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ELECTRICAL AND ELECTRONICS ENGINEERING

Paper-I (Choose any one subject)

S.No	**Name of the subject and Subject code**
1.	Analysis of Power Electronic Converters – 10EE101
2.	Electrical Distribution Systems – 10EE102
3.	Power System Dynamics and Stability – 10EE103
4.	Electrical Machine Modeling and Analysis – 10EE104
5.	Partial Discharges in HV Equipment – 10EE105
6.	Power Electronic Control of DC Drives – 10EE106
7.	Power Quality – 10EE107
8.	Programmable Logic controller&applications – 10EE108
9.	Voltage Stability – 10EE109
10.	Demand Side Energy Management –10EE110
11.	AI Techniques – 10EE111
12.	System Identification & parameter Estimation –10EE112

Paper-II (Choose any one subject)

S.No	**Name of the subject**
1.	Advanced Digital Signal Processing – 10EE201
2.	Digital Control Systems – 10EE202
3.	EHV AC Transmission – 10EE203
4.	FACTS Controllers – 10EE204
5.	High Voltage Testing Technology – 10EE205
6.	Renewable Energy Resources – 10EE206
7.	Power Electronic Control of AC Drives – 10EE207
8.	Advanced Power Semi devices & Protection – 10EE208
9.	Power System Reliability -- 10EE209
10.	Reactive power compensation & Management -10EE210
11.	Special Machines and Control – 10EE211
12.	Power System Deregulation – 10EE212
13.	Advanced Power System Protection – 10EE213

Paper-I
ANALYSIS OF POWER ELECTRONICS CONVERTERS

Unit-I Single Phase AC voltage Controllers
Single Phase AC Voltage Controllers with RL and RLE loads-ac voltage controller's with PWM control-Effects of source and load inductances -synchronous tap changers -Application- numerical problems

Unit-II Three Phase AC Voltage Controllers
Three Phase AC Voltage controllers-Analysis of Controllers with star and delta connected resistive, resistive -inductive loads-Effects of source and load inductances-Application- numerical problems.

Unit -III Single phase ac-dc converters
Single phase Half controlled and Fully controlled Converters with RL load- Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-Power factor improvementsExtinction angle control-symmetrical angle control-PWM single phase sinusoidal PWM-Single phase series converters- numerical problems

Unit-IV Three Phase ac-dc Converters
Three Phase ac-dc Converters- Half controlled and fully controlled Converters with RL load- Evaluation of input power factor and harmonic factor-Continuous and Discontinuous load current-three phase dual converters-Power factor improvements-three phase PWM-twelve pulse converters- numerical problems

Unit-V Power Factor Correction Converters
Single-phase single stage boost power factor corrected rectifier, power circuit principle of operation, and steady state- analysis, three phase boost PFC converter

Unit -VI Single phase PWM Inverters
Principle of operation-Voltage control of single phase inverters - sinusoidal PWM - modified PWM - phase displacement Control - Trapezoidal, staircase, stepped, harmonic injection and delta modulation - numerical problems

Unit VII: Three Phase PWM Inverters
Voltage Control of Three-Phase Inverters- Sinusoidal PWM- 60^0 PWM- Third Harmonic PWM- Space Vector Modulation- Comparison of PWM Techniques-current source inverters-Variable dc link inverter - numerical problems

Unit VIII: Multi level inverters
Introduction, Multilevel Concept, Types of Multilevel Inverters- Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode-Clamped Inverter- Flying-Capacitors Multilevel Inverter- Principle of Operation, Features of Flying-Capacitors Inverter- Cascaded Multilevel Inverter- Principle of Operation- Features of Cascaded Inverter- Switching Device Currents-DC-Link Capacitor Voltage Balancing- Features of Multilevel Inverters- Comparisons of Multilevel Converters

Textbooks

1. Power Electronics-Md.H.Rashid -Pearson Education Third Edition- First Indian Reprint- 2008
2. Power Electronics- Ned Mohan, Tore M.Undelan and William P.Robbins -John Wiley & Sons -2nd Edition.

ELECTRICAL DISTRIBUTION SYSTEMS

Unit 1 : General : Introduction to Distribution systems, an overview of the role of computers in distribution system planning-Load modeling and characteristics: definition of basic terms like demand factor, utilization factor, load factor, plant factor, diversity factor, coincidence factor, contribution factor and loss factor-Relationship between the load factor and loss factor - Classification of loads (Residential, Commercial, Agricultural and Industrial) and their characteristics.

Unit 2 : Distribution Feeders and Substations : Design consideration of Distribution feeders: Radial and loop types of primary feeders, voltage levels, feeder-loading.

Unit 3 : Design practice of the secondary distribution system.
Location of Substations : Rating of a Distribution Substation, service area with primary feeders. Benefits derived through optimal location of substations.

Unit 4 : System analysis : Voltage drop and power loss calculations : Derivation for volt-drop and power loss in lines, manual methods of solution for radial networks, three-phase balanced primary lines, nonthree-phase primary lines.

Unit 5 : Protective devices and coordination : Objectives of distribution system protection, types of common faults and procedure for fault calculation.

Unit 6 : Protective Devices: Principle of operation of fuses, circuit reclosers, line sectionalizer and circuit breakers. Coordination of protective devices : General coordination procedure.

Unit 7 : Capacitive compensation for power factor control: Different types of power capacitors, shunt and series capacitors, effect of shunt capacitors (Fixed and switched) power factor correction, capacitor location. Economic justification. Procedure to determine the best capacitor location.

Unit 8 : Voltage control : Equipment for voltage control, effect of series capacitors, effect of AVB/AVR, line drop compensation.

Reference Books :

1. "Electric Power Distribution System Engineering " by Turan Gonen, Mc.Graw-Hill Book Company,1986.

2. Electric Power Distribution-by A.S.Pabla, Tata Mc Graw-Hill Publishing Company, 4th edition, 1997.

POWER SYSTEM DYNAMICS & STABILITY

Unit 1 : System Dynamics : Synchronous machine model in state space form , computer representation for excitation and governor systems -modelling of loads and induction machines.

Unit 2 : Stability - steady state stability limit - Dynamic Stability limit - Dynamic stability analysis.

Unit 3 : State space representation of synchronous machine connected to infinite bus, Time response - Stability by eigen value approach.

Unit 4 : Digital Simulation of Transient Stability : Swing equation, Machine equations

Unit 5 : Concept of Multimachine Stability, Multimachine Transient Stability Under Different Faulted Conditions.

Unit 6 : Effect of governor action and exciter on power system stability. Effect of saturation, saliency & automatic voltage regulators on stability.

Unit 7 : Excitation Systems : Rotating Self-excited Exciter with direct acting Rheostatic type, voltage regulator - Rotating main and Pilot Exciters with Indirect Acting Rheostatic Type Voltage Regulator.

Unit 8 : Rotating Main Exciter, Rotating Amplifier and Static Voltage Regulator - Static excitation scheme - Brushless excitation system.

Reference Books :

1. Power System Stability by Kimbark Vol. I&II, III - 1968, Dover Publication Inc, New York 1968.
2. Power System control and stability by Anderson and Fund, Vol - I, P.M.Arolerson & A.A.fouad, Galgotia Publications 3B/12, Uttari marg Rajunder Nagar, New Delhi - 110060, 1981, 1 st edition.
3. Power System Dynamics Stability and Control by K.R.Padiyar, Second edition B.S.Publications 2002.
4. Computer Applications to Power Systems-Glenn.W.Stagg & Ahmed. H.El.Abiad
5. Power Systems Analysis & Stability - S.S.Vadhera Khanna Publishers.
6. Power System Analysis by "Hadi Saadat" - Tata McGraw Hill Publications
7. Power System Analysis by John J.Graniger William D.Stevenson. JR. - Tata McGraw Hill Publications.

ELECTRICAL MACHINE MODELING AND ANALYSIS

Unit I: Basic concepts of Modeling

Basic Two-pole Machine representation of Commutator machines, 3-phase synchronous machine with and without damper bars and 3-phase induction machine, Kron's primitive Machine-voltage, current and Torque equations.

Unit II: DC Machine Modeling

Mathematical model of separately excited D.C motor - Steady State analysis-Transient State analysisSudden application of Inertia Load-Transfer function of Separately excited D.C Motor- Mathematical model of D.C Series motor, Shunt motor-Linearization Techniques for small perturbations

Unit III: Reference frame theory

Real time model of a two phase induction machine- Transformation to obtain constant matrices-three phase to two phase transformation-Power equivalence-

Unit IV: Dynamic modeling of three phase Induction Machine

Generalized model in arbitrary reference frame-Electromagnetic torque-Derivation of commonly used Induction machine models- Stator reference frame model-Rotor reference frame model-Synchronously rotating reference frame model-Equations in flux linkages-per unit model-Dynamic Simulation

Unit V: Small Signal Modeling of Three Phase Induction Machine

Small signal equations of Induction machine-derivation-DQ flux linkage model derivation-control principle of Induction machine.

Unit VI: Symmetrical and Unsymmetrical 2 phase Induction Machine

Analysis of symmetrical 2 phase induction machine-voltage and torque equations for unsymmetrical 2 phase induction machine-voltage and torque equations in stationary reference frame variables for unsymmetrical 2 phase induction machine-analysis of steady state operation of unsymmetrical 2 phase induction machine- single phase induction motor - Cross field theory of single-phase induction machine.

Unit VII: Modeling of Synchronous Machine

Synchronous machine inductances -voltage equations in the rotor's dq0 reference frame-electromagnetic torque-current in terms of flux linkages-simulation of three phase synchronous machine- modeling of PM Synchronous motor.

Unit VIII: Dynamic Analysis of Synchronous Machine

Dynamic performance of synchronous machine, three-phase fault, comparison of actual and approximate transient torque characteristics, Equal area criteria.

Reference Books:

1. Electric Motor Drives - Modeling, Analysis& control -R.Krishnan- Pearson Publications-1st edition -2002 (For chapter III, IV, V)
2. Analysis of Electrical Machinery and Drive systems - P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff - Second Edition-IEEE Press (for Chapters VI, VII,VIII)
3. Generalized Theory of Electrical Machines - P.S.Bimbra-Khanna publications-5th edition-1995(For chapter I,II)
4. Dynamic simulation of Electric machinery using Matlab / Simulink -Chee Mun Ong-Prentice Hall

PARTIAL DISCHARGES IN HIGH VOLTAGE EQUIPMENT

Unit 1 : Types of partial discharges and its occurrence and recurrence and magnitudes : Definition of Partial discharges, inception of internal discharges, Inception of corona discharges.

Unit 2 : Discharges by electrical treeing. Discharges at AC Voltages, corona discharges, Discharges at D.C. Voltages, discharges at impulse voltages.
Object of discharge detection, Quantities related to the magnitude of discharges, choice of PD as a measure for discharges.

Unit 3 : Electrical discharge detection & Detection circuits : Basic diagram, amplification of impulses, sensitivity, resolution, observation. Straight detection.

Unit 4 : Balanced detection, calibrators, Interferences, choice between straight detection & balance detection, common mode rejection.

Unit 5 : Location of Partial discharges : Non-electric location, location by separation of electrodes, location with electrical probes.

Unit 6 : location by traveling waves, PD location in cables & switchgear by traveling waves. Evaluation of discharges : Recognition, mechanisms of deterioration, evaluation, specification.

Unit 7 : Detection in actual specimen : Detection in capacitors, cables, bushings.

Unit 8 : Transformers, machine insulation, Gas-insulated switchgear.

Reference Book :

Partial Discharges in HV Equipment by F..Kruguer, Butterworths & Co., Publications Ltd., 1989.

POWER ELECTRONIC CONTROL OF DC DRIVES

Unit-I Speed Torque characteristics of DC Motors
Separately excited DC motors, Shunt motor, series motor and compound motor

Unit-II: Controlled Bridge Rectifier (1-Φ) with DC Motor Load
Separately excited DC motors with rectified single phase supply- single phase semi converter and single phase full converter for continuous and discontinuous modes of operation - power and power factor.

Unit-III: Controlled Bridge Rectifier (3-Φ) with DC Motor Load
Three phase semi converter and three phase full converter for continuous and discontinuous modes of operation - power and power factor - Addition of Free wheeling diode - Three phase double converter.

Unit-IV: Three phase naturally commutated bridge circuit as a rectifier or as an inverter
Three phase controlled bridge rectifier with passive load impedance, resistive load and ideal supply - Highly inductive load and ideal supply for load side and supply side quantities, shunt capacitor compensation, three phase controlled bridge rectifier inverter.

Unit-V: Closed loop control of phase controlled DC motor Drives
Open loop Transfer function of DC Motor drive- Closed loop Transfer function of DC Motor drive - Phase-Locked loop control.

Unit-VI:Chopper controlled DC motor drives
Principle of operation of the chopper - Four quadrant chopper circuit - Chopper for inversion - Chopper with other power devices - model of the chopper -input to the chopper - Steady state analysis of chopper controlled DC motor drives - rating of the devices.

Unit- VII:Closed loop control of chopper fed DC motor Drives
Speed controlled drive system - current control loop - pulse width modulated current controller - hysteresis current controller - modeling of current controller - design of current controller

Unit-VIII:Simulation of DC motor Drives
Dynamic simulations of the speed controlled DC motor drives - Speed feedback speed controller - command current generator - current controller.

REFERENCES

1. Power Electronics and Motor Control - Shepherd, Hulley, Liang - II Edition, Cambridge University Press
2. Power Electronic Circuits, Devices and Applications - M. H. Rashid - PHI.
3. Electric Motor Drives Modeling, Analysis and Control - R. Krishnan, Prentice Hall India.
4. Fundamentals of Electric Drives - G. K. Dubey - Narosa Publications - 1995.
5. Power Semiconductor drives - G. K. Dubey.

POWER QUALITY

Unit 1 : Power and Voltage Quality : General, classes of Power Quality Problems, Power quality terms, Power frequency variations, the power quality evaluation procedure.

Unit 2 : Voltage quality : Transients, long and short duration Voltage variations, Voltage imbalance, waveform distortion, Voltage Flicker.

Unit 3 : Voltage sags and Interruptions : Sources of sags and Interruptions. Estimating Voltage sag performance.

Unit 4 : Fundamental Principles of Protection. Solutions at the end-user level. Evaluating Ride-through Alternatives. Motor-Starting Sags.

Unit 5 : Fundamentals of Harmonics : Harmonic distortion. Voltage versus Current distortion. Harmonic indexes. Harmonic sources from commercial loads. Harmonic sources from industrial loads. Locating Harmonic sources. System response characteristics. Effects of Harmonic Distortion.

Unit 6 : Distributed Generation and Power Quality : Resurgence of DG. DG Technologies. Interface to the Utility System. Power Quality Issues. Operating Conflicts. DG on distribution Networks . Siting DG distributed Generation, Interconnection standards.

Unit 7 : **Wiring and Grounding :** Resourses, Definitions, Reasons for Grounding, Typical wiring and grounding problems, Solution to wiring and grounding problems.

Unit 8 : Power Quality Monitoring : Monitoring Consideration. Historical Perspective of power quality measurement equipment. Assessment of Power Quality.

Reference

1. Electrical Power Systems Quality : By ROGER C.DUGAN, Electrotek Concepts Inc. (second edition)

PLC CONTROLLERS AND ITS APPLICATIONS

Unit 1:
PLC Basics: PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

Unit 2:
PLC Programming: Input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill press operation.

Unit 3:
Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams and sequence listings, ladder diagram construction and flow chart for spray process system.

Unit 4:
PLC Registers: Characteristics of Registers, module addressing, holding registers, input registers, output registers.

Unit 5:
PLC Functions: Timer functions and Industrial applications, counters, counter function industrial applications, Arithmetic functions, Number comparison functions, number conversion functions.

Unit 6:
Data Handling functions: SKIP, Master control Relay, Jump, Move, FIFO, FAL, ONS, CLR and Sweep functions and their applications.

Unit 7:
Bit Pattern and changing a bit shift register, sequence functions and applications, controlling of two axis and three axis Robots with PLC, Matrix functions.

Unit 8:
Analog PLC operation: Analog modules and systems, Analog signal processing, multi bit data processing, analog output application examples, PID principles, position indicator with PID control, PID modules, PID tuning, PID functions.

Reference Books:

1. Programmable Logic Controllers - Principle and Applications by John W. Webb and Ronald A. Reiss, Fifth Edition, PHI
2. Programmable Logic Controllers - Programming Method and Applications by JR. Hackworth and F.D Hackworth Jr. - Pearson, 2004.

VOLTAGE STABILITY

Unit 1 : Reactive Power flow and voltage stability in power systems**:** Physical relationship indicating dependency of voltage on reactive power flow - reactive power transient stability; Q-V curve; definition of voltage stability, voltage collapse and voltage security. Voltage collapse phenomenon, Factors of voltage collapse, effects of voltage collapse, voltage collapse analysis.
Reasons for aggravation of the problem.

Unit 2 : Power system loads : Load characteristics that influence voltage stability such as - Discharge lighting, Induction motor, Air conditioning and heat pumps, Electronic power supplies, Over Head lines and cables.

Unit 3 : Reactive Power compensation : Generation and absorption of reactive power - Reactive power compensators & voltage controllers : - shunt capacitors, synchronous phase modifier - static VAR system
- on load tap changing transformer, booster transformers.

Unit 4 : Voltage stability static indices : Development of voltage collapse index - power flow studies - singular value decomposition - minimum singular value of voltage collapse - condition number as voltage collapse index.

Unit 5 : voltage stability margins & Improvement of voltage stability: Stability margins, voltage stability margin of un compensated and compensated power system . Dynamic voltage stability - voltage security , Methods of improving voltage stability and its practical aspects.

References:

1. Performance operation and control of EHV power transmission SystemsA chakrabarti, D.P.Kothari, A.K. Mukhopadhyay, A.H. Wheeler publishing, 1995.

2. Power system Voltage stability - C.W. Taylor , Mc. Graw Hill, 1994

DEMAND SIDE ENERGY MANAGEMENT

Unit-1 : Energy Audit : Definitions-Need-concepts-Types of energy audit; Energy index - cost index - pieharts - Sankey diagrams.

Unit-2 : Energy Economics: Introduction-Cost benefit risk analysis-Payback period-Straight line depreciation-Sinking fund depreciation—Reducing balance depreciation-Net present value methodInternal rate of return method-Profitability index for benefit cost ratio.

Unit-3 : Energy Conservation in Electric utilities and Industry: Electrical load management: Energy and load management devices-Conservation strategies; conservation in electric utilities and industry: Introduction-Energy conservation in utilities by improving load factor-Utility voltage regulation-Energy conservation in Industries-Power factor improvement.

Unit-4 : Energy-efficient electric motors (EEMs) : Energy efficient motors-construction and technical features-case studies of EEMs with respect to cost effectiveness-performance characteristics; Economics of EEMs and system life cycle-direct savings and payback analysis-efficiency factor or efficiency evaluation factor

Unit-5 : Electric Lighting: Introduction-Need for an energy management program-Building analysisModification of existing systems-Replacement of existing systems-priorities:
Illumination requirement : Task lighting requirements-lighting levels-system modifications-non illumination modifications-lighting for non task areas-reflectances-space geometry ;System elements.

Unit-6 : Light sources - characteristics of families of lamps-lamp substitution in existing systemsselection of Higher efficiency lamps for a new system-Luminaries-ballasts-energy conservation in lighting. White light LED and conducting Polymers.

Unit-7 : Space Heating ,Ventilation, Air-Conditioning(HVAC) and Water Heating: Introduction-Heating of buildings-Transfer of Heat-Space heating methods-Ventilation and air-conditioning-Insulation-Cooling load-Electric water heating systems-Energy conservation methods.

Unit-8 : Co-generation and storage: Combined cycle cogeneration-energy storage: pumped hydro schemes-compressed air energy storage(CAES)-storage batteries-superconducting magnetic energy storage (SMES)

References:

1.Energy management Hand book by Wayne C.Turner,John wiley and sons publications

2.Electric Energy Utilization and Conservation by S C Tripathy,Tata McGraw hill publiching company ltd.New Delhi

3.Energy efficient electric motors selection and application by John C.Andreas

4.Hand book on Energy Audit and Management by Amit kumar Tyagi,published by TERI(Tata energy research Institute)

5.Energy management by Paul W.O' Callaghan McGraw hill book company

6.Energy conversion systems by Rakosh Das Begamudre New age international publishers

Energy Management - by W.R.Murphy & G.Mckey Butterworths.

AI TECHNIQUES

Unit - I: Introduction to Neural Networks
Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models. introduction-neural network models-architectures-knowledge representationlearning process-learning tasks.

Unit- II:**Feed Forward Neural Networks**
Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem, Limitations of the Perceptron Model, Applications.

Unit-III: ANN paradigm-back propagation-RBF algorithms-Hope field networkS

Unit IV : genetic algorithms-introduction-encoding-fitness function-reproduction operators

Unit V: genetic modelling-genetic operators-cross over and mutation-generational cycle-coveragence of genetic algorithm-

Unit - VI: Classical AND Fuzzy Sets
Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions.

UNIT VII:**Fuzzy Logic System Components**
Fuzzification, Membership value assignment, development of rule base and decision making ystem, Defuzzification to crisp sets, Defuzzification methods.

UNIT VIII: APPLICATION OF AI TECHNIQUES-load forecasting-load flow studies-economic load dispatch-load frequencycontrol-reactive power control-speed control of dc and ac motors

TEXT BOOK:
1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai - PHI Publication.
2. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.

SYSTEM IDENTIFICATION AND PARAMETER ESTIMATION

UNIT I

Review of probably theory and random variable, random process, A Family of Transfer function ModelsEquation Error Model Structure-Linear Regression- ARMAX Model Structure- Other Equation-ErrorType Model Structures-Output Error Model Structure- Box- Jenkins Model Structure- A General Family of Model Structures- Continuous Time Black -Box Model.

UNIT II

Recursive least squares (RLS), Consistency of estimation, Weighted LS.

UNIT III

Parametric models, LS estimation, bias; generalized least squares (GLS) and instrumental variable (IV) method.

UNIT IV

Persistently exciting input signal; Likelihood functions and maximum likelihood estimation (MLE); Singular value decomposition (SVD).

UNIT V

Stochastic approximation algorithm (STA); Model order and structure determination.

UNIT VI

Kalman filter state and parameter estimation.

UNIT VII

Extended Kalman Filters for continuous and discrete time systems.

UNIT VIII

Multi-variable system representation, controllability and observability indices; Feedback system identification.

Text Books:

1. Probability, Random Variables and Stochastic Process- Papoulis and Pillai, McGraw Hill, 2002.
2. Lessons in Estimation Theory for Signal Processing, Communications, and Control- Jerry M. Mendel, Prentice-Hall, 1995.

References:

1. Introduction to Stochastic Control Theory: Karl J Astrom, Mathematics in Series and Engg., Vol. 70.
2. Filtering and System Identification A Least Squares Approach- Michel Verhaegen and Vincent Verdult, Cambridge Univ. Press, 2007.
3. Kalman Filtering Theory and Practice Using Matlab- M.S. Grewal and A.P. Andrews, John Wiley, 2008.

Paper -II

ADVANCED DSP

UNIT-I: Digital Filter Structure

Block diagram representation-Equivalent Structures-FIR and IIR digital filter Structures All pass Filterstunable IIR Digital Filters-IIR tapped cascaded Lattice Structures-FIR cascaded Lattice structures-Parallel-Digital Sine-cosine generator-Computational complexity of digital filter structures.

UNIT-II: Digital filter design

Preliminary considerations-Bilinear transformation method of IIR filter design-design of Low pass highpass-Bandpass, and Band stop- IIR digital filters-Spectral transformations of IIR filters- FIR filter design-based on Windowed Fourier series- design of FIR digital filters with least -mean- Square-error-constrained Least-square design of FIR digital filters

UNIT-III: DSP algorithm implementation

Computation of the discrete Fourier transform- Number representation-Arithmetic operations-handling of overflow-Tunable digital filters-function approximation.

UNIT-IV Analysis of finite Word length effects

The Quantization process and errors- Quantization of fixed -point and floating -point Numbers-Analysis of coefficient Quantization effects - Analysis of Arithmetic Round-off errors-Dynamic range scaling-signal- to- noise ratio in Low -order IIR filters-Low-Sensitivity Digital filters-Reduction of Product round-off errors using error feedback-Limit cycles in IIR digital filters- Round-off errors in FFT Algorithms.

UNIT V: Power Spectrum Estimation

Estimation of spectra from Finite Duration Observations signals - Non-parametric methods for power spectrum Estimation - parametric method for power spectrum Estimation-Estimation of spectral formFinite duration observation of signals-Non-parametric methods for power spectrum estimation-Walsh methods-Blackman & torchy method.

Reference Books:

1. Digital signal processing-sanjit K. Mitra-TMH second edition
2. Discrete Time Signal Processing - Alan V.Oppenheim, Ronald W.Shafer - PHI-1996 1st edition-9th reprint
3 Digital Signal Processing principles, algorithms and Applications - John G.Proakis -PHI -3rd edition-2002
4 Digital Signal Processing - S.Salivahanan, A.Vallavaraj, C. Gnanapriya - TMH - 2nd reprint-2001
5 Theory and Applications of Digital Signal Proceesing-LourensR. Rebinar&Bernold
Digital Filter Analysis and Design-Auntonian-TMH

DIGITAL CONTROL SYSTEMS

Unit 1: Discrete data and digital Control Systems - basic elements, advantages and disadvantages, examples, - Impulse sampling and data hold - transfer functions of Zero order hold and First order hold. Reconstructing original signals from sampled signals - sampling theorem, ideal low pass filter, frequency response characteristics of the Zero order hold.

Unit 2 : The Z-transform, Z transforms of some elementary functions, Important properties and theorems of the Z-transform, The inverse Z-transform, S-transform method for solving difference equations, the pulse transfer function, realization of digital controllers.

Unit 3: Mapping between the s-plane and the z-plane, the Jury stability test, stability analysis by use of the bilinear transformation and Routh stability criterion. Liapunov stability analysis of discrete time systems.

Unit 4: Transient response specifications, steady state error analysis. Design based on frequency response method, Analytical design method.

Unit 5: Concept of the state space method, State space representations of discrete time systems, solving discrete time state space equations. Discretisation of continuous time state space equations.

Unit 6: Controllability, Observability, Principle of Duality, Design via pole placement necessary and sufficient condition. Ackerman's formula, Dead Beat response.

Unit 7: State observers - necessary and sufficient condition for state observation, full order state observer, minimum order state observer.

Unit 8: Microprocessor and DSP control : Microprocessor control of control systems, single-board controllers with custom-designed chips, DMC - 105 board, digital signal processors - TMS 320 DSPs, development system and support tools. Effects of finite word length and quantization on controllability and closed loop pole placement. Effect of quantization - least upper bound on quantization error.

Reference Books :

1. Discrete-time Control Systems, 2nd edition K.OGATA, Pearson Education Asia.
2. Digital Control Systems : 2nd edition, B.C.KUO, Oxford University Press

EHVAC TRANSMISSION

Unit 1 : E.H.V. A.C. Transmission , line trends and preliminary aspects ,standard transmission voltages - power handling capacities and line losses - mechanical aspects.

Unit 2 : Calculation of line resistance and inductance : resistance of conductors, temperature rise of conductor and current carrying capacity. Properties of bundled conductors and geometric mean radius of bundle, inductance of two conductor lines and multi conductor lines, Maxwell's coefficient matrix.

Unit 3 : Line capacitance calculation : capacitance of two conductor line, and capacitance of multi conductor lines, potential coefficients for bundled conductor lines, sequence inductances and capacitances and diagonalization.

Unit 4 : Calculation of electro static field of AC lines - Effect of high electrostatic field on biological organisms and human beings.

Unit 5 : Surface voltage Gradient on conductors, surface gradient on two conductor bundle and cosine law, maximum surface voltage gradient of bundle with more than 3 sub conductors, Mangolt formula.

Unit 6 : Corona : Corona in EHV lines - corona loss formulae - attenuation of traveling waves due to corona - Audio noise due to corona, its generation, characteristics and limits, measurement of audio noise.

Unit 7 : Power Frequency voltage control : Problems at power frequency, generalized constants, No load voltage conditions and charging currents, voltage control using synchronous condenser, cascade connection of components : Shunt and series compensation, sub synchronous resonance in series - capacitor compensated lines

Unit 8 : Static reactive compensating systems : Introduction, SVC schemes, Harmonics injected into network by TCR, design of filters for suppressing harmonics injected into the system.

Reference Books :

1. Extra High Voltage AC Transmission Engineering - Rakosh Das Begamudre, Wiley Eastem ltd., New Delhi - 1987.
2. EHV Transmission line reference book - Edision Electric Institute (GEC) 1986.

FACTS CONTROLLERS

Unit 1 : Transmission interconnections, power flow in an AC System, loading capability limits, Power flow and Dynamic stability considerations, importance of controllable parameters.

Unit 2 : Opportunities for FACTS, basic types of FACTS controllers, benefits from FACTS controllers, Requirements and Characteristics of High Power devices - Voltage and Current rating, losses and speed of switching, parameter trade-off of devices.

Unit 3 : Basic concept of Voltage source converter, Single phase full wave bridge converter, Single phase-leg (pole) operation, Square-wave voltage harmonics for a single phase Bridge, 3 Phase full wave bridge converter.

Unit 4 : Transformer connections for 12 pulse, 24 and 48 pulse operation. Three level voltage source converter, pulse width modulation converter, basic concept of current source converters, comparison of current source converters with voltage source converters.

Unit 5 : Objectives of shunt compensation, mid point voltage regulation for line segmentation, End of line voltage support to prevent voltage instability, improvement of transient stability, Power oscillation damping.

Unit 6 : Methods of controllable var generation: variable impedance type static var generators - TCR and TSR, TSC, FC-TCR, TSC-TCR, switching converter type var generators, hybrid var generators.

Unit 7 : SVC and STATCOM : The regulation and slope transfer function and dynamic performance, transient stability enhancement and power oscillation damping, operating point control and summary of compensation control.

Unit 8 : Static series compensators : Concept of series capacitive compensation, improvement of transient stability, power oscillation damping, functional requirements. GTO thyristor controlled series capacitor (GSC), thyristor switched series capacitor (TSSC), and thyristor controlled series capacitor (TCSC), control schemes for GSC, TSSC and TCSC.

Reference Book:

1. "Understanding FACTS " N.G.Hingorani and L.Guygi, IEEE Press.
   Indian Edition is available:--Standard Publications, 2001.
3. "Flexible a c transmission system (FACTS)" Edited by YONG HUE SONG and
   ALLAN T JOHNS, Institution of Electrical Engineers, London.

HIGH VOLTAGE TESTING TECHNOLOGY

Unit 1 : Non Destructive Testing Techniques : Measurement of DC Resistivity - Dielectric loss and dielectric constant of insulating materials - Schering bridge method - Transformer ratio arm bridge for high voltage and high current applications - null detectors.

Unit 2 : High Voltage Testing of Power Apparatus : Need for testing standards - Standards for porcelain/Glass insulators-Classification of porcelain/glass insulator tests - Tests for cap and pin porcelain/Glass insulators.

Unit 3 : High voltage AC testing methods-Power frequency tests-Over voltage tests on insulators, Isolators, Circuit Breakers and power cables.

Unit 4 : Artificial Contamination Tests : Contamination flashover phenomena-Contamination SeverityArtificial contamination tests-Laboratory Testing versus in-Service Performance-Case study.

Unit 5 : Impulse Testing : Impulse testing of transformers-Surge diverters and other apparatus.

Unit 6 : Partial Discharge Measurement : PD equivalent model-PD currents-PD measuring circuitsStraight and balanced detectors-Location and estimation of PD in power apparatus-PD measurement by non electrical methods-Calibration of PD detectors.

Unit 7 : RIV Measurements : Radio Interference - RIV - Measurement of RI and RIV in laboratories and in field. Different test arrangements and their limitations.

Unit 8 : Why do Insulators fail? : Handling-Vandalism-Quality control-Application problems.
Detecting defective Insulators : Introduction-Detecting defective Porcelain insulators-Detecting defective Non Ceramic Insulators.
Making Insulators work in contaminated environments : Cleaning-Modification of Insulator designMobile protective coatings-Solid water Repellent coatings-Line voltage reduction.

Reference Books :

1. High Voltage Engineering - by E.KUFFEL and W.S.ZAENGL, Pergamon press, Oxford 1984.
2. High Voltage Engineering - by M.S.Naidu and V.Kamaraju, Tata Mc Graw Hill Publishing Company Limited, New Delhi - 2001.
3. Discharge Detection in H.V. Equipment - by KREUGER, F.H. Haywood London - 1964.

Outdoor Insulators - by Gorur & Cherney

RENEWABLE ENERGY RESOURCES

Unit-I

Solar Energy - Availability - Solar radiation data and measurement - Estimation of average solar radiation - Solar water heater types - Heat balance - Flat plate collector efficiency - Efficiency of heat removal - Thermo siphon flow calculation - Forced circulation calculation - Evacuated collectors - Basics of solar concentrators

Unit-II

Solar Energy Applications - Solar air heaters - Solar Chimney - Crop driers - Passive solar system - Active solar systems - Water desalination - Output from solar still - Principle of solar ponds.

Unit-III

Wind Energy - Nature of wind - Characteristics - Variation with height and time - Power in wind - Aerodynamics of Wind turbine - Momentum theory - Basics of aerodynamics - Aerofoils and their characteristics - HAWT - Blade element theory - Prandtl's lifting line theory (prescribed wake analysis) VAWT aerodynamics - Wind turbine loads - Aerodynamic loads in steady operation - Yawed operation and tower shadow.

Unit-IV

Wind Energy Conversion System - Siting - Rotor selection - Annual energy output - Horizontal axis wind turbine (HAWT) - Vertical axis wind turbine (VAWT) - Rotor design considerations - Number of blades - Solidity - Blade profile - Upwind/Downwind - Yaw system - Tower - Braking system - Synchronous and asynchronous generators and loads - Integration of wind energy converters to electrical networks - Inverters - Control system - Requirement and strategies - Noise - Applications of wind energy

Unit-V

Biomass energy - Bio fuel classification - Examples of thermo chemical, Pyrolysis, biochemical and agrochemical systems - Energy farming - Direct combustion for heat - Process heat and electricity - Ethanol production and use - Anaerobic digestion for biogas - Different digesters - Digester sizing - Applications of Biogas - Operation with I.C.Engine

Unit-VI

Ocean Energy - OTEC Principle - Lambert's law of absorption - Open cycle and closed cycle - heat exchanger calculations - Major problems and operational experience.

Unit-VII

Tidal Power - Principles of power generation - components of power plant - Single and two basin systems - Turbines for tidal power - Estimation of energy - Maximum and minimum power ranges - tidal powerhouse.

Wave Energy - Concept of energy and power from waves - Wave characteristics - period and wave velocities - Different wave energy conservation devices (Saltor duck, oscillating water column and dolphin types) - operational experience.

Unit-VIII

Geothermal Energy - Classification- Fundamentals of geophysics - Dry rock and hot aquifier energy analysis - Estimation of thermal power - Extraction techniques - Prime movers.

References:

1Renewable Energy Resources / John Twidell and Tony Weir / E & F.N.Spon

2 Renewable Energy Resources Basic Principles and Applications / G.N.Tiwari and M.K.Ghosal / Narosa

3 Solar Energy - Principles of thermal collection and storage/ S.P. Sukhatme / TMH

4 Solar Energy Thermal Processes,/Duffie & Beckman

5 Solar Heating and Cooling / Kreith & Kreider

6 Wind Energy Handbook / Tony Burton, David Sharpe, Nick Jenkins and Ervin Bossanyi / WileyWind Electrical Systems / S.N.Bhadra, D.Kastha and S.Banerjee / Oxford

7 Biogas Technology - A Practical Hand Book / K.Khendelwal & S.S. Mahdi / McGraw-Hill

POWER ELECTRONIC CONTROL OF AC DRIVES

Unit-I: **Introduction**

Review of steady-state operation of Induction motor, Equivalent circuit analysis, torque-speed characteristics.

Unit II: Voltage Source Inverter Fed Induction motor drives

Scalar control- Voltage fed Inverter control-Open loop volts/Hz control-Speed control with slip regulation-Speed control with torque and Flux control-Current controlled voltage fed Inverter Drive

Unit III Current Source Inverter Fed Induction motor drives

Current-Fed Inverter control-Independent current and frequency control-Speed and flux control in Current-Fed Inverter drive-Volts/Hz control of Current-Fed Inverter drive-Efficiency optimization control by flux program.

Unit IV Slip power recovery schemes

Slip-power recovery Drives-Static Kramer drive-Phasor diagram-Torque expression-Speed control of a Kramer drive-Static scherbius drive-Modes of operation

Unit-V: Vector control of Induction Motor:

Principles of vector control, Direct vector control, derivation of indirect vector control, implementation - block diagram; estimation of flux, flux weakening operation.

Unit-VI: Control of Synchronous motor drives:

Synchronous motor and its characteristics- Control strategies-Constant torque angle control- power factor control, constant flux control, flux weakening operation, Load commutated inverter fed synchronous motor drive, motoring and regeneration, phasor diagrams.

UNIT-VII: PMSM and BLDC Drives:

Characteristics of permanent magnet, synchronous machines with permanent magnet, vector control of PMSM- Motor model and control scheme. Modeling of PM brushless dc motor, drive scheme -Three-phase full wave Brushless dc motor -Sinusoidal type of Brushless dc motor - current controlled Brushless dc motor Servo drive

UNIT-VIII: Variable Reluctance Motor Drive

Variable Reluctance motor drives- Torque production in the variable reluctance motor -Drive characteristics and control principles - Current control variable reluctance motor servo drive

Text Book:

1. Electric Motor Drives Modeling, Analysis & control -R. Krishnan- Pearson Education

Reference Books:

2. Modern Power Electronics and AC Drives -B. K. Bose-Pearson Publications-
3. Power Electronics control of AC motors - MD Murphy & FG Turn Bull Pergman Press -1st edition-1998
4. Fundamentals of Electrical Drives - G.K. Dubey - Narosa Publications -1995
5. Power Semiconductor drives- G.K. Dubey-Prentice hall

ADVANCED POWER SEMICONDUCTOR DEVICES & PROTECTION

Unit I: Overview of Power Switching Devices: Introduction to power switching devices, classification of devices, controlled and un-controlled devices, i-v characteristics of ideal and real switching devices,

Unit-II: Power Diodes: Device structure and i-v characteristics, ratings & specifications, switching characteristics, reverse recovery, classification of various diodes: Schotky diode, line frequency diodes, fast recovery diodes,

Unit-III: Power Transistors: Device structure and i-v characteristics, ratings & specifications, switching characteristics, ON to OFF and OFF to ON state transitions, ON/OFF transition loss analysis, driver circuit.

Unit-IV: Power MOSFETs: Device structure and i-v characteristics, ratings & specifications, switching characteristics, ON to OFF and OFF to ON state transitions, ON/OFF transition loss analysis, driver circuit.

Unit-V: IGBT: Device structure and i-v characteristics, ratings & specifications, switching characteristics, ON to OFF and OFF to ON state transitions, ON/OFF transition loss analysis,. Comparison of all the above devices with reference to power handling capability, frequency of operation, driver circuit, .emerging power switching devices.

Unit-VI: Protection of the Switching Devices: Device protection against over voltage/currents, di/dt and dv/dt; safe operating area, design of snubbers for power devices.

Unit-VII: Thermal Management: Conduction and transition losses computation, thermal model of the device, steady-state temperature rise, electrical equivalent circuit of thermal model, sizing of the heat sink.

Unit-VIII: Passive Components: Magnetic circuit, review of design of line frequency inductors and transformers, design of high frequency inductors and transformers.

Text book

1. Power Electronics Circuits- B. W. Williams

Reference books

1. Power Electronics Circuits, Devices and Applications - M. H. Rashid-PHI-

2. Power Electronics -Converters, Applications and Design - Mohan and Undeland-John Wiley & Sons

3. Power Electronics: L. Umanand

POWER SYSTEM RELIABILITY

UNIT - I **Basics of Probability theory & Distribution :** Basic probability theory - rules for combining probabilities of events - Bernoulli's trials - probabilities density and distribution functions - binomial distribution - expected value and standard deviation of binomial distribution.

UNIT - II **Network Modelling and Reliability Analysis :** Analysis of Series, Parallel, SeriesParallel networks - complex networks - decomposition method.

UNIT - III **Reliability functions :**Reliability functions f(t), F(t), R(t), h(t) and their relationships - exponential distribution - Expected value and standard deviation of exponential distribution - Bath tub curve - reliability analysis of series parallel networks using exponential distribution - reliability measures MTTF, MTTR, MTBF.

UNIT - IV **Markov Modelling :** Markov chains - concept of stochastic transitional probability Matrix, Evaluation of limiting state Probabilities. - Markov processes one component repairable system - time dependent probability evaluation using Laplace transform approach - evaluation of limiting state probabilities using STPM - two component repairable models.

UNIT - V **Frequency & Duration Techniques :** Frequency and duration concept - Evaluation of frequency of encountering state, mean cycletime, for one , two component repairable models - evaluation of cumulative probability and cumulative frequency of encountering of merged states.

UNIT - VI **Generation System Reliability Analysis** : Reliability model of a generation systemrecursive relation for unit addition and removal - load modeling - Merging of generation load model -
evaluation of transition rates for merged state model - cumulative Probability, cumulative frequency of failure evaluation - LOLP, LOLE.

UNIT - VII **Composite Systems Reliability Analysis :** Decompositions method - Reliability Indices - Weather Effects on Transmission Lines.

UNIT - VIII **Distribution System and Reliability Analysis :** Basic Concepts - Evaluation of Basic and performance reliability indices of radial networks.

Reference Books :

1. Reliability Evaluation of Engg. System - R. Billinton, R.N.Allan, Plenum Press, New York.
2. Reliability Evaluation of Power systems - R. Billinton, R.N.Allan, Pitman Advance Publishing Program, New York.
3. An Introduction to Reliability and Maintainability Engineering. Charles E. Ebeling, TATA Mc Graw - Hill - Edition.

REACTIVE POWER COMPENSATION AND MANAGEMENT

UNIT I: Load Compensation

Objectives and specifications - reactive power characteristics - inductive and capacitive approximate biasing - Load compensator as a voltage regulator - phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT II: Steady - state reactive power compensation in transmission system:

Uncompensated line - types of compensation - Passive shunt and series and dynamic shunt compensation - examples

UNIT III: Transient state reactive power compensation in transmission systems:

Characteristic time periods - passive shunt compensation - static compensations- series capacitor compensation -compensation using synchronous condensers - examples

UNIT-IV: Reactive power coordination:

Objective - Mathematical modeling - Operation planning - transmission benefits - Basic concepts of quality of power supply - disturbances- steady -state variations - effects of under voltages - frequency - Harmonics, radio frequency and electromagnetic interferences

UNIT-V: Demand side management:

Load patterns - basic methods load shaping - power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels

UNIT-VI: Distribution side Reactive power Management:

System losses -loss reduction methods - examples - Reactive power planning - objectives - Economics Planning capacitor placement - retrofitting of capacitor banks

UNIT-VII: User side reactive power management:

KVAR requirements for domestic appliances - Purpose of using capacitors - selection of capacitors - deciding factors - types of available capacitor, characteristics and Limitations

UNIT-VIII: Reactive power management in electric traction systems and are furnaces:

Typical layout of traction systems - reactive power control requirements - distribution transformers- Electric arc furnaces - basic operations- furnaces transformer -filter requirements - remedial measures - power factor of an arc furnace

Reference Books:

1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982 (Units I to IV)

2. Reactive power Management by D.M.Tagare,Tata McGraw Hill,2004.(Units V toVIII

SPECIAL MACHINES AND CONTROLS

Unit I: Stepper Motors
Constructional features, Principle of operation, Modes of excitation torque production in Variable Reluctance (VR) stepping motor

Unit II: Characteristics of Stepper Motors
Dynamic characteristics, Drive systems and circuit for open loop control, closed loop control of stepping motor.

Unit III: Switched Reluctance Motors
Constructional features, Principle of operation. Torque equation, Characteristics, Control Techniques, Drive Concept.

Unit IV: Permanent Magnet Brushless DC Motors
Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessors based controller.

Unit V: Permanent Magnet Synchronous Motors
Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power Controllers, Torque speed characteristics, Self control, Vector control, Current control Schemes.

Unit VI: Servomotors
Servomotor - Types - Constructional features - Principle of Operation - Characteristics - Control - Microprocessor based applications.

Unit VII: AC Tachometers
Schematic diagram, Operating principle, numerical problems

Unit VIII: Linear Motors
Linear Motors: Linear Induction Motor (LIM) Classification - Construction - Principle of operation - Concept of Current sheet -Goodness factor - DC Linear Motor (DCLM) types - Circuit equation - DCLM control-applications.

References

1. Miller, T.J.E. “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
2. Kenjo, T, “Stepping Motors and their Microprocessor control”, Clarendon Press, Oxford, 1989.
3. Naser A and Boldea I, “Linear Electric Motors: Theory, Design and Practical Application”, Prentice Hall Inc., New Jersey,1987
4. Floyd E Saner,”Servo Motor Applications”, Pittman USA, 1993.
5. Kenjo, T and Naganori, S “Permanent Magnet and brushless DC motors”, Clarendon Press, Oxford, 1989.
6. Generalized Theory of Electrical Machines - P.S.Bimbra-Khanna publications-5th edition-1995

POWER SYSTEM DEREGULATION

UNIT I

Need and conditions for deregulation. Introduction of Market structure, Market Architecture, Spot market, forward markets and settlements. Review of Conceptsmarginal cost of generation, least-cost operation, incremental cost of generation.
Power System Operation: Old vs. New

UNIT II

Electricity sector structures and Ownership /management, the forms of Ownership and management. Different structure model like Monopoly model, Purchasing agency model, wholesale competition model, Retail competition model.

UNIT III

Framework and methods for the analysis of Bilateral and pool markets, LMP based markets, auction models and price formation, price based unit commitment, country practices.

UNIT IV

Transmission network and market power. Power wheeling transactions and marginal costing, transmission costing. Congestion management methods- market splitting, counter-trading; Effect of congestion on LMPs- country practices

UNIT V

Ancillary Services and System Security in Deregulation. Classifications and definitions, AS management in various markets- country practices. Technical, economic, & regulatory issues involved in the deregulation of the power industry.

Reference Books:

1. Power System Economics: Designing markets for electricity - S. Stoft
2. Power generation, operation and control, -J. Wood and B. F. Wollenberg
3. Operation of restructured power systems - K. Bhattacharya, M.H.J. Bollen and J.E. Daalder
4. Market operations in electric power systems - M. Shahidehpour, H. Yaminand Z. Li
5. Fundamentals of power system economics - S. Kirschen and G. Strbac
6. Optimization principles: Practical Applications to the Operation and Marketsof the Electric Power Industry - N. S. Rau
7. Competition and Choice in Electricity - Sally Hunt and Graham Shuttleworth

ADVANCED POWER SYSTEM PROTECTION

Unit 1 :CLASSIFICATION OF STATIC RELAYS : Basic construction of static relays, Classification of protective schemes, Comparison of Static relays with electromagnetic relays, Amplitude comparator,Phase comparator, Principle of Duality.

UNIT 2: AMPLITUDE AND PHASE COMPARATORS(2-INPUT):
Rectifier bridge circulating and opposed Voltage type- Averaging -phase splitting type -Sampling type of amplitude Comparison. Block spike type-Phase splitting type- Transistor integrating typeRectifier bridge type- Vector product type Phase comparison.

Unit 3 : STATIC OVER CURRENT RELAYS : Instantaneous- Definite time - Inverse timeDirectional- IDMT- Very inverse Time-Extremely inverse time over current relays. Time current characteristics of Over current relays-applications

Unit 4 : DISTANCE PROTECTION: Impedance Relay: operating principle- relay CharacteristicProtective Schemes-Static Impedance Relay- Static reactance relay- static MHO relay-effect of arc resistance,effect of power surges,effect of line length and source impedance on performance of distance relays-Quadrilateral relay - Elliptical relay.-selection of distance relays

UNIT 5: PILOT RELAYING SCHEMES: Wire pilot protection:circulating current schemebalanced voltage scheme-translay scheme-half wave comparison scheme- Carrier current protection: phase comparison type-carrier aided distance protection-operational comparison of transfer trip and bloking schemes-optical fibre channels

UNIT6: AC MACHINES AND BUS ZONE PROTECTION: Protection of Alternators: stator protection-rotor protection-over voltage protection-over speed protection-Transformer protection: earth faults in transformers-percentage differential protection-protection against magnetic inrush current-generator and transformer unit protection-Bus zone protection: differential current protectionhigh impedance relay scheme-frame leakage protection

Unit 7 : MICROPROCESSOR BASED PROTECTIVE RELAYS:
Introduction-over current relays-Impedance relay-Directional relay-Reactance relay.

Unit 8: PROTECTION AGAINST OVER VOLTAGES: Protection of transmission lines, stations, and substations against direct lightning strokes-protection against travelling waves-Insulation coordination.

Reference Books :

1.Power system protection ---by TSM Rao.
2.Power system protection and switch gear--by Badri Ram& DN Vishwakarma.
3.Switch gear and protection---by MV Deshpande.
4.Protective relaying vol-2 ---by Warrington.
5. Power system protection and switch gear---by Ravindranath & Chandan.