Veer Surendra Sai University of Technology, Burla
Department of Electrical Engineering
Master of Technology in Power System Engineering (Two Years Regular Course) 2010-11

1st. Semester							
Sl.No.	Subject Code	Subject	Hours			Credit	Total Contact Hours
			L	T	P		
1		Power System Management	4	0	0	4	
2		Power System Analysis	4	0	0	4	
3		Operation and Control of Restructered Power System	4	0	0	4	
4		Distribution System Engineering	4	0	0	4	
5		**Elective -I(Any one)**	4	0	0	4	
		Power Electronics Control of Drives					
		Power System Transients					
		Dynamics of Electrical Machines					
		Advanced Control Systems					
6		Power System Lab.-I	0	0	6	4	
7		Seminar-I	0	0	3	2	
8		Comprehensive Viva Voce	0	0	3	2	
		Total	20	0	12	28	32

2nd. Semester							
Sl.No.	Subject Code	Subject	Hours			Credit	Total Contact Hours
			L	T	P		
1		Power System Dynamics	4	0	0	4	
2		Reliability of Power System	4	0	0	4	
3		FACTS Modelling, Control & Applications	4	0	0	4	
4		Power System Optimisation	4	0	0	4	
5		**Elective-II (Any one)**	4	0	0	4	
		Computer Aided Power System Protection					
		Power Quality					
		Non Linear System Theory					
		Non-Conventional Electrical Energy Systems					
6		Power System Lab.-II	0	0	6	4	
7		Seminar-II	0	0	3	2	
8		Comprehensive Viva Voce	0	0	3	2	
		Total	20	0	12	28	32

3rd. Semester							
Sl.No.	Subject Code	Subject	Hours			Credit	Total Contact Hours
			L	T	P		
1		Dissertation Interim Evaluation	0	0	0	10	
2		Seminar on Dissertation	0	0	0	3	
3		Comprehensive Viva Voce	0	0	0	2	
		Total	0	0	0	15	

4th. Semester							
Sl.No.	Subject Code	Subject	Hours			Credit	Total Contact Hours
			L	T	P		
1		Dissertation Open Defence	0	0	0	5	
2		Dissertation Evalaution	0	0	0	20	
		Total	0	0	0	25	

(1ST SEMESTER)

MEE-101 POWER SYSTEM MANAGEMENT (3-1-0)

MODULE-I (10 HOURS)

Load characteristics and load forecast

Basic definitions- load definitions, load factor definitions, diversity principle in distribution systems, Load Forecast- factors affecting load forecasting methods, small areas load forecasting, spatial load forecasting methods, simulation, trending and mixed load forecasting methods

MODULE-II (10 HOURS)

Basics of Power System Economics & Short-term Operation Planning of Power System, Load curves and load duration curves, Economic load dispatch- concept of marginal cost and Kuhn-Tucker's condition of optimum in power dispatch, participation factors Classical method to calculate loss coefficients, Loss coefficient calculation using Y-Bus, Loss coefficients using sensitivity factors, Transmission loss coefficients, Transmission loss formula

MODULE-III (10 HOURS)

Power Pools & Electricity Markets

Inter-area transactions, multi-area power interchanges, Energy brokerage systems, Market design and auction mechanism, Pool versus bilateral markets and price formation, Role of independent generators and system operator

MODULE-IV (10 HOURS)

Power Sector Financing

Time value of money, utility economic evaluation, Capacity planning issues and methods- Levelizing and levelized bus-bar analysis, Screening curve analysis, Horizon-year generation additions analysis, Capacity planning in competitive environment

BOOKS

[1]. A. J. Wood and B. F. Wollenberg, *"Power generation, operation and control"*, Wiley-Interscience, 2nd Edition, 1996.

[2]. H. G. Stoll, *Least-cost electric utility planning*, Wiley-Interscience, 1989.

[3]. K. Bhattacharya, M. H. J. Bollen and J. E. Daalder, *Operation of restructured power systems,* Kluwer Academic Publishers, USA, 2001.

(1ST SEMESTER)

MEE-102 POWER SYSTEM ANALYSIS (3-1-0)

MODULE-I (10 HOURS)

Power Systems Review: Review of basic concepts- per unit systems, ac circuits, phasors, power system structure and topology

System Modeling: From Detailed to Approximate Including Their Controls

Generation: generator, exciter, voltage and frequency regulators, prime-mover

Transmission systems: transformers and lines, including distributed parameter models

Loads: RL, motor drives and aggregated models

MODULE-II (10 HOURS)

Power flow analysis, Optimal power flow, Solution of OPF by Gradient method, Newton's method, LP method, Security constrained OPF, Continuation power flow, Sparse matrix techniques for large scale system problems

MODULE-III (10 HOURS)

Unit commitment of generators, Hydro-thermal coordination- hydrological coupling between hydro power stations, power balance and discharge equations, formulation of the operational planning problem, pumped storage units and their scheduling, Generation with limited energy supply, Probabilistic production simulation

MODULE-IV (10 HOURS)

Power System Security, Contingency analysis, sensitivity factors, preventive & corrective measures, State Estimation in Power Systems, Weighted lest square estimation, Estimation in AC network, Orthogonal decomposition.

BOOKS

[1]. P. Kundur, *Power system stability and control*, McGraw-Hill, 1994

[2]. Stagg G.W. , EL Abiad A.H. , "*Computer methods in power system analysis*", McGraw Hill, 1968.

[3]. A. J. Wood and B. F. Wollenberg, "*Power generation, operation and control*", Wiley-Interscience, 2nd Edition, 1996.

[4]. A. R. Bergen and V. Vittal, *Power systems analysis*, Second Edition, Prentice-Hall

[5]. J. Arrillaga and C. P. Arnold, *Computer analysis of power systems*, John Wiley, 1990.

(1ST SEMESTER)

MEE-103 OPERATION AND CONTROL OF RESTRUCTURED POWER SYSTEMS (3-1-0)

MODULE-I (10 HOURS)

Fundamentals of Electricity Markets and Energy Auctions

Review of Concepts- marginal cost of generation, least-cost operation, incremental cost of generation; Kuhn-Tucker's conditions of optimum, inter-utility interchanges, Supply and demand functions, equilibrium, types of electricity markets, imperfect markets, Bilateral and pool markets, LMP based markets, auction models and price formation, price based unit commitment, country practices, Market power and imperfect competition

MODULE-II (10 HOURS)

Transmission Open Access

Power wheeling transactions and marginal costing, transmission costing, Transmission pricing paradigms- embedded cost based, incremental cost based methods, country practices

MODULE-III (10 HOURS)

Transmission Congestion Management and Transmission Rights

Congestion management methods- market splitting, counter-trading; Effect of congestion on LMPs-country practices, Firm Transmission Rights, FTRs as benefits and liability, FTR auction models, country practices

MODULE-IV (10 HOURS)

Ancillary Services and System Security in Deregulation

Congestion management methods- market splitting, counter-trading; Effect of congestion on LMPs-country practices, Firm Transmission Rights, FTRs as benefits and liability, FTR auction models, country practices, Classifications and definitions, AS management in various markets- country practices, Frequency regulation, reserves & AGC services, Reactive power ancillary services in electricity markets- country practices, System security in deregulation

BOOKS

[1]. S. Stoft, *Power System Economics: Designing markets for electricity*, Wiley-Interscience, 2002.

[2]. K. Bhattacharya, M.H.J. Bollen and J.E. Daalder, *Operation of restructured power systems*, Kluwer Academic Publishers, 2001

[3]. M. Shahidehpour, H. Yamin and Z. Li, *Market operations in electric power systems*, Wiley Interscience, 2002

[4]. D. S. Kirschen and G. Strbac, *Fundamentals of power system economics*, John Wiley & Sons, 2004

(1ST SEMESTER)

MEE-104 DISTRIBUTION SYSTEM ENGINEERING (3-1-0)

MODULE-I (10 HOURS)

Distribution system planning

Short term planning, Long term planning, Dynamic planning, Sub-transmission and substation design, Sub-transmission networks configurations, Substation bus schemes, Distribution substations ratings, Service areas calculations, Substation application curves

MODULE-II (10 HOURS)

Distributed Generation

Standards, DG potential, Definitions and terminologies; current status and future trends, Technical and economical impacts, Definitions and terminologies; current status and future trends, Technical and economical impacts

DG Technologies, DG from renewable energy sources, DG from non-renewable energy sources, Distributed generation applications, Operating Modes, Base load; peaking; peak shaving and emergency power, Isolated, momentary parallel and grid connection

MODULE-III (10 HOURS)

Primary and secondary system design considerations

Primary circuit configurations, Primary feeder loading, secondary networks design

Economic design of secondaries, Unbalance loads and voltage considerations

MODULE-IV (10 HOURS)

Distribution system performance and operation

Distribution automation and control, Voltage drop calculation for distribution networks, Power loss Calculation, Application of capacitors to distribution systems, Application of voltage regulators to distribution systems

BOOKS

[1]. Anthony J. Pansini "*Electrical Distribution Engineering*", CRC Press.

[2]. H Lee Willis, "*Distributed Power Generation Planning and Evaluation*", CRC Press.

[3]. James A Momoh, "*Electric Power Distribution Automation Protection And Control*" CRC Press

[4]. James J. Burke "*Power distribution engineering: fundamentals and applications*", CRC Press.

[5]. T. Gonen, "*Electric Power Distribution System Engineering*", McGraw-Hill, 1986, ISBN 0-07-023707-7

(1ST SEMESTER)

(ELECTIVE-I)

MEE-105 POWER ELECTRONICS CONTROL OF DRIVES (3-1-0)

MODULE-I (10 HOURS)

DC Drives: Evaluation of a dc drive performance, Chopper-fed dc motor drives, Features of a chopper-fed separately-excited dc motor, Current limit control, Steady-state performance of a

dc motor fed from chopper and phase-controlled rectifiers, Dual converters, Three-phase dc motor drives Principles of adjustable-speed ac drives: Selecting an adjustable-speed drive, Constant volts/hertz operation, Generation of adjustable-frequency ac power, Adjustable frequency operation of ac motors.

MODULE-II (10 HOURS)

Speed control of wound-rotor induction motor drives: Theoretical principles of slip-energy recovery, Subsynchronous static converter cascade, Static control of rotor resistance

MODULE-III (10 HOURS)

Adjustable-frequency Induction motor drives: Constant terminal volt/hertz operation and control, constant air-gap flux operation and control, controlled current slip operation, Constant horse power operation, Terminal V/f control, Air-gap flux control Field-oriented control, Implementation of Field-Oriented Control(FOC)

MODULE-IV (10 HOURS)

Adjustable-frequency Synchronous Motor Drives: Types of synchronous machine and their steady-state theory of operation, Adjustable frequency operation.

BOOKS

[1]. V.Subramanyam, “*Thyristorised control of Electric Drives*”, TMH Publishing Company

[2]. J.M.D. Murphy and F.G. Turnbull , ”*Power Electronic control of AC Motors*”, Pregman press, Great Britain,1989

[3]. B.K. Bose, “*Modern Power Electronics and AC Drives*”, Pearson Education, Asia 2002

(1ST SEMESTER)

(ELECTIVE-I)

MEE-106 POWER SYSTEMS TRANSIENTS (3-1-0)

MODULE-I (10 HOURS)

Simple switching transient: - Circuit closing transients, Recovery transients initiated by removal of short circuits, double frequency transients.

Damping: - Generalized damping curves, series R-L-C circuits resistance switching, load switching, and other forms of damping.

Abnormal switching transients: - Normal and abnormal switching, current suppression, capacitance switching, other restriking phenomena.Ferroresonance.

MODULE-II (10HOURS)

Transients in 3phase circuits: Importance of the type of neutral connection, switching a 3-phase reactor with an isolated neutral, 3-phase capacitance switching, the symmetrical component method of solving 3-phase switching transients in star connected transformers, circuit reduction.

Transients in D.C. Circuits and conversion equipments: - Interruption of direct currents, delayed and periodic functions characteristics of thyristor and commutation transients. The current limiting static circuit breaker.Topics on electromagnetic phenomena: - A review of electromagnetic induction with respect to transients. Penetration of magnetic field into conductors under steady state and transient condition. Electromagnetic shielding. Importance of electromagnetic effects for cryogenic systems.

MODULE-III (10 HOURS)

Fast transients: Origin and nature of power system Transients, traveling waves on transmission system, the line equation, the shape attenuation and distortion of waves, reflection of traveling waves , successive reflections, traveling waves on multi conductor systems, transition points on multi conductor circuits.

Travelling waves in transmission lines: Circuit with distributed parameters, wave equation, reflection and refraction of travelling waves, behavior of travelling waves at the line terminations Lattice diagram. Attenuation and disfortion of travelling waves.Multi conductor systems and multi velocity waves.

Lighting phenomena: Scope of lightning problems, the physical phenomena of lightning, interaction of lightning with power systems Factors contributing to good line design.

Switching surges: Normal frequency effects, high charging currents, cancellation waves, recovery voltage, restricting phenomena. Protection of transmission systems against surge. High Frequency Oscillations and terminal transients of Transformer

MODULE-IV (10 HOURS)

INSULATION COORDINATION: Insulation coordination procedures (IEC) for high voltage systems: Design criteria, classification of overvoltages, insulation design for switching, lightning and temporary overvoltages, pollution, application of arresters for protection of lines and stations, statistical methods of insulation coordination, risk of failure, test prescriptions. Insulation coordination procedures (IEC) for low voltage systems: representative overvoltages, selection of clearance and creepage distances, macro and micro environments, testing techniques, transient (switching and lightning) voltage surge suppression in industrial and commercial electrical installations, protection of electronic devices.

BOOKS

[1]. Allan Greenwood , "*Electrical Transients in power Systems*", Wiley Iterscience, 1991

[2]. Lou Van Der Sluis, "*Transients in power Systems*", John Wiley & Sons Ltd, 2001

[3]. R Rudenberg, "*Transient Performance of Electric power systems, Phenomenon in Lumped Networks*", MGH, 1950

[4]. R Rudenterg, "*Electric Stroke waves in power systems, Harvard University press, Cambridge*", Massachusetts, 1968

[5]. Transmission Line Reference Book, EPRI, USA, 1982

(1ST SEMESTER)

(ELECTIVE-I)

MEE-203 DYNAMICS OF ELECTRICAL MACHINES (3-1-0)

MODULE-I (10 HOURS)

Electro dynamical Equations and their Solution . A Spring and Plunger System- Rotational Motion System . Mutually Coupled Coils . Lagrange.s Equation . Application of Lagrange.s Equation to Electromechanical Systems . Solution of Electrodynamical Equations by Euler.s method and Runge-Kutta method . Linearisation of the Dynamic Equations and Small Signal Stability . Differential Equations of a smooth air-gap two winding machine . Conditions for Conversion of Average Power in such a Machine . A two phase machine with current excitation - Interpretation of the Average Power Conversion Conditions in terms of air-gap Magnetic Fields. The Primitive 4 Winding Commutaor Machine- The Commutator Primitive Machine . The Brush Axis and its Significance . Self and Mutually induced voltages in the stationary and commutator windings . Speed e.m.f induced in Commutator Winding . Rotational Inductance Coefficients . Sign of Speed e.m.f terms in the Voltage Equation . The Complete Voltage Equation of Primitive 4 Winding Commutator Machine . The Torque Equation . Analysis of Simple DC Machines using the Primitive Machine Equations.

MODULE-II (10 HOURS)

The Three Phase Induction Motor . Equivalent Two Phase Machine by m.m.f equivalence . equivalent two phase machine currents from three phase machine currents . Power Invariant Phase Transformation . Voltage Transformation . Voltage and Torque Equations of the Equivalent Two Phase Machine . Commutator Transformation and its interpretation . Transformed Equations . Different Reference Frames for Induction Motor Analysis . Nonlinearities in Machine Equations . Equations under Steady State - Solution of Large Signal Transients in an Induction Machine . Linearised Equations of Induction Machine . Small Signal Stability . Eigen Values . Transfer Function Formulation.

MODULE-III (10 HOURS)

The Three Phase Salient Pole Synchronous Machine . Three Phase to Two Phase Transformation . Voltage and Torque Equations in stator, rotor and air-gap field reference frames . Commutator Transformation and Transformed Equations . Parks Transformation . Suitability of Reference Frame Vs kind of Analysis to be Carried out . Steady State Analysis . Large Signal Transient Analysis . Linearisation and Eigen Value Analysis . General Equations for Small Oscillations . Small Oscillation Equations in State Variable form . Damping and Synchronizing Torques in Small Oscillation Stability Analysis. Application of Small Oscillation Models in Power System Dynamics.

MODULE-IV (10 HOURS)

Dynamical Analysis of Interconnected Machines . Machine Interconnection Matrices. Transformation of Voltage and Torque Equations using Interconnection Matrix . Large Signal Transient Analysis using Transformed Equations. Small Signal Model using Transformed Equations. The DC Generator/DC Motor System, The Alternator /Synchronous Motor System, Hunting Analysis of Interconnected Machines Selection of proper reference frames for individual machines in an Interconnected System.

BOOKS

[1]. D.P. Sengupta & J.B. Lynn, "*Electrical Machine Dynamics*", The Macmillan Press Ltd.

[2]. C.V. Jones, "*The Unified Theory of Electrical Machines*", Butterworth, London.

[3]. Woodson & Melcher, "*Electromechanical Dynamics*", John Wiley & Sons

[4]. P.C. Kraus, "*Analysis of Electrical Machines*", McGraw Hill Book Company

[5]. I. Boldia & S.A. Nasar, "*Electrical Machine Dynamics*", The Macmillan Press Ltd.

(1ST SEMESTER)

(ELECTIVE-I)

MEE-202 ADVANCED CONTROL SYSTEM (3-1-0)

MODULE-I (10 HOURS)

SISO Control Analysis and Design Analysis of SISO Control Loops, Classical PID Control, Synthesis of SISO Controllers, Fundamental Limitations in SISO Control, Model error Limitations, Structural Limitations, Frequency Domain design limitations, Architectural Issues in SISO Control, Internal Model Principle , Feedforward and Cascade Control, Anti-wind-up scheme, Introduction to Model Predictive Control

MODULE-II (10 HOURS)

Digital Computer Control, Models for sampled Data Systems, Sample Data Design, Internal Model Principle for Digital Control, Models for hybrid Control, Systems, Analysis of Intersample behaviour

MODULE-III (10 HOURS)

Advanced SISO Control. SISO CONTROLLER Parametrisations, Control Design Based on Optimisation, Synthesis via state space methods, Introduction to Nonlinear Control

MODULE-IV (10 HOURS)

MIMO Control Essentials, Analysis of MIMO Control Loops, Exploiting SISO Techniques in MIMO Control, MIMO Control Design: Design via Optimal control techniques, Model Predictive Control MIMO Controller Parametrisations, Decoupling

Books

[1]. Graham C. Goodwin, Stefan F.Graebe, Mario E.Salgado, “*Control System Design*”, PHI-2002.

[2]. M. Athans and P. Falb, “*Optimal control*”, MGH

[3]. K. Astrom, and B.wittenmark, “*Computer Control Systems: Theory and design*”, Prentice Hall

(1ST SEMESTER)

MEE-191 POWER SYSTEM LAB-I (0-0-6)

Power flow solution using Newton-Raphson Method & Fast Decoupled Load Flow

Optimal Power Flow

Fault Analysis-1

Stability Analysis-1

Simulation of a power plant

Study of single machine infinite bus system

Two Problems using PSCAD/EMTDC software

Two Problems using ETAP software

Two Problems using SIMPOWER

(2^{ND} SEMESTER)

MEE-107 POWER SYSTEM DYNAMICS (3-1-0)

MODULE-I (10 HOURS)

Power System Stability Problems: Basic concepts and definitions, Rotor angle stability, Synchronous machine characteristics, Power versus angle relationship, Stability phenomena, Voltage stability and voltage collapse, Mid-term and long-term stability, Classification of stability.

MODULE-II (10 HOURS)

Small Signal Stability: State space concepts, Basic linearization technique, Participation factors, Eigen properties of state matrix, small signal stability of a single machine infinite bus system, Studies of parametric effect: effect of loading, effect of K_A, effect of type of load, Hopf bifurcation, Electromechanical oscillating modes, Stability improvement by power system stabilizers. Design of power system stabilizers.

MODULE-III (10 HOURS)

Large Perturbation Stability: Transient stability: Time domain simulations and direct stability analysis techniques (extended equal area criterion)

Energy function methods: Physical and mathematical aspects of the problem, Lyapunov's method, Modeling issues, Energy function formulation, Potential Energy Boundary Surface (PEBS): Energy function of a single machine infinite bus system, equal area criterion and the energy function, Multimachine PEBS.

MODULE-IV (10 HOURS)

Sub Synchronous Oscillations: Turbine generator torsional characteristics, Shaft system model, Torsional natural frequencies and mode shapes, Torsional interaction with power system controls: interaction with generator excitation controls, interaction with speed governors, interaction with nearby DC converters, Sub Synchronous Resonance (SSR): characteristics of series capacitor – compensated transmission systems, self – excitation due to induction generator effect, torsional interaction resulting in SSR, Analytical methods, Counter measures to SSR problems.

Voltage stability, System oscillations

BOOKS

[1]. P. Kundur, "*Power system stability and control*", McGraw-Hill, 1994

[2]. P. Sauer and M. Pai, "*Power system dynamics and stability*", Prentice Hall, 1998.

(2ND SEMESTER)

MEE-108 RELIABILITY OF POWER SYSTEM (3-1-0)

MODULE-I (10 HOURS)

Generating Capacity Basic Probability Methods: The generation system model, Loss of load indices, Equivalent forced outage rate, Capacity expansion analysis, Scheduled outages, Evaluation methods on period basis, Load forecast uncertainty, Forced outage rate uncertainty, Loss of energy indices.

Generating Capacity Frequency & Duration Method: The generation model, System risk indices.

MODULE-II (10 HOURS)

Interconnected Systems: Probability error method in two interconnected systems, Equivalent assisting unit approach to two interconnected systems, Factors affecting the emergency assistance available through the interconnections, Variable reserve versus maximum peak load reserve, Reliability evaluation in three interconnected system, multi connected system, Frequency & duration approach.

Operating Reserve: General concepts, PJM method, Extension to PJM method, Modified PJM method, Postponable outages, Security function approach, Response risk, Interconnected systems.

MODULE-III (10 HOURS)

Composite Generation & Transmission Systems: Radial configurations, Conditional probability approach, Network configurations, State selection, System & load point indices, Application to practical systems, Data requirements for composite system reliability.

Plant & Station Availability: Generating plant availability, Derated states & auxiliary systems, Allocation & effect of spares, Protection systems, HVDC systems.

MODULE-IV (10 HOURS)

Distribution Systems Basic Techniques & Radial Networks: Evaluation techniques, additional interruption indices, Application to radial systems, effect of lateral distributor protection, Effect of disconnects, Effect of protection failures, effect of transferring loads, Probability distributions of reliability indices.

Distribution Systems-Parallel & Meshed Networks: Basic evaluation techniques, Inclusion of busbar failures, Inclusion of scheduled maintenance, Temporary & transient failures, Inclusion of weather effects, Common modes failures, Common mode failures & weather effects, Inclusion of breaker failures.

BOOKS

[1]. Billinton Roy& Allan Ronald “*Reliability of Power system*”, Pitman Pub. 1984

[2]. Richard Elect. Brown, “*Electric Power Distribution Reliability*”, CRC Press.

(2^{ND} SEMESTER)

MEE-109 FACTS MODELING CONTROL & APLLICATION (3-1-0)

MODULE-I (10 HOURS)

FACTS concepts and general system considerations: Power flow in AC system, transint stabiltiy and dynamic stability, basic description of FACTS controllers, brief review of voltage sourced converter and current sourced converter, modeling philosophy

Static var compensator (SVC and STATCOM): objectives of shunt compensation, methods of controllable Var Generation, regulation slope, transfer function, V-I and V-Q characteristics, transient stability enhancement, var reserve control, conventional power flow models, shunt variable susceptance model, firing angle model, transient stability model, voltage magnitude control using SVC & STACOM, Application example

MODULE-II (10 HOURS)

Static Series compensators (TCSC and SSSC): objectives of series compensation, improvements of voltage and transient stability, power oscillation damping, subsynchronous damping, transmittable power and transmittable angle charcteristics, control range, conventional power flow models, variable series impedance model, firing angle model, transient stability model, active power flow control using TCSC & SSSC, Application example

MODULE-III (10 HOURS)

Static voltage and phase angle regulator (TCVR and TCPAR): objectives of voltage and phase angle regulators, approaches to TCVR and TCPAR, switching converter based voltage and pahse angle regulators

Unified power flow controller: Basic operating principles, transmission control, independent real and reactive power flow control, power flow models, transient stability model, control structure, basic control system for P and Q control, dynamic performance, Application example

MODULE-IV (10 HOURS)

Breif control studies such as Steady state analysis and control, EMTP studies, power oscillation stability analysis and control, transient stability control

BOOKS

[1]. Y. H. Songs, A. T. Johns, *“Flexible AC Transmission Systems”*, IEE Press, 1999

[2]. N. G. Hingorani, L. Gyugyi, *“Understanding FACTS”*, IEEE Press, Indian Edition, 2001.

[3]. E. Acha, *“FACTS: modelling and simulation in power networks”*, John Wiley & Sons, 2004.

(2ND SEMESTER)

MEE-110 POWER SYSTEM OPTIMIZATION (3-1-0)

MODULE-I (10 HOURS)

Economic Load Dispatch Of thermal Generating Units: Introduction, Generator operating cost, Economic Dispatch problem on a bus bar, Optimal generation scheduling, Economic dispatch using Newton-Raphson method, Economic dispatch using the approximate Newton-Raphson method, Economic dispatch using efficient method,: Function of generation & loads.

MODULE-II (10 HOURS)

Optimal Hydro thermal Scheduling: Introduction, Hydro plant performance Models, Short- Range Fixed-Head Hydro thermal Scheduling, Newton-Raphson for short-range fixed –head hydro thermal scheduling, Approximate Newton-Raphson method for short –range fixed-head hydro thermal Scheduling, Short-Range variable-head hydro thermal scheduling-Classical Method, Approximate Newton-Raphson method for short -range variable-head hydro thermal scheduling, Hydro plant modeling for long term operation, Long-Range generation scheduling of hydro thermal systems.

MODULE-III (10 HOURS)

Multi-Objective Generation Scheduling: Introduction, Multi objective optimization- State of the art, Fuzzy set theory in power system, the surrogate worth trade of approach for multi objective thermal power dispatch problem, multi objective thermal power dispatch- weighing method, multi objective dispatch for active & reactive power balance.

MODULE-IV (10 HOURS)

Stochastic Multi Objective Generation Scheduling: Introduction, multi-objective stochastic optimal thermal power dispatch- $\in$-constant method, multi-objective stochastic optimal thermal power dispatch- The surrogate worth trade-off method, multi-objective stochastic optimal thermal power dispatch- weighing method, stochastic economic-emission load dispatch, multi-objective optimal thermal dispatch- risk/dispersion method, stochastic multi-objective short term hydro thermal scheduling, stochastic multi -objective long-term hydro thermal scheduling

BOOKS

[1]. Kothari D.P, Dhillon J.S, “Power System Optimization” – PHI Private Limited.

[2]. James A Momoh, *“Electric Power System Application of Optimization”*, CRC Press

(2ND SEMESTER)

(ELECTIVE-II)

MEE-111 COMPUTER AIDED POWER SYSTEM PROTECTION (3-1-0)

MODULE-I (10 HOURS)

Introduction To Computer Relaying: Development of computer relaying, Historical background, Expected benefits of computer relaying, Computer relay architecture, Analog to digital converter, Anti-aliasing filter, Substation computer hierarchy.

Relaying Practices: Introduction to protection systems, Functions of a protection system, Protection of transmission lines, Transformer, reactor & generator protection, Bus protection, Performance of current & voltage transformers.

MODULE-II (10 HOURS)

Mathematical Basis For Protective Relaying Algorithms: Introduction, Fourier series, Other orthogonal expansion, Fourier transform, Use of fourier transform, Discrete fourier transform, Introduction to probability & random processes, Random processes, Kalman filtering.

Transmission Line Relaying: Introduction, Sources of error, relaying as parameter estimation, Beyond parameter estimation, Symmetrical component distance relay, protection of series compensated lines.

MODULE-III (10 HOURS)

Protection Of Transformers, Machines & Buses: Introduction, Power transformer algorithms, Generator protection,, Motor protection, Digital bus protection.

Hardware Organisation In Integarted Systems: The nature of hardware issues, Computers for relaying, The substation environment, Industry environmental standards, Countermeasures against EMI, Supplementary equipment, Redundancy & backup, Servicing, training & maintenance.

MODULE-IV (10 HOURS)

System Relaying & Control: Introduction, Measurement of frequency & phase, Sampling clock synchronization, Application of phasor measurements to state estimation, Phasor measurement in dynamic state estimation, Monitoring.

Developments In New Relaying Principles: Introduction, Traveling waves on single-phase lines, Traveling waves on three-phase lines, Traveling waves due to faults, Directional wave relays, Traveling wave distance relay, Differential relaying with phasors, Traveling ` wave differential relays, Adaptive relaying, Examples of adaptive relaying, fault location algorithms, Other recent developments.

BOOKS

[1]. A.G. Phadke and J.S. Thorp, "*Computer Relaying for Power Systems*", John Wiley and Sons, 1994.

[2]. Stanley H. Horowitz and Arun G. Phadke, "*Power System Relaying*", Research Studies Press Ltd., England. J.L. Blackburn, “*Protective, Relaying*”, Marcel Dekker, Inc., 1987.

[3]. "*Computer Relaying*", IEEE Tutorial Course (79EH0148-7-PWR), IEEE Power Engineering Society, NJ, 1979.

(2ND SEMESTER)

(ELECTIVE-II)

MEE-112 POWER QUALITY (3-1-0)

MODULE-I (10 HOURS)

PQ Definitions and StandardsGeneral Classification of PQ Phenomena IEEE and IEC PQ Standards, PQ Monitoring and MeasuringAvailable monitoring techniques and their drawbacks Commercial power quality monitors, Power quality monitors sensitivity PQ Problems Identification, PQ Phenomena ClassificationIdentification and localization of PQ problems Different PQ classification techniques and case studies

MODULE-II (10 HOURS)

Harmonic Sources, Effects, Analysis, and Modeling, Harmonic Distortion MitigationVoltage vs. Current Distortion, Harmonics vs. Transients Harmonic Sources from Commercial and Industrial Loads, Time domain versus frequency domain Different Harmonic filters (passive, active and hybrid); and case studies

MODULE-III (10 HOURS)

Voltage Sag, Swell and Interruptions, Transient Over-voltages, Sources of Sags and Interruptions, Fundamental Principles of Protection, Motor-Starting Sags, Utility System Fault-Clearing.Issues, and Case Studies, Sources of Transient Overvoltages; Principles of Overvoltage Protection and Switching Transient Problems with Loads

MODULE-IV (10 HOURS)

Voltage Flicker, Voltage Unbalance, Voltage RegulationSources of voltage flicker; Effects and mitigation techniques Sources of voltage unbalance; Effects and mitigation techniques Devices for Voltage Regulation; Utility Voltage Regulator Application and End-User Capacitor Application

BOOKS

[1]. R. Dugan, M. McGranaghan, S. Santoso and H. Beaty, Electrical Power System Quality, Second Edition, McGraw-Hill, 2002, ISBN 0-07-138622-X.

[2]. J. Arrillaga, B. Smith, N. Watson and A. Wood, "*Power System Harmonic Analysis*", John Wiley, 1997

[3]. Math H. Bollen , "*Understanding Power Quality*", IEEE Press

[4]. J. Arrillaga, "*Power System Quality Assessment.*", John Wiley, 2000

(2^{ND} SEMESTER)

(ELECTIVE-II)

MEE-113 NON LINEAR SYSTEM THEORY (3-1-0)

MODULE-I (10 HOURS)

Non Linear Systems:

Ordinary differential equation (ODE) systems, Differential & algebraic equation (DAE) systems, Equilibrium points, Limit cycles, pointcare maps, monodromy matrices, dynamic manifolds, region of attraction, Lyapunov stability,

MODULE-II (10 HOURS)

Numerical Methods: Newton Raphson, eigen value computation, initial value problems (IVP) and boundary value problems (BVP)

Definitions of local and global bifurcations saddle node bifurcations, transcritical bifurcations, pitchforks and Hopf bifurcations, Limit induced bifurcations, center manifolds

Normal forms: Lyapunov Schmidt reduction

DAE systems: bifurcations transversality conditions and singularity induced bifurcations

MODULE-III (10 HOURS)

Singular bifurcations computations: continuation methods and direct methods, optimization techniques

Hopf bifurcations computations: continuation methods and direct methods

Bifurcations of limit cycle: definition and computation

MODULE-IV (10 HOURS)

Chaotic Behavior:

Definition and examples of continuous and discrete (fractal) strange attractors.

Mechanisms that lead to chaos: Torus bifurcations period doubling, intermittency, instant chaos, fractal, dimensions, Lyapunov exponents, power spectra.

BOOKS

[1]. R Seydel, "*Practical Bifurcation and Stability Analysis*", Springer Verlag

[2]. M Vidyasagar, "*Nonlinear Systems Analysis*", Prentice Hall

(2ND SEMESTER)

(ELECTIVE-II)

MEE-114 NON CONVENTIONAL ELECTRICAL ENERGY SYSTEMS (3-1-0)

MODULE-I (10 HOURS)

INTRODUCTION TO RENEWABLE ENERGY SOURCES: Introduction to Non-conventional/Renewable Energy Sources & Technologies. Their Importance for Sustainable Development and Environmental Protection. SOLAR RADIATIONS: Measurement and Prediction of Solar Radiations; Instruments for Solar Radiation; Characteristics of Solar Spectra including Wavelength Distribution; Radiation Properties and Spectral Characteristics of Materials; Selective Surfaces & Basics of Solar Collectors. SOLAR THERMAL SYSTEM: Solar Collection Devices; their analysis; Solar Collector Characteristics; Solar Pond; application of solar energy to space heating etc.

MODULE-II (10 HOURS)

BIOMASS: Biomass as an Energy Source; Energy Plantations; Conversion Technologies – Thermal, Chemical and Biological; Photosynthesis, Biogas generation, Classification of Biogas plants. BIOGAS: Principles of Bioconversion: Types of Bioreactors – Batch, Continuous, Plug-flow, Stirred Tank & Film, Reaction Kinetics, Reactor Design and Analysis, materials-Municipal Refuse, Sewerage, Industrial Wastes, Agricultural Wastes, Animal and Human Wastes; Landfill systems; Properties and Uses of Biogas.

BIOFUELS: Bioconversion Techniques – Direct Combustion, Pyrolysis, Flash Pyrolysis Fermentation and Gasification; Utilization of Industrial Wastes such as Bagasse; Household and Community

Combustion Systems – Improved Cook-stoves; Industrial Biomass Combustion Systems; Gasification; Sizing; Beneficiation of Fuels. Thermodynamics & Kinetics of Gasification; Types of Gasifiers–Downdraft, Updraft, Cross flow, Fluidized. Combustion Characteristics of Biofuels; Utilization in Conventional Engines and or Power Generation including Cogeneration.

MODULE-III (10 HOURS)

OTHER RENEWABLE SOURCES OF ENERGY: Waves: Nature and availability of Energy from waves Onshore & Off-shores: Principles of Wave Converters – Raft, Duck, Oscillating Water Columns, Tapered Channels & Buoys; Energy Conversion & Transmission; Secondary Applications of Waves such as Harbour Wall, Seawater Pumping.

WIND ENERGY: Basic Principle; Basic components of a WECS, Classification of W.E.C., Their types, Applications of Wind Energy, Environmental aspects, Wind Energy Developments in India.

MODULE-IV (10 HOURS)

Tides: Origin & nature of Tides, Tidal Heads & Duration; Principles of Tidal Energy Conversion, Site Selection – Single and Multiple Bay System; Cycles & Load Factors; Regulation and Control of Tidal

Power Generator (Ocean Thermal Energy Conversion): Temperate & Tropical Oceans; Principles of OTEC Systems; Site Selection; Power Cycles; Selection of Working Fluids; Pumps & Turbines; Heat Exchanger Criteria; Bio-fueling; Secondary Applications such as Fresh Water Production, Maniculture, etc., Power Transmission & System Efficiency

GEOTHERMAL ENERGY:

Name of Geothermal Resources, Location and Potential Assessment, Classification & Characteristics of Geothermal Resources – Hot Rock, Hot Water & Steam, Chemical & Physical Properties of Geothermal Brines: Control of Scale Deposition, Drilling, Logging & Cementing Operations for Geothermal Wells; Principles of Power Production System & Cycles: Refrigeration, Two-Phase Flow Turbines; Thermal Phase Flow Turbines; Thermal Utilization & Mineral Recovery; Ecological and Safety Considerations.

BOOKS

[1]. S.P. Sukhatme, "*Solar Energy: Principles of thermal Collection and Storage*", Tata McGraw Hill,

[2]. H.P. Garg and Jai Prakash, "*Solar Energy: Fundamentals and Applications*",Tata McGraw Hill

[3]. Chang, "*Energy Conversion*", Prentice Hall

[4]. Soo, "*Direct Energy Conversion*", Prentice Hall

[5]. Bockris and Srinivasan, "*Fuel Cells*", McGraw Hill

[6]. Duffic and Beckman, "Solar Engineering of Thermal Processes", John wiley

(2ND SEMESTER)

MEE-194 POWER SYSTEM LAB-II (0-0-6)

Economic load dispatch using traditional optimization methods

Load forecasting using conventional and soft computing method

Fault Analysis-2

Stability Analysis-2

Fuzzy Inference System

Study of single machine infinite bus system

Two Problems using PSCAD/EMTDC software

Two Problems using ETAP software

Two Problems using SIMPOWER