Analysis and Dynamics*, New Age International Publishers, New Delhi

EE 2135 Renewable Energy & Grid Integration

Syllabus: Wind energy conversion systems, Wind turbines, Turbine characteristics, Various electrical generators, Induction generators, doubly-fed induction generator, Synchronous generator and permanent magnet synchronous generator (PMSG). Power conversion through power electronics converters, Maximum Power point tracking (MPPT), Controlled rectifiers and DC-DC converters for MPPT, Voltage source inverters, Modeling and control of WECS for grid interface, Standalone and grid interface application, Solar photovoltaic (PV) system, classifications, PV characteristics, MPPT methods, DC-DC converters and VSI, roof-top and domestic PV systems, Grid connected PV system, Fuel cells, classification and characteristics, power electronics interfaces, Hybrid systems, Other renewable sources of energy, Integration of renewable energy systems.
Components required for grid integration. Energy storage components and integration with the grids.Large energy storage technologies (MW).Grid integration issues and standards. Adequate converter topologies, tariff related to renewable energy interface.

References:

1. M. R. Patel, *Wind and Solar Power Systems*, Tailor & Francis CRC Press, USA, 2006.
2. M. H. Rashid (ed), *Power Electronics Handbook*, Academic Press, Florida, 2001.
3. Bin Wu, Yongqiang Lang, NavidZargari, *Power Conversion and Control of Wind Energy Systems*, WILEY 2011.
4. A. Ghosh and G. Ledwich, *Power Quality Enhancement using Custom Power Devices*, Kluwer Academic Publisher, Boston, MA, 2002.

EE 2152 Power System Lab I

LIST OF EXPERIMENTS

1. Discrete Fourier transform and its application for extraction of fundamental phasor in Power Transmission System
2. Study of SVC and STATCOM and their Models incorporated in Transmission System
3. Current transformer saturation detection and its effect on the performance of Distance Relay.

4. Explain for a small disturbance the phenomenon of steady state stability and transient stability for a transmission system. Obtain the natural response of rotor angle and frequency.
5. Discuss the numerical solution of swing equation by means of runga-kutta method.
6. For a two area system with primary load frequency control loop obtain the frequency deviation for a step disturbance in the load.
7. By the pole placement design obtain the profile of compensated frequency deviation for step input.
8. For a source voltage given by v(t) = 151sin(377t+k) determine the current response after closing the switch with and without dc offset.
9. Load flow analysis with incorporation of FACTS in a transmission system.
10. Determine the ABCD parameter of transmission line.

EE 2253 : Advanced Power System Protection Lab

LIST OF EXPERIMENTS

1. Classification and localization of fault in Transmission system using Neural Network.
2. Mann-Morisson algorithm & its implementation for estimation of peak in fault signal & its application for fault detection objective.
3. Two sample and three sample algorithm for estimation of peak in fault signal.
4. KALMAN filter & its application for fault detection objective.
5. In a transmission system, simulate the fault-current & voltage waveform with distributed parameter of a Transmission line; hence determine the faulted current peak by discrete Fourier transform.
6. High voltage impulse generation test, dielectric test and corona.
7. Application of recursive estimation using least square estimate for relaying algorithm.
8. CT modelling & detection of saturation by Jiles-Arthton theory of ferromagnetic hysteresis.
9. Back-propagation neural network & its exploration for fault classification objective in a transmission system.
10. Study of different Electro-Magnetic relay such as over-current, differential & percentage biased differential protection.

EE 2231 Distribution Automation

Overview of Distribution System Planning – Tools for distribution system planning and design.
Substation Automation – Data acquisition from field devices and supervisory control of field devices, Fault location, Fault isolation, service restoration, substation reactive power control
Feeder level Automation- -Data acquisition from Field devices at feeder level, supervisory control of field devices, Fault location, Fault isolation, service restoration, Feeder reconfiguration, feeder reactive power control.
Customer level Automation- automatic meter reading, Remote programming of time-of-use (TOU) meters, Remote service connect / disconnect, Automated customer claims analysis
Control hierarchy and control centre architecture, RTU's, IEDs, PLCs, Use of GPS and GIS systems for Asset/Facilities management.
Cost benefit analysis of Distribution Automation schemes, distribution automation roadmaps of prominent utilities in Europe and US, distribution automation in Indian utilities.

References:

1. Mary S. Nardone, *Direct Digital Control Systems: Application Commissioning*, Kluwer.
2. Klaus-Peter Brand and others, *Substation Automation Handbook*
3. M.K.Khedkar, G.M. Dhole, *Electric Power Distribution Automation*, University Science Press
4. A.S.Pabla, *ElectricPower Distribution*, TMH

EE2232 Reliability Engineering

Principles, Concepts and Definitions of Reliability Engineering, Common Tools for Improving R&M; (Maintainability Engineering), Basic Reliability Calculations, Predictions and Estimation, Apportionment Methods; (Reliability Measures, Static Rel Models), Review of Probability Concepts, Discrete & Continuous Models, Life Distributions; Exponential Distribution; Weibull Distribution, Basics of reliability & Empirical Reliability Measures, Part Selection and Derating, Reliability Plots and Model Selection, Reliability Testing & Planning; (Success/Failure Testing Schemes), Failure Mode & Effect Analysis/Fault Tree Analysis, Design Review Procedures (one session), Reliability Growth Management (one session), Life Cycle Costing

References:

1. Lloyd and Lipow, *Reliability: Management, Methods, and Mathematics*
2. O'Connor, *Practical Reliability Engineering*

3. Kapur & Lamberson, *Reliability in Engineering Design*
4. Lewis, *Introduction to Reliability Engineering*

EE 2233 HVDC Transmission

Introduction of DC Power transmission technology: Comparison of AC and DC transmission, Application of DC transmission, Description of DC transmission system, Planning for HVDC transmission, Modern trends in DC transmission

Analysis of HVDC converters: Number of pulses, Choice of converter configuration, Simplified analysis of Graetz circuit, Converter bridge characteristics.

Compounding and regulations**:** General, Required regulation, Inverter compounding, Uncompounded inverter, Rectifier compounding, Transmission characteristics with the rectifier and inverter compounding, Communication link, Current regulation from the inverter side , Transformer tap changing

Harmonics and filters: Introduction, Generation of harmonics, Design of AC filters and DC filters, EMI.

HVDC cables and simulation of HVDC systems: Introduction of DC cables, Basic physical phenomenon arising in DC insulation, Practical dielectrics, Dielectric stress consideration, Economics of DC cables compared with AC cables. Introduction to system simulation, Philosophy and tools, HVDC system simulation, Modeling of HVDC systems for digital dynamic simulation. Recent trends like HVDC Lite, offshore Wind Turbines etc.(VSC-HVDC)

References:

1. K. R. Padiyar, *HVDC Power Transmission System*, Wiley Eastern Limited, New Delhi. Second Edition, 1990
2. Edward Wilson Kimbark, *Direct Current Transmission*, Vol.-I, Wiley Interscience, New York, London, Sydney, 1971
3. Colin Adamson and Hingorani N G, *High Voltage Direct Current Power Transmission*, Garraway Limited, London, 1960.
4. J. Arrillaga, *High Voltage Direct Current Transmission*, Peter Pregrinus, London, 1983.
5. Rakesh Das Begamudre, *Extra High Voltage AC Transmission Engineering*, New Age International (P) Ltd., New Delhi, 1990

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EE 2234 Power System Planning

System planning from national policy document published by power grid. Objectives of planning–Load forecasting and its methodology-peak demand forecasting – total forecasting – annual and monthly peak demand forecasting.

Reliability Analysis in a statistical perspective– exponential distributions – meantime to failure – series and parallel system Markov process –recursive technique-Generator system reliability analysis. Probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis – corporate model – energy transfer and off peak loading.

Transmission system reliability and its analysis–average interruption rate-LOLP method-frequency and duration method.

Two plant single load system-two plant two load system-load forecasting uncertainty in interconnections. System modes of failure.

References:

1. Sullivan, R.L., *Power System Planning*, Heber Hill, 1987.

EE2235 Power System Communication

Introduction: Communication links required in telemetry, tele-control and tele-protection. . Analogue and Digital Communication: Speed and banding requirements, Noise in Power Systems. Communication Links: PLCC, Microwave, Telephone Line, Satellite. Fibre Optic, Requirements of Various Communication Equipments used in Power Systems, Computer Networking in Power Systems.

References:

1.William Stallings, *Data and Computer Communication*, PHI, 1994.
2. John Gowar, *Optical Communications Systems*, PHI, 1993.
3. R.E. Collin,*Foundations of Microwave Engineering*.
4. Theodore S. Rappaport,*Wireless Communication*, Principles and Practice, IEEE Press; PH PTR,1996
5. K. Feher, *Wireless Digital Communications*, PHI, 1995.
6. A.S. Tanenbaum, *Computer Network*:
7. *Related IEEE/IEE Publications.*

EE 2236 Power System Dynamics

Unit –I
Introduction General basic concept of Power System Stability, States of operation & System Security, System Dynamics Problems, Review of Classical Model, System Model, Analysis of Steady State Stability & Transient Stability

Unit –II
Modeling of Synchronous Machine Synchronous Machine, Park's Transformation, Analysis of Steady State Performance, P. U. Quantities, Equivalent Circuit of Synchronous Machine

Unit –III
Excitation systems & Prime Mover Controllers: Simplified Representation of Excitation Control, Excitation systems, Modeling, Std. Block Diagram, State Equations, Prime Mover Control System, Transmission Line & Load Modeling

Unit –IV
Dynamics of Synchronous Generator Connected to Infinite Bus System Model, Synchronous Machine Model, System Simulation, Consideration of other Machine Models including SVC Model

Unit –V
Small signal Stability -Single and multi-machine system, Damping and Synchronizing torque Analysis, Power System Stabilizers

Unit –VI
Transient Stability and Voltage Stability Evaluation and Simulation, application of energy functions for direct stability evaluation, TS controllers. Voltage Stability: Introduction, affecting factors, analysis, comparison with angle stability

Reference Books :

1. K. R. Padiyar, *Power System Dynamics – Stability & Control*, BS Publications
2. I. J. Nagrath and M. Gopal, *Control system engineering*, Wiley Eastern Ltd, 3rd edition, 2000.
3. Benjamin C. Kuo, *Automatic Control system,* Prentice Hall of India Pvt Ltd.
4. Prabha Kundur, *Power System Stability and Control,* Tata McGraw Hill