

**Kalinga University Atal Nagar (C.G.)**



**SCHEME OF EXAMINATION  
& SYLLABUS**

**of**

**M.Tech Electrical  
Power System & Control**

**UNDER**

**Faculty of Engineering and Technology**

**w.e.f. Session 2021-22**

**RAIPUR**

**Kalinga University, Raipur**  
**M.Tech Electrical**  
**Power System & Control (2 yrs Programme)**  
**w.e.f 2021-22 Session**

<b>Semester - I</b>						
<b>Code No.</b>	<b>Paper</b>	<b>Lecture</b>	<b>T/P (Tutorial/Practical)</b>	<b>End Semester Exam</b>	<b>Internal Marks</b>	<b>Total Marks</b>
MEPS101	Power System Dynamics	3	1	100	50	150
MEPS102	Power System Optimization	3	1	100	50	150
MEPS103	Power System Protection	3	1	100	50	150
MEPS104	Non Linear Control	3	1	100	50	150
<b>Refer Below Elective – I</b>		3	1	100	50	150
MEPS105A	Flexible AC Transmission System					
MEPS105B	Power Electronics					
MEPS105C	Distributed Generation					
MEPS106-P	Power System Protection Lab		5	30	20	50
MEPS107-P	Control Systems Engg. Lab		5	30	20	50
<b>Total</b>		<b>15</b>	<b>15</b>			<b>850</b>
<b>Semester - II</b>						
<b>Code No.</b>	<b>Paper</b>	<b>Lecture</b>	<b>T/P (Tutorial/Practical)</b>	<b>End Semester Exam</b>	<b>Internal Marks</b>	<b>Total Marks</b>
MEPS201	EHV AC – DC	3	1	100	50	150
MEPS202	Power Quality	3	1	100	50	150
MEPS203	Power System Stability & Control	3	1	100	50	150
MEPS204	Digital Control Systems	3	1	100	50	150
<b>Refer Below Elective – II</b>		3	1	100	50	150
MEPS205A	Transients in Power System					
MEPS205B	Restructuring Power System					
MEPS205C	Distribution System Automation					
MEPS206-P	Power System Computation & Simulation Lab		5	30	20	50
MEPS207-P	Power Electronics & Power Quality Lab		5	30	20	50
<b>Total</b>		<b>15</b>	<b>15</b>			<b>850</b>

**Semester - III**

<b>Code No.</b>	<b>Paper</b>	<b>Lecture</b>	<b>T/P (Tutorial/Practical)</b>	<b>End Semester Exam</b>	<b>Internal Marks</b>	<b>Total Marks</b>
MEPS301	Optimal Control Theory	3	1	100	50	150
MEPS302	Communication & Research Methodology	3	1	100	50	150
<b>Refer Below Elective – III</b>		3	1	100	50	150
MEPS303A	Energy Conservation & Audit					
MEPS303B	ANN & FUZZY Techniques					
MEPS303C	Power System Reliability					
MEPS304	Preliminary Work on Dissertation			100	50	150
MEPS305	Seminar Based on Dissertation			100	50	150
	<b>Total</b>	9	3			750

**Semester - IV**

<b>Code No.</b>	<b>Paper</b>	<b>Lecture</b>	<b>T/P (Tutorial/Practical)</b>	<b>End Semester Exam</b>	<b>Internal Marks</b>	<b>Total Marks</b>
MEPS401	Dissertation			300	200	500
	<b>Total</b>			<b>300</b>	<b>200</b>	<b>500</b>

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# Semester-I

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## Power System Dynamics

**Unit: I this topics are proposed to remove from syllabus.**

**Elementary Mathematical Model:** Swing Equation, Units, Mechanical Torque, Electrical Torque, Power - Angle Curve of a Synchronous Machine, Natural Frequencies of Oscillation of a Synchronous Machine, System of One Machine against an Infinite Bus-The Classical Model, Equal Area Criterion, Classical Model of a Multi machine System, Classical Stability Study of a Nine-Bus System, Shortcomings of the Classical Model, Block Diagram of One Machine.

### Unit: II

**Synchronous Machine:** Park's Transformation, Flux Linkage Equations, Voltage Equations, Formulation of State - Space Equations, Current Formulation, Per Unit Conversion, Normalizing the Voltage Equations, Normalizing the Torque Equations, Torque and Power, Equivalent Circuit of a Synchronous Machine, The Flux Linkage State-Space Model, Load Equations, Sub transient and Transient Inductances and Time Constants, Turbine Generator Dynamic Models

### Unit: III

**Simulation of Synchronous Machine:** Steady-State Equations and Phasor Diagrams, Machine Connected to an Infinite Bus through a Transmission Line, Machine Connected to an Infinite Bus with Local Load at Machine Terminal, Determining Steady- State Conditions, Initial Conditions for a Multimachine System, Determination of Machine Parameters from Manufacturers' Data, Analog Computer Simulation of the Synchronous Machine, Digital Simulation of Synchronous Machines.

**Linear Model of Synchronous Machine:** Linearization of the Generator State -Space Current Model, Linearization of the Load Equation for the One-Machine Problem, Linearization of the Flux Linkage Model, Simplified Linear Model, Block Diagrams, State-Space Representation of Simplified Model.

### Unit: IV

**Excitation Systems:** Simplified View of Excitation Control, Control Configurations, Typical Excitation Configurations, Excitation Control System Definitions, Voltage Regulator, Exciter Buildup, Excitation System response, State - Space Description of the Excitation System, State Space Representation of the Excitation system, Computer Representation of Excitation Systems, Typical Systems Constants, The effect of Excitation on Generator Performance.

**Effect of Excitation on Stability:** Effect of Excitation on Generator Power limits, Effect of the Excitation System on Transient Stability, Effect of Excitation on Dynamic Stability, Root - Locus Analysis of a Regulated Machine Connected to an Infinite Bus, Approximate System Representation, Supplementary Stabilizing Signals, Liner Analysis of the Stabilized Generator. General Comments on the Effect of Excitation on Stability.

### Unit: V

**Multimachine Systems with Constant Impedance Load:** Statement of the Problem, Matrix representation of a Passive Network, Converting Machine Coordinates to System Reference, Relation Between Machine Currents & Voltages, System Order, Machines Represented by Classical Methods, Linearized Model for the Network, Hybrid Formulation, Network Equation with Flux Linkage Model, Total System Equation, Multimachine System Study.

### Text Books:

1. Power System Control and Stability Vol -I By P. M. Anderson & A. A. Fouad.
2. Power System Stability and Control by Prabha Kundur- EPRI. McGraw Hill Inc.

### Reference Books:

1. Power System Dynamic Stability and Control, Padiyar Interline Publisher Bangalore.
2. Advanced Power System Analysis and Dynamics By Laksheshwar Prakash Singh, New Age International.



## Power System Optimization

### Unit: I

#### Linear Programming

Introduction to optimization and classical optimization techniques, linear programming- standard form geometry of LPP, simplex method of solving LPP, revised simplex method, duality, decomposition principle and transportation problem.

### Unit: II

#### Non-Linear Programming

Non-linear problem(NLP): one dimensional method, elimination method, interpolation method, nonlinear programming(NLP) : unconstrained optimization techniques-direct search and descent method, steepest descent, direct and indirect methods, Hessian based algorithm-Newton, quasi-Newton method

### Unit: III

#### Constrained Optimization Problem

Necessary and sufficient conditions, Equality and Inequality constraints, Lagrange variables, Karush-Kuhn-Tucker conditions, gradient projection method, Penalty method, Quadratic programming, Iterative schemes for constrained problems, sequential quadratic programming method.

### Unit: IV

#### Dynamic Programming

Multistage decision processes, concept of sub optimization and principle of optimality, conversion of final value problem into an initial value problem, CPM & PERT.

### Unit:V

#### Applications to Power System

Economic Load Dispatch in thermal and hydro thermal system using GA and classical optimization techniques, unit commitment problem, reactive power optimization, optimal power flow, LPP & NLP techniques to optimal flow problem.

#### Text Books:-

1. Optimization – Theory and Applications, S.S. Rao, Wiley–Eastern Ltd.
2. Introduction of Linear and Non-linear programming, David G. Luenberger, Wesley Publishing Company.
3. Optimization for Engineering Design: Algorithms & Examples, Kalyanmaoy deb, PHI
4. Advanced Power System Analysis & Dynamics, L.P.Singh, Wiley Eastern Ltd.
5. Power System Analysis, HadiSaadat, TMH Publication.

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## Power System Protection

### Unit:I

Protective Relaying - Qualities of relaying, Definitions, Codes, Standards, Characteristic Functions, Classification, analog-digital - numerical, schemes and design, factors affecting performance, zones and degree of protection, faults types and evaluation, Instrument transformers for protection.

### Unit:II

Basic static relay units, sequence networks, fault sensing data processing units, FFT and Wavelet based algorithms, Phase & Amplitude Comparators, Duality, Zero Crossing/Level Defectors, Relay Schematics and Analysis, Over Current Relay, Instantaneous/Inverse Time –IDMT Characteristics; Directional Relays; Differential Relays, Restraining Characteristics; Distance Relays: Types, Characteristics;

### Unit:III

Protection of Power System Equipment, Generator, Transformer, Generator, Transformer Units, Transmission Systems, Bus-bars, Motors; Pilot wire and Carrier Current Schemes; System grounding, ground faults and protection, Load shedding and frequency relaying, Out of step relaying, Re-closing and synchronizing.

### Unit:IV

Numerical relays, Characteristics, Functional Diagrams, architecture, algorithms, Microprocessor & DSP based relays, sampling, aliasing, filter principles, Integrated and multifunction protection schemes, SCADA based protection systems, FTA, Testing of Relays.

### Unit:V

AC Circuit Breakers : Current interruption, Transient Recovery Voltage (TRV) , Rate of rise of TRV, Resistance switching, Damping of TRV, Opening Resistors, Inductive & Capacitive current interruptions , Current chopping , Rated characteristics of Circuit breakers, Types of Circuit Breakers, Testing of High Voltage AC Circuit Breakers

### Text Books:-

- 1 C.R. Mason, The art and science of protective relaying, John Wiley & Sons. 2
- A.R.Warrington, Protective Relays, Vol .1&2, Chapman and Hall.

### Reference Books:

1. T.S.Madhav Rao, Power system protection static relays with microprocessor applications, Tata McGraw Hill Publication.
2. Fundamentals of Power System Protection By Paithankar Y. G., Yeshwant G. Paithankar, S. R. Bhide, bhide S. R, PHI.
3. Power System Protection Vol. I, II , III&IV, The Institution Of Electrical Engineers, Electricity Association Services Ltd., 1995
4. Helmut Ungrad , Wilibald Winkler, Andrzej Wiszniewski, Protection techniques in electrical energy systems, Marcel Dekker, Inc.
5. Badri Ram , D.N. Vishwakarma, Power system protection and switch gear, Tata McGraw Hill.
6. Blackburn, J. Lewis , Protective Relaying, Principles and Applications, Marcel Dekker, Inc., 1986.
7. Anderson, P.M, Power System Protection., McGraw-Hill, 1999
8. Singh L.P , Digital Protection, Protective Relaying from Electromechanical to Microprocessor, John Wiley & Sons, 1994 Wright, A. and Christopoulos, C, Electrical Power System Protection., Chapman & Hall, 1993.

## Non Linear Control

### Unit: I

#### State space analysis

State space Representation, Solution of state Equation, State Transition Matrix, canonical Forms- controllable canonical form, Observable canonical form, Jordan canonical form.

#### Controllability and observability

Test for controllability and observability for continuous time system- Time varying case. Minimum energy control, time invariant case, principle of duality, Controllability and Observability form Jordan canonical form and other canonical forms.

### Unit: II

#### Describing function analysis

Introduction to nonlinear systems, Types of nonlinearities, describing functions, describing function analysis of nonlinear control systems, Production of limit cycles

#### Phase-plane analysis

Introduction to phase-plane analysis. Method of isoclines for constructing Trajectories, Singular points, Phase-plane analysis of nonlinear control systems.

### Unit: III

#### Stability Analysis

Stability in the sense of Lyapunov, Lyapunov's stability and Lyapunov's instability theorems. Direct method of Lyapunov for the linear and Nonlinear continuous time autonomous systems.

Perturbation techniques, Lure's formulation, Popov stability criteria, circle criteria.

### Unit: IV

#### Control Design Techniques

Feedback Linearization, I/O Linearization, Full state linearization of SISO & MIMO system , variable structure control, sliding surface design, approximation of switching laws.

### Unit: V

#### Robust Control

Introduction, definition of robust control, classification of robust control, elements of robust control theory, modeling, design objectives and specifications, additive and multiplicative perturbations, plant-controller configuration. Modeling of Parametric Uncertain Systems, robust stability analysis, Boundary crossing theorem, Schur stability test, Hurwitz stability test, robustness under perturbations, small gain theorem, stability margins.

#### Text Books:

1. Slotine, J.J.E and W. Lee, Applied Non-linear Control, Prentice Hall Inc., 1991
2. Mohlar R.R., Non-linear systems Dynamics & Control, Prentice Hall Inc., 1991
3. Control System Engg. , I.J. Nagrath& M. Gopal, New Age Intl, (P) Ltd.
4. Alberto Isidori, Non Linear control systems, Springer Veriag, 1999.
5. M. Vidyasagar, Non-linear System Analysis, Prentice Hall, 1993.



## **Flexible AC Transmission System**

### **Unit: I**

FACTS Concept and General System Considerations, Power Flow in AC System, Definitions on FACTS, Basic Types of FACTS Controllers. Converters for Static Compensation, Three Phase Converters and Standard Modulation Strategies (Programmed Harmonic Elimination and SPWM), GTO Inverters, Multi - Pulse Converters and Interface Magnetics,

### **Unit: II**

Transformer Connections for 12 , 24 and 48 pulse operation, Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM), Multi-level inverters of Cascade Type and their modulation, Current Control of Inverters

### **Unit: III**

Static Shunt Compensators, SVC and STATCOM, Operation and Control of TSC, TCR, STATCOM, Compensator Control, Comparison between SVC and STATCOM, STATCOM for transient and dynamic stability enhancement

### **Unit: IV**

Static Series Compensation, GCSC, TSSC, TCSC and SSSC, Operation and Control, External System Control for Series Compensators, SSR and its damping, Static Voltage and Phase Angle Regulators, TCVR and TCPAR, Operation and Control

### **Unit: V**

UPFC and IPFC, The Unified Power Flow Controller, Operation, Comparison with other FACTS devices, control of P and Q, Dynamic Performance, Special Purpose FACTS Controllers, Interline Power Flow Controller, Operation and Control.

### **Text Books:**

1. N.G. Hingorani & L. Gyugyi: Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems. IEEE Press, 2000.
2. T.J.E Miller, Reactive Power Control in Electric Systems John Wiley & Sons

### **Reference Books:**

1. Ned Mohan et.al: Power Electronics. John Wiley and Sons.
2. 'FACTS Controllers and applications' course book for STTP, 2003, Dr Ashok S & K S Suresh kumar



## **Power Electronics**

### **Unit: I**

Overview of power semi conductor device, Ideal and Real switches Power diodes Structure and I-V characteristic, Switching characteristic, Breakdown voltage consideration. Schottky diodes. Power BJT, Basic structure and Switching characteristic, Safe operating area. Power MOSFETS & IGBT'S:

-Structure and I-V Characteristics, Switching characteristic, safe operating area G TO'S: - Basic Structure, V-I characteristic, Physics of Turn off operation, G TO'S Protection

### **Unit: II**

AC switching controllers, Single-phase resistive load, Integral half cycle control and phase control, Single phase R -L Load. Three-phase application of switching control for Star and Delta connected loads.

### **Unit: III**

**Inverters:** - Type of Inverters VSI, CSI and current regulated inverters Single phase half bridge Inverter - Circuit configuration and switching. Single phase full bridge configuration Control of AC frequency and voltage, PWM switching scheme, Implementation of SPWM in Half Bridge and Full Bridge Inverters. Three phase inverters, circuit configuration and switching sequence, waveform of current for star and delta connected loads, Waveform shaping using SPWM.

### **Unit: IV**

Buck, Boost, Buck-Boost SMPS Topologies . Basic Operation- Waveforms - modes of Basic Operation- Waveforms - modes of operation –Continuous and discontinuous, Cuk dc-dc converters Output voltage ripple .

### **Unit: V**

Introduction to Resonant Converters. Classification of Resonant Converters. Basic Resonant Circuit Concepts. Load Resonant Converter. Resonant Switch Converter.

### **Text Books:**

1. Ned Mohan et.al : Power Electronics, John Wiley and Sons
2. Mohammed Rashid : Power Electronics, Tata McGrawHill Publication .

### **Reference Books:**

1. G.K.Dubey et.al : Thyristorised Power Controllers Wiley Eastern Ltd.
2. Dewan & Straughen : Power Semiconductor Circuits John Wiley & Sons
3. G.K. Dubey & C.R. Kasaravada, Power Electronics & Drives Tata McGraw Hill
4. IETE Press Book : Power Electronics
5. Joseph Vithaythil : Power Electronics, McGraw Hill Publication

## Distributed Generation

### Unit:I

#### Concepts of Distributed Generation:

Centralized Generation : Main features, Economics, Advantages & Disadvantages De-centralised/ Distributed/ Embeded/Dispersed Generation, Operation of Distributed Generation Systems, Consideration of Reliability & Economics Advantages & Disadvantages, Introduction to energy conversion, Principles of renewable energy systems-technical and social implication.

### Unit:II

#### Solar energy:

Overview of solar energy conversion methods, Solar radiation components-collector measurements-estimation, Solar water heating –Calculation- Types analysis economics- Applications, Solar thermal power generation.

### Unit: III

#### Direct energy conversion (DEC)

DEC devices-photo voltaic system-solar cells-cell efficiency-Limitations-PV modules-Battery back up-Systems design -Lighting and water pumping applications:

### Unit:IV

#### Wind energy:

Wind power characteristics-power extraction-types of wind machines, Dynamics matchingperformance of wind generators, Wind mills-application-economics of wind power.

### Unit: V

#### Other Energy Sources:

Fuel cells, types-losses in fuel cell, Application: MHD generators- application of MHD generation, Biofuels-classification -biomass conversion process-application,ocean thermal energy conversion systems, Tidal and wave power-applications, Micro and mini hydel power, Hybrid Energy Systemimplementation –case study, Geo Thermal Energy.

#### Text Books:-

1. J.N.Twidell&A.D.Weir-Renewable Energy Sources, University press, Cambridge
2. S.L.Soo,Direct Energy Conversion, Prentice Hall Publication.

#### Reference Books:

1. Sukhatme, S.P., Solar Energy -Principles of Thermal Collection and Storage, Tata McGraw -Hill ,New Delhi.
2. Kreith, F.,andKreider,J.F.Principles of Solar Engineering ,Mc-Graw-Hill Book Co.
3. James Larminie , Andrew Dicks,Fuel Cell Systems,JohnWeily& Sons Ltd.
4. J.F. Manwell, J.G. McGowan, A.L. Rogers, Wind Energy Explained John Willy & Sons Ltd.
5. E.J. Womack MHD Power Generation Engineering aspects, Chapman and Hall Publication.
6. G.D. Rai, Non Conventional energy Sources, Khanna Publications, New Delhi

## Power System Protection Lab

### List of Experiments:

1. Determination of various reactances of a synchronous machine.
2. Determination of sequence impedances of a cylindrical rotor synchronous machine.
3. Fault analysis of
  - (i) L-G Fault
  - (ii) L-L Fault
  - (iii) L-L-G Fault
  - (iv) L-L-L-G Fault
4. Power angle characteristics of salient pole synchronous machine.
5. Equivalent circuit of a 3 winding transformer.
6. Characteristics of IDMT overcurrent relay (Electromagnetic type).
7. Characteristics of static negative sequence relay.
8. Characteristics of overvoltage relay.
  - (i) Electromagnetic Type
  - (ii) Microprocessor Type
9. Characteristics of percentage biased differential relay
  - (i) Electromagnetic Type
  - (ii) Static Type
10. Simulation of 220 kV transmission line model.
  - (i) Ferranti Effect
  - (ii) Transmission line parameter
  - (iii) Surge Impedance Loading
  - (iv) Voltage control Methods
11. Transformer oil testing.

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## Control Systems Engg. Lab

### List of Experiments:

1. To obtain the Torque speed characteristics of DC machine and its parameters, and hence determine the transfer function of a DC machine. Obtain the closed loop system response using P,PI and PID controllers.
2. To obtain the torque speed characteristics of a 2-phase ac servomotor and hence determine the incremental transfer function at different operating condition.
3. To obtain position and speed control of a DC motor (i) with/without velocity feedback  
(ii) with PID controller
4. To regulate the outlet water temperature of process control system using (i) on-off controller  
(ii) industrial controllers (P,PI,PID controllers).
5. To obtain mathematical model of liquid level system and control the water level of a coupled tank setup using different control laws.
6. To obtain the galvanometer constants and its response in the time domain and frequency domain respectively.
7. Familiarization with MATLAB programs and obtain the response of dynamic systems and its stability analysis using MATLAB programs.
8. Response of a simple DC drive system with load torque using MATLAB simulink software.
9. To obtain (i) the parameters of an electronic oven and hence find its transfer function  
(ii) the time response of thermal system using on/off (or relay) and P, PI, PID controllers. (selecting control parameters using Ziegler and Nichols tuning technique.)
10. To design compensator using Bode plot & Nyquist plot.
11. Transform given dynamical system from input/output model to state variable model and vice versa.

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# Semester-II

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## EHV AC – DC

### Unit: I

Sequential impedances of AC systems EHVAC transmission over voltages, insulation design of lightning and switching over voltages, High voltage testing of AC equipments, Reactive Power compensation of EHV AC lines.

### Unit: II

#### DC Power Transmission Technology

Application of DC Transmission, Description of DC Transmission System, Planning for HVDC Transmission, Modern Trends in DC Transmission, Thyristor Device, Thyristor Valve, Valve Tests, Recent Trends in valves. Comparison of EHV AC & DC transmission.

### Unit: III

#### HVDC Converters

Pulse Number, Choice of Converter Configuration, Simplified Analysis of Graetz Circuit, Converter Bridge Characteristics. Characteristics of a Twelve Pulse Converter, Detailed Analysis of Converters

**HVDC System Control:** Principal of DC Link Control, Converter Control Characteristics, System Control Hierarchy, Firing Angle Control, Current and Extinction Angle Control, Starting and Stopping of DC Link, Power Control, Higher Level Controllers, Telecommunication Requirements.

### Unit: IV

#### Converter Faults and Protection

Converter Faults , Protection Against Overcurrents, Over voltages in a Converter Station , Surge Arresters, Protection Against Over voltages.

#### Smoothing Reactor and DC Line

Smoothing Reactors, DC Line, Transient over Voltages In DC Line, Protection of DC Line, DC Breakers, Monopolar Operation, Effects of Proximity of AC and DC Transmission Lines

### Unit: V

#### Reactive Power Control

Reactive Power Requirements in Steady State, Sources of Reactive Power, Static Var Systems, Reactive Power Control during Transients **Harmonics and Filters:** Generation of Harmonics, Design of AC Filters, DC Filters, Carrier Frequency and RI Noise.

#### Text Book:

1. HVDC Power Transmission System: K.R. Padiyar , Wiley Eastern Limited.

#### Reference Book:

1. Power System Stability and Control by Prabha Kundur- EPRI. McGraw Hill Inc.

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## Power Quality

### Unit: I

Introduction - power quality, voltage quality, overview of power quality phenomena, classification of power quality issues, power quality measures and standards, THD -TIF-DINC- message weights-flicker factor-transient phenomena, occurrence of power quality problems, power acceptability curves, IEEE guides, standards and recommended practices.

### Unit: II

Harmonics, individual and total harmonic distortion, RMS value of a harmonic waveform, triplex harmonics, important harmonic introducing devices, SMPS, Three phase power converters, arcing devices, saturable devices, harmonic distortion of fluorescent lamps, effect of power system harmonics on power system equipment and loads. Modeling of networks and components under non-sinusoidal conditions, transmission and distribution systems, shunt capacitors, transformers, electric machines, ground systems, loads that cause power quality problems, power quality problems created by drives and its impact on drives

### Unit: III

Power factor improvement, Passive Compensation, Passive Filtering, Harmonic Resonance, Impedance Scan Analysis, Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC Based on Bilateral Single Phase and Three Phase Converter. Static VAR compensators, SVC and STATCOM.

### Unit: IV

Active Harmonic Filtering, Shunt Injection Filter for single phase, three -phase three -wire and three-phase four-wire systems, d-q domain control of three phase shunt active filters uninterruptible power supplies-constant voltage transformers, series active power filtering techniques for harmonic cancellation and isolation . Dynamic Voltage Restorers for sag , swell and flicker problems.

### Unit: V

Grounding and wiring, introduction, NEC grounding requirements, reasons for grounding, typical grounding and wiring problems, solutions to grounding, and wiring problems.

### Text books:-

1. Electric power quality by g.t.heydt
2. Understanding Power Quality Problems by Math H. Bollen

### Reference Books:

1. J. Arrillaga, .Power System Quality Assessment., John wiley, 2000
- 2 J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,.Power system Harmonic .Analysis, Wiley, 1997Selected Topics in Power Quality and Custom Power", Course book for STTP, 2004, Ashok S. Surya Santoso, H. Wayne Beaty, Roger C. Dugan, Mark F. McGranaghan, Electrical Power System Quality , MC GrawHill, 2002

## Power System Stability & Control

### Unit: I

#### Power System Structure

Operating states, control problem, control loops. Power System Stability – classification, terms and definitions.

#### Power system components

Hydraulic and steam turbine, Effect of exciter and governor. Excitation system – requirements, functions, types and modeling of excitation systems, IEEE standards and models.

### Unit: II

#### Control of Power and Frequency

Power, Frequency characteristics, Division of load, Load frequency control, Generator, load and Prime mover models, Governor models, AGC in a two area system, AGC in a multi area system parameter setting constants, Tie- line bias control, AGC with optimal dispatch of Generation, AGC including Excitation system, Conventional PI and PID controllers for AGC, AI applications automatic generation control.

### Unit:III

#### Control of voltage and Reactive Power

Relation between voltage, power and reactive power, Generation and absorption of reactive power, voltage control and voltage stability analysis, V-Q curves and sensitivity analysis, Voltage stability indices, Factors affecting voltage instability and voltage collapse.

### Unit:IV

#### Stability Studies

Concepts, steady state and transient stability, small signal stability analysis, excitation system, Dynamic and transient stability analysis of single machine and multi –machine systems, power system stabilizer design and analysis for stability problem. Transient Stability: Solution of swing equations, swing curves, stability criterion.

### Unit:V

#### Techniques for the improvement of stability

operation under abnormal and distressed condition, Enhancement of small signal stability: use of power system stabilizers, supplementary control of Static VAR compensators, supplementary control of HVDC links, Techniques for improvement of transient stability, Integrated analysis of Voltage and Angle stability, Control of voltage instability, concepts of load shedding.

#### Text Books:

1. PrabhaKundur, “Power System Stability and Control” Mc-Graw Hill Inc, New York, 1993.
2. Taylor C.W.,” Power System Voltage Stability” Mc-Graw Hill Inc, New York, 1993.

#### Reference Books:

1. K.R.Padiyar, „Power System Dynamic . Stability and Control., Inter Publishing (P) Ltd., Bangalore, 1999 .
2. P.S.R. Murthy , “ Power System Operation and Control,” Tata Mc-Graw ,New Delhi 1984.
3. Nagrath IJ, Kothari ., “ Power System Engineering ,” Tata Mc-Graw ,New Delhi 1994.
4. Weedy B.M. “ Electric Power System” John Wiley and Sons ,3rd edition .
5. O.I Elgerd,” Electric Energy System Theory : an Introduction ,” Mc-Graw Hill, NX, 1983 ( Mainly for Unit –II ).



## Digital Control Systems

### Unit: I

#### Sampling and Reconstruction

Introduction, Examples of data control systems – Digital to analog conversion and Analog to digital conversion, sample and hold operations

#### The Z-transforms

Introduction, Linear difference equation, pulse response, Z-transforms, Theorems of Z-transforms, Inverse Z-transforms, Modified Z-transforms

#### Z-plane analysis of discrete time control system

Z-transform method for solving difference equations, pulse transfer function, block diagram analysis of sampled data system, mapping between S-plane and Z-plane

### Unit: II

#### State Space Analysis

State Space representation of discrete time systems, pulse transfer function matrix solving discrete time state space equations, State transition matrix and its properties, methods for computation of state transition matrix, discretization of continuous time state-space equations

#### Controllability and Observability

concepts of controllability and observability, test for controllability and observability, duality between controllability and observability, controllability and observability conditions for pulse transfer function.

### Unit: III

#### Stability Analysis

Mapping between the s-plane and z-plane – primary strips and complementary strips – constant frequency loci, constant damping ratio loci, stability analysis of closed loop system in the Z-plane, jury stability test-stability analysis by use of bilinear transformation and Routh stability criterion, Liapunov stability analysis.

### Unit: IV

#### Design of discrete time control system by classical methods

Transient and steady state response analysis – design based on frequency response method – bilinear transformation and design procedure in the w-plane, lead, lag and lead lag compensator and digital PID controllers.

### Unit: V

#### State feedback controllers and observers

Design of state feedback controller through pole placement-necessary and sufficient conditions, Ackerman's formula, state observer – full order and reduced order observers.

#### Text Books:

1. Discrete time control systems, K. Ogata, Pearson Edu./PHI, 2<sup>nd</sup> Edition

#### Reference Books:

1. Digital Control Systems, Kuo, Oxford University Press, 2<sup>nd</sup> Edition, 2003
2. Digital Control and State Variable Methods by M. Gopal, TMH



## **Transients in Power System**

### **Unit: I**

Origin and nature of transients and surges. Equivalent circuit representations. Lumped and distributed circuit transients. Line energisation and de-energisation transients. Earth and earth wire effects.

### **Unit: II**

Current chopping in circuit breakers. Short line fault condition and its relation to circuit breaker duty. Trapped charge effects. Effect of source and source representation in short line fault studies. Control of transients.

### **Unit: III**

Lightning phenomena. Influence of tower footing resistance and earth resistance. Traveling waves in distributed parameter multi-conductor lines, parameters as a function of frequency.

### **Unit: IV**

Simulation of surge diverters in transient analysis. Influence of pole opening and pole closing. Fourier integral and Z transform methods in power system transients. Bergeron methods of analysis and use of EMTP and EMTDC/PSCAD package.

### **Unit: V**

Insulation Coordination: over voltage limiting devices, dielectric properties, breakdown of gaseous insulation, tracking and erosion of insulation, high current arcs.

### **Text Books:**

1. Transients in Power System By V. A. Vanikov, Mir Publications, Moscow.
2. Electrical Transients in Power Systems By Greenwood:A., John Wiley & Sons.

### **Reference Books:**

1. Power System Transients by C. S. Indulkar and D.P. Kothari
2. Power Circuit breaker theory and design by Flursheim C.H.
3. Traveling Waves on Transmission Lines Bewley; L.V., Dover Publications Inc., New York.
4. EMTP Rulebook
5. EMTDC/PSCAD Rulebook

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## **Restructuring Power System**

### **Unit: I**

Introduction: Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.

### **Unit: II**

Power System Restructuring: An overview of the restructured power system, Difference between integrated power system and restructured power system. Explanation with suitable practical examples.

### **Unit: III**

Deregulation of Power Sector: Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, Multilateral trade model. Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services.

### **Unit: IV**

Transmission Pricing: Marginal pricing of Electricity, nodal pricing, zonal pricing, embedded cost, Postage stamp method, Contract Path method, Boundary flow method, MW-mile method, MVA-mile method, Comparison of different methods.

### **Unit: V**

Congestion Management: Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC), Different Experiences in deregulation: England and Wales, Norway, China, California, New Zealand and Indian power system.

### **Text Books:**

1. "Power System Restructuring and Deregulation" edited by Loi Lei Lai, John Wiley & Sons Ltd.
2. "Restructured Power Systems", by S. A. Khaparde, A. R. Abhyankar, Narosa Publishing House, New Delhi

### **Reference Books:**

1. "Operation of Restructured Power Systems", by Kankar Bhattacharya, Math H.J. Bollen, Jaap E. Daalder, Springer Ltd.
- 2 "Restructured Electrical Power Systems: Operation, Trading, and Volatility", by Mohammad Shahidepour, Muwaffaq Alomoush, CRS Press.
- 3 "Understanding Electric Utilities and Deregulation", by Lorrin Philipson and H. Lee Willis, Marcel Dekker Inc, New York.
4. "Restructured Power Systems (Engineering and Economics)" by David, A. Kumar, Wen, F.S., Springer Ltd.

## **Distribution System Automation**

### **Unit:I**

Distribution System Automation and Planning, Factors Affecting System Planning, Present Distribution Planning Techniques, Planning in the Future, Power System reliability, Basic Reliability Concepts and Series, Parallel, Series -Parallel Systems, Development of State Transition Model to Determine the Steady State Probabilities.

### **Unit:II**

Electrical System Design, Distribution System Design, Electrical Design Aspects of Industrial, Commercial Buildings, Electrical Safety and Earthing Practices at various voltage levels, IS Codes

### **Unit:III**

Power Quality: Sags, Swells, Unbalance, Flicker, Distortion, Current Harmonics, Sources of Harmonics in Distribution Systems and its Effects, Energy Management, Energy Conservation Through Energy Management Demand Side Management, Load Management, Reactive Power Control. Custom Power: Concept, Custom Power Devices, Operation and Applications

### **Unit:IV**

Deregulated Systems: Reconfiguring Power systems, Unbundling of Electric Utilities, Competition and Direct access.

### **Unit: V**

Project planning for distribution automation-communication, sensors, supervisory control and data acquisition, consumer information system (CIS), geographical information system (GIS).

### **Text Books :**

- 1.TuranGonen: .Electric Power Distribution System Engineering. - McGraw Hill Company.
- 2.Pansini: .Electrical Distribution Engineering.

### **Reference Books:**

- 1). IEEE recommended practice for electric power distribution for industrial plants, - December 1993.
- 2). M.V Deshpande: .Electrical Power System Design. - Tata -McGraw Hill. 3).
- Pabla H S.: .Electrical Power Distribution Systems.. Tata McGraw Hill.
- 4). IEEE Slandered 739 . 1984 Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities.
- 5). Lakervi& E J Holmes .Electricity distribution Network Design., 2nd Edition Peter Peregrinus Ltd.

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## Power System Computation & Simulation Lab

### List of Experiments:

1. Solution of simultaneous Algebraic equation by Gauss- Elimination, crout,s method and cholesky method
2. Solution of simultaneous differential equation by Rk-4 and Modified Euler's method
3. Program to read and print out the power system load flow data of 5 Bus, IEE 14 Bus and IEEE 30 Bus systems.
4. Load flow by Gauss seidel, Newton Raphson and Fast Decoupled using two-dimensional arrays, sparsity techniques and MATLAB
5. AC/DC load flow study.
6. NR-load flow study with FACTS.
7. Simulation of single area and two area systems using MATLAB.
8. Study of load frequency control problem of (i) uncontrolled and (ii) controlled cases.
9. Economic dispatch if (i) Thermal units and (ii) Thermal plants using conventional GA or any other algorithms.
10. To obtain steady sate, transient and sub-transient short-circuit currents in and alternator.
11. To formulate the Y-Bus matrix and perform load flow analysis.
12. To compute voltage, current, Power factor, regulation and efficiency at the receiving end of a three phase transmission line when the voltage and power at the sending end are given. Use pi model.
13. To perform symmetrical fault analysis in a power system.
14. To perform unsymmetrical fault analysis in a power system.
15. Simulation if single are and two area system using MATLAB.
16. Study of load frequency control problem of (i) uncontrolled and (ii) controlled cases.

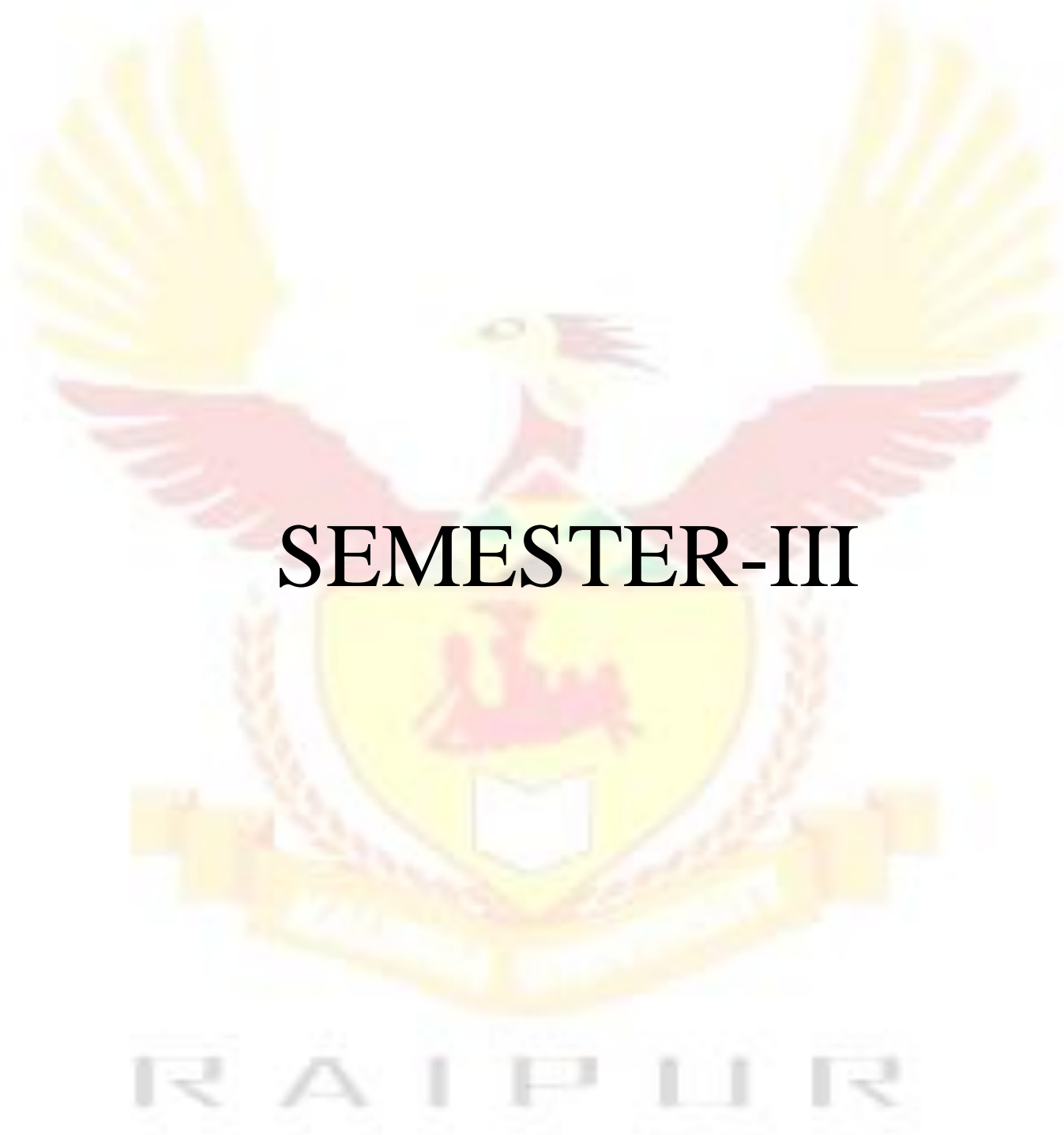
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**List of Experiment**

1. Operation of synchronous machine as motor and generator when connected to grid.
2. Performance characteristics of 1-phase induction motor and estimation of optimum capacitance value during starting.
3. Effect of 3<sup>rd</sup> harmonics in 3-phase transformers and in a bank of 3-phase transformer for various connections.
4. Experiments of single phase Fully controlled and Semi-controlled bridge converters.
5. Experiments on 3 phase Fully controlled and Semi-controlled bridge converters.
6. To measure the performance like THD, PF of a three phase fully controlled converter feeding a resistive load.
7. To measure the performance like DF & CF of a single phase fully controlled converter feeding a RL load.
8. To measure and analyze the harmonic contents of a three phase inverter fed non linear load.
9. Simulation of D-STATCOM for Power factor correction using MATLAB / SIMULATION.
10. To measure and analyze the source voltage and input current wave form for three phase induction motor fed through indirect vector control drive unit.







# SEMESTER-III

## Optimal Control Theory

### Unit: I

#### Linear Spaces and Linear operators

Introduction, Fields, vectors and vector spaces, linear combination and bases, linear transformations and matrices, scalar product and norms.

### Unit: II

#### General Mathematical Procedures

Introduction, formulation of the optimal control problem, calculus of variation, numerical solution of 2 point boundary value problem.

### Unit: III

#### Optimal Feedback Control

Discrete time linear state regulator, continuous time linear state regulator, time invariant linear state regulator.

### Unit: IV

#### State Regulators

Use of Linear State Regulators Results to Solve Other Linear Optimal Control Problem, sub-optimal linear regulators, minimum time control of linear time invariant systems

### Unit: V

#### Stochastic Optimal Linear Estimation and Control

Introduction, stochastic processes and linear systems, optimal estimation for linear continuous time systems, optimal estimation linear discrete time systems, stochastic optimal linear regulator

#### Text Books:

1. Modern Control System Theory, M. Gopal, New Age International Pub.
2. Optimal Control: Linear quadratic methods, Brian D.O. Anderson, John B. Mure, Prentice Hall

#### Reference Books :

1. F.L. Lewis and V.L. Syrmos, optimal control, John Wiley and Sons, NY 1955

## Communication & Research Methodology

### Unit: I

Concepts of Communications: Definition, Forms of Communication, Objectives of Communication, Characteristics of Communication, Process of Communication, Communication, Roadblocks, Role of Verbal and Non-verbal Symbols in Communication, Barriers to Effective Communication, Overcoming Communication Barriers.

**Nonverbal communication:** Body Language, Gestures, Postures, Facial Expressions, Dress codes; the Cross Cultural Dimensions of Business Communication; Listening and Speaking, techniques of eliciting response, probing questions, Observation. Business and social etiquettes; **Listening Skills:** Definition, Anatomy of poor Listening, Features of a good Listener, Role Play, Group Discussion and Interviews, Meetings: Ways and Means of conducting meetings effectively, Mock Meetings and Interviews

### Unit: II

**Reading and language skills:** The reading process, purpose, different kinds of texts, reference material, scientific and technical texts, active and passive reading, strategies - vocabulary skills, eye reading and visual perception, prediction techniques, scanning skills, distinguishing facts and opinions, drawing inferences and conclusions, comprehension of technical material - scientific and technical texts, instructions and technical manuals, graphic information. Forms of Communication in Written mode: Basics Body language of Business Letters and Memos, Tone of writing, Enquiries, orders and replying to them, sales letters, Job applications and resume, E-mail: How to make smart e-mail, Writing Business Reports and Proposals, Practice for Writing.

### Unit: III

**Referencing and Writing skills:** Business letters: Enquiries, Circulars, Quotations, Orders, Acknowledgments, Executions, Complaints, Claims and adjustments, Collection letter, Banking correspondence, Agency correspondence, Bad news and persuading letters, Sales letters, Job application letters - Biodata, Covering Letter, Interview Letters, Letter of Reference, Memos, minutes, Circulars & notices. **Types of Business Reports** - Format, Choice of vocabulary, coherence and cohesion, paragraph writing, organization reports by individual, Report by committee.

### Unit: IV

Introduction to Research and Research Design: Nature and scope of research, information based decision making and source of knowledge. The research process; basic approaches and terminologies used in research. Defining research question and framing of hypotheses, preparing a research plan, qualitative and quantitative research designs, Experimentation, Observational studies, Exploring secondary data. Measurement and Scaling, Data Source and Data Collection Field research: primary data collection from observations, surveys and experimentation. Measurement and scaling; commonly used scales in reliability and validity of scales. Designing instrument for data collection; testing the instrument, data collection process, Sampling methods and procedures and sample size decisions.

### Unit: V

Data Analysis and Presentation Editing and coding of data, tabulation, graphic presentation of data, cross tabulation, Testing of hypotheses; type I and II errors, one tailed and two tailed tests of significance, Parametric and nonparametric tests for Univariate and Bivariate data. Tests of association; simple linear regression and other non parametric tests. **Technical Writing:** Technical Proposal writing: Definition, Purpose, types, characteristics, Elements of structure, style and appearance, evaluation, exercises, Research report writing, Proposal writing, referencing, forms of reports, bibliography, etc. Research paper, Dissertation, and Thesis,

Instruction Manuals, Type of instructions, Writing Instructions, Technical Descriptions, Process descriptions, Guidelines for Writing Good Descriptions.

**Text Books:**

1. Lesikar, R. V. & Flatley, Basic Business Communication Skills for Empowering the Internet Generation. TMH.
2. Meenakshi Raman, Sangeeta Sharma, Technical Communications, Oxford Latest Edition.
3. D. K. Bhattacharyya, Research Methodology, Excel Books 2nd Edition.

**Reference Books:**

1. Bowman, J.P. & Branchaw, P.P. Business Communications, Process to Product Dryden Press, Chicago.
2. M Ashraf Rizvi, Effective Technical Communication, Tata McGraw Hill.
3. E. H. McGrath, Basic Managerial Skills, Prentice hall India
4. Sajitha, Technical Writing, Himalaya Latest Edition



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**Elective-III**  
MEPS303A

## **Energy Conservation & Audit**

### **Unit:I**

System approach and End use approach to efficient use of Electricity; Electricity tariff types; Energy auditing: Types and objectives -audit instruments- ECO assessment and Economic methods –specific energy analysis-Minimum energy paths-consumption models-Case study.

### **Unit:II**

Electric motors, Energy efficient controls and starting efficiency, Motor Efficiency and Load Analysis, Energy efficient /high efficient Motors, Case study; Load Matching and selection of motors. Variable speed drives; Pumps and Fans, Efficient Control strategies, Optimal selection and sizing, Optimal operation and Storage; Case study.

### **Unit:III**

Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study, Reactive Power management, Capacitor Sizing, Degree of Compensation, Capacitor losses-Location, Placement, Maintenance, case study; Peak Demand controls- Methodologies, Types of Industrial loads, Optimal Load scheduling –case study.

### **Unit: IV**

Lighting- Energy efficient light sources-Energy conservation in Lighting Schemes- Electronic ballast-Power quality issues -Luminaries, case study; Cogeneration - Definition and scope, topping and bottoming cycles, cogeneration technologies, industry suitable for cogeneration, sale of electricity to utility, impact of pricing on cogeneration, integrated energy system, potential of cogeneration in India.

### **Unit: V**

Electric loads of Air conditioning & Refrigeration -Energy conservation measures- Cool storage .Types- Optimal operation-case study; Electric water heating-Gysers-Solar Water Heaters-Power Consumption in Compressors, Energy conservation measures; Electrolytic Process; Computer Controls- softwares-EMS.

### **Text Books:**

1. IEEE Bronze Book- .Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities. IEEE Inc, USA. Giovanni
2. Petrecca, .Industrial Energy Management: Principles and Applications., The Kluwer international series -207,(1999)

### **Reference Books:**

- 1 . Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998).
- 2 . Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2nd edition (1994).
- 3 . Turner, Wayne C., .Energy Management Handbook., Lilburn, The Fairmont Press, 2001.
- 4 . Albert Thumann , .Handbook of Energy Audits., Fairmont Pr; 5th edition (1998).
- 5 . Albert Thumann, P.W, Plant Engineers and Managers Guide to Energy Conservation. –



Seventh Edition-TWI Press Inc, Terre Haute.

6 . Donald R. W., .Energy Efficiency Manual., Energy Institute Press.

7 . TripathyS.C.,'Electric Energy Utilization And Conservation', Tata McGraw Hill.

8 . NESCAP -Guide Book on Promotion of Sustainable Energy Consumption.



**Unit: I**

Biological neurons and their artificial models, models of artificial neural networks, feed forward and feed backward networks, supervised and unsupervised learning, Neural network learning rules - Hebbian rule, perceptron rules, delta rules, Widrow -Hoff rule, correlation rule, winner- take- all rule, outstar learning rule.

**Unit: II**

Single Layer Perceptron Classifier: Classification model, features, decision regions, discriminant functions, linear machine and minimum distance classification, training and classification using discrete Perceptron algorithm, single layer continuous Perceptron networks for linearly separable classification, multi category single layer Perceptron networks. Multi Layer Feed Forward Networks- Linearly non-separable pattern classification, delta learning rule for multi Perceptron layer, generalised delta rules, error back propagation training.

**Unit: III**

Single Layer Feedback Networks: Basic concepts of dynamical systems, mathematical foundation of discrete time Hopfield networks, mathematical foundation of gradient type Hopfield networks transient response of continuous time networks, relaxation modeling in single layer feedback networks, optimization problems. Associative Memories: Basic concepts, linear associator, basic concept of and performance analysis of recurrent auto associative memory, bi-directional associative memory, associative memory of spatio-temporal patterns.

**Unit: IV**

Fuzzy sets. Fuzzy set operations . Properties, Membership functions, Fuzzy to crisp conversion. fuzzification and defuzzification methods, applications in engineering problems.

**Unit: V**

Fuzzy control systems. Introduction, simple fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems. Inverter pendulum. image processing . home heating system . Adaptive fuzzy systems, hybrid systems.

**Text Books:**

1. J.M. Zurada, .Introduction to artificial neural systems., Jaico Publishers, 1992.
2. Simon Haykins, .Neural Networks . A comprehensive foundation., Macmillan College, Proc, Con, Inc, New York, 1994.

**Reference Books:**

1. D. Driankov, H. Hellendorn, M. Reinfrank, .Fuzzy Control . An Introduction., Narora Publishing House, New Delhi, 1993.
2. H.J. Zimmermann, .Fuzzy set theory and its applications., III Edition, Kluwer Academic Publishers, London.
3. G.J. Klir, Boyuan, .Fuzzy sets and fuzzy logic., Prentice Hall of India (P) Ltd., 1997.
4. Stamatios V Kartalopoulos, .Understanding neural networks and fuzzy logic .basic concepts and applications., Prentice Hall of India (P) Ltd., New Delhi, 2000.
5. Timothy J. Ross, .Fuzzy logic with engineering applications., McGraw Hill, New York.
6. SuranGoonatilake, SukhdevKhebbal (Eds), .Intelligent hybrid systems., John Wiley & Sons, New York, 1995.

**Unit: I**

Generating Capacity Basic Probability Methods:- Introduction, The generation system model, Generating unit unavailability Capacity outage probability tables, Comparison of deterministic and probabilistic criteria, Recursive algorithm for capacity model building , Recursive algorithm for unit removal, Alternative model –building techniques , Loss of load indices , Concepts and evaluation techniques , Numerical examples, Equivalent forced outage rate, capacity expansion analysis , Evaluation techniques , Perturbation effects, Scheduled outages , Evaluation methods on period bases , Load forecast uncertainty, Forced outage rate uncertainty , Exact method , Approximate method , Application, LOLE computation .

**Unit: II**

Generating Capacity, Frequency and Duration Method, Introduction, The generation model, Fundamental development, Recursive algorithm for capacity model building, System risk indices, Individual state load model, Cumulative state load model, Practical system studies, Base case study, System expansion studies, Load forecast uncertainty .

**Unit: III**

Interconnected Systems:-Introduction , Probability array method in two interconnected system , Concepts , Evaluation techniques , Equivalent assisting unit approach to two interconnected system, Factors affecting the emergency assistance available through the interconnections, Introduction , Effect of tie capacity , Effect of tie line reliability , Effect of number of tie line , Effect of tie capacity uncertainty, Effect of load forecast uncertainty , Variable reserve versus maximum peak load reserve , Reliability evaluation in three interconnected systems, Direct assistance from two systems, Indirect assistance from two systems.

**Unit: IV**

Operating Reserve:- General concepts, PJM method, Concepts, Outage replacement rate, Generation model , Unit commitment , Extensions to PJM method , Load forecast uncertainty, Derated (Partial output ) states. Modified PJM method, Concepts, Area risk curves. Modelling rapid start unit, Modelling hot reserve units, Unit commitment risk, Numerical examples, Postponable outage, Concepts in Modelling postponable outages, Unit commitment risk , Security function approach , Concepts , Security function model, Response risk, Concepts, Evaluation techniques, Effect of disturbing spinning reserve, Effect of hydro- electric units, Effect of rapid start units, Interconnected systems. .

**Unit: V**

Composite Generation and Transmission systems:- Introduction , Radial configurations , Conditional probability approach, Network configurations, State selection, Concepts , Application , System and load point indices , Concepts , Numerical evaluation, Application to practical systems. Data requirements for composite system reliability evaluation , Concepts , Deterministic data, Stochastic data , Independent outages, dependent outages, common mode outages, station originated outages.

**Text Book:**

1. Reliability Evaluation of Power System by Roy Billinton, Ronald and Allan, Plenum Press, NYLondon.

## **Preliminary Work on Dissertation**

The student will submit a synopsis at the beginning of the semester for approval from the departmental committee in a specified format. The student will have to present the progress of the work through seminars and progress reports.



MEPS305

### **Seminar Based on Dissertation**

The student will deliver a seminar on the topic chosen by him and approved by Departmental committee for evaluation at the end of semester.







# Semester-IV

MEPS401

## **Dissertation**

The student will submit a detailed Project Report on the topic approved by Departmental committee in a specified format and will also deliver a Presentation on the topic chosen at the end of semester.

