### M.E. POWER SYSTEMS ENGINEERING

#### SEMESTER I

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COURSE OBJECTIVES

- To introduce different techniques of dealing with sparse matrices for large scale power systems.
- To impart in-depth knowledge on different methods of power flow solutions.
- To perform optimal power flow solutions in detail.
- To perform short circuit fault analysis and understand the consequence of different types of faults.
- To illustrate different numerical integration methods and factors influencing transient stability.

UNIT I SOLUTION TECHNIQUE
Sparse matrix techniques for large scale power systems: Optimal ordering schemes for preserving sparsity. Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bifactorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices.

UNIT II POWER FLOW ANALYSIS
Power flow equation in real and polar forms; Review of Newton’s method for solution; Adjustment of P-V buses; Review of Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment.

UNIT III OPTIMAL POWER FLOW
Problem statement; Solution of Optimal Power Flow (OPF) – The gradient method, Newton’s method, Linear Sensitivity Analysis; LP methods – With real power variables only – LP method with AC power flow variables and detailed cost functions; Security constrained Optimal Power Flow; Interior point algorithm; Bus Incremental costs.

UNIT IV SHORT CIRCUIT ANALYSIS
Formation of bus impedance matrix with mutual coupling (single phase basis and three phase basis) - Computer method for fault analysis using $Z_{bus}$ and sequence components. Derivation of equations for bus voltages, fault current and line currents, both in sequence and phase – symmetrical and unsymmetrical faults.

UNIT V TRANSIENT STABILITY ANALYSIS

L:45 + T: 15 TOTAL: 60 PERIODS
TEXTBOOKS

REFERENCES:

PS8102 POWER SYSTEM OPERATION AND CONTROL L T P C 3 0 0 3

COURSE OBJECTIVES
• To understand the fundamentals of speed governing system and the concept of control areas.
• To provide knowledge about Hydrothermal scheduling, Unit commitment and solution techniques.
• To understand the role of energy control center, SCADA and EMS functions.

UNIT I INTRODUCTION
System load variation: System load characteristics, load curves - daily, weekly and annual, load-duration curve, load factor, diversity factor. Reserve requirements: Installed reserves, spinning reserves, cold reserves, hot reserves. Overview of system operation: Load forecasting, techniques of forecasting, basics of power system operation and control.

UNIT II REAL POWER - FREQUENCY CONTROL
Fundamentals of speed governing mechanism and modelling: Speed-load characteristics – Load sharing between two synchronous machines in parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis of uncontrolled and controlled cases, Economic Dispatch Control. Multi-area systems: Two-area system modelling; static analysis, uncontrolled case; tie line with frequency bias control of two-area system derivation, state variable model.

UNIT III HYDROTHERMAL SCHEDULING PROBLEM
with pumped hydro plant during off-peak seasons: algorithm. Selection of initial feasible trajectory for pumped hydro plant: Pumped hydro plant as spinning reserve unit-generation of outage induced constraint-Pumped hydro plant as Load management plant.

UNIT IV  UNIT COMMITMENT AND ECONOMIC DISPATCH
Statement of Unit Commitment (UC) problem; constraints in UC: spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints; UC solution methods: Priority-list methods, forward dynamic programming approach, numerical problems .Incremental cost curve, co-ordination equations without loss and with loss, solution by direct method and λ-iteration method. Base point and participation factors.-Economic dispatch controller added to LFC control.

UNIT V  COMPUTER CONTROL OF POWER SYSTEMS
Energy control centre: Functions – Monitoring, data acquisition and control. System hardware configuration – SCADA and EMS functions: Network topology determination, state estimation, security analysis and control. Various operating states: Normal, alert, emergency, in-extremis and restorative-State transition diagram showing various state transitions and control strategies.

TOTAL : 45 PERIODS

TEXTBOOKS

REFERENCES:
HV8151  ELECTRICAL TRANSIENTS IN POWER SYSTEM  LTPC  3003

OBJECTIVES:
- To gain knowledge in the sources and effects of lightning, switching and temporary overvoltages.
- Ability to model and estimate the overvoltages in power system.
- To coordinate the insulation of power system and protective devices.
- Ability to model and analyze power system and equipment for transient overvoltages using Electromagnetic Transient Program (EMTP).

UNIT I  LIGHTNING OVERVOLTAGES  9
Mechanism and parameters of lightning flash, protective shadow, striking distance, electrogeometric model for lightning strike, Grounding for protection against lightning – Steady-state and dynamic tower-footing resistance, substation grounding Grid, Direct lightning strokes to overhead lines, without and with shield Wires.

UNIT II  SWITCHING AND TEMPORARY OVERVOLTAGES  9
Switching transients – concept – phenomenon – system performance under switching surges, Temporary overvoltages – load rejection – line faults – ferroresonance, VFTO.

UNIT III  TRAVELLING WAVES ON TRANSMISSION LINE  9
Circuits and distributed constants, wave equation, reflection and refraction – behaviour of travelling waves at the line terminations – Lattice Diagrams – attenuation and distortion – multi-conductor system and multivelocity waves.

UNIT IV  INSULATION CO-ORDINATION  9
Classification of overvoltages and insulations for insulation co-ordination – Characteristics of protective devices, applications, location of arresters – insulation co-ordination in AIS and GIS.

UNIT V  COMPUTATION OF POWER SYSTEM TRANSIENTS  9
Modelling of power apparatus for transient studies – principles of digital computation – transmission lines, cables, transformer and rotating machines – Electromagnetic Transient program – case studies: line with short and open end, line terminated with R, L, C, transformer, typical power system case study: simulation of possible overvoltages in a high voltage substation.

TOTAL : 45 PERIODS

REFERENCES


MA8156  APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS  L T P C
                                                    3 1 0 4

OBJECTIVES:
• To develop the ability to apply the concepts of Matrix theory and Linear programming in Electrical Engineering problems.
• To achieve an understanding of the basic concepts of one dimensional random variables and apply in electrical engineering problems.
• To familiarize the students in calculus of variations and solve problems using Fourier transforms associated with engineering applications.

UNIT I  MATRIX THEORY  (9+3)
The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition.

UNIT II  CALCULUS OF VARIATIONS  (9+3)
Concept of variation and its properties – Euler’s equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – problems with constraints - Direct methods: Ritz and Kantorovich methods.

UNIT III  ONE DIMENSIONAL RANDOM VARIABLES  (9+3)

UNIT IV  LINEAR PROGRAMMING  (9+3)
Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT V  FOURIER SERIES  (9+3)

L:45 +T: 15 TOTAL: 60 PERIODS

BOOKS FOR STUDY:

REFERENCES:

PE8152  ANALYSIS OF ELECTRICAL MACHINES  LT P C
3 0 0 3

OBJECTIVES:
- To provide knowledge about the fundamentals of magnetic circuits, energy, force and torque of multi-excited systems.
- To analyze the steady state and dynamic state operation of DC machine through mathematical modeling and simulation in digital computer.
- To provide the knowledge of theory of transformation of three phase variables to two phase variables.
- To analyze the steady state and dynamic state operation of three-phase induction machines using transformation theory based mathematical modeling and digital computer simulation.
- To analyze the steady state and dynamic state operation of three-phase synchronous machines using transformation theory based mathematical modeling and digital computer simulation.

UNITI  PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION  9
Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations.

UNIT II  DC MACHINES  9
Elementary DC machine and analysis of steady state operation - Voltage and torque equations – dynamic characteristics of permanent magnet and shunt d.c. motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation – digital computer simulation of permanent magnet and shunt d.c. machines.

UNIT III  REFERENCE FRAME THEORY  9
Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.
UNIT IV
INDUCTION MACHINES

UNIT V
SYNCHRONOUS MACHINES
Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park’s equations) – analysis of dynamic performance for load torque variations – digital computer simulation.

TEXT BOOKS

REFERENCES

PS8111 POWER SYSTEM SIMULATION LABORATORY
L T P C
0 0 3 1

COURSE OBJECTIVES

- To have hands on experience on various system studies and different techniques used for system planning, software packages.
- To perform the dynamic analysis of power system

1. Power flow analysis by Newton-Raphson method and Fast decoupled method
2. Transient stability analysis of single machine-infinite bus system using classical machine model
3. Contingency analysis: Generator shift factors and line outage distribution factors
4. Economic dispatch using lambda-iteration method
5. Unit commitment: Priority-list schemes and dynamic programming
6. Analysis of switching surge using EMTP: Energisation of a long distributed-parameter line
7. Analysis of switching surge using EMTP: Computation of transient recovery voltage
8. Familiarization of Relay Test Kit
9. Simulation and Implementation of Voltage Source Inverter
10. Digital Over Current Relay Setting and Relay Coordination.
11. Co-ordination of over-current and distance relays for radial line protection

TOTAL : 45 PERIODS
COURSE OBJECTIVES

- To illustrate concepts of transformer protection
- To describe about the various schemes of Over current protection
- To analyze distance and carrier protection
- To familiarize the concepts of Busbar protection and Numerical protection

UNIT I  EQUIPMENT PROTECTION

Types of transformers – Phasor diagram for a three – Phase transformer-Equivalent circuit of transformer – Types of faults in transformers- Over – current protection Percentage Differential Protection of Transformers - Inrush phenomenon-High resistance Ground Faults in Transformers - Inter-turn faults in transformers - Incipient faults in transformers - Phenomenon of over-fluxing in transformers - Transformer protection application chart .Electrical circuit of the generator –Various faults and abnormal operating conditions-rotor fault –Abnormal operating conditions; numerical examples for typical transformer and generator protection schemes

UNIT II  OVER CURRENT PROTECTION

Zones of protection – Primary and Backup protection – operating principles and Relay Construction - Time – Current characteristics-Current setting – Time setting-Over current protective schemes - Reverse power or directional relay - Protection of parallel feeders - Protection of ring feeders - Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective scheme directional earth fault relay - Static over current relays; numerical example for a radial feeder

UNIT III DISTANCE AND CARRIER PROTECTION OF TRANSMISSION LINES

Braw back of over – Current protection – Introduction to distance relay – Simple impedance relay – Reactance relay – mho relays comparison of distance relay – Distance protection of a three – Phase line-reasons for inaccuracy of distance relay reach - Three stepped distance protection - Trip contact configuration for the three - Stepped distance protection - Three-stepped protection of three-phase line against all ten shunt faults - Impedance seen from relay side - Three-stepped protection of double end fed lines-need for carrier – Aided protection – Various options for a carrier –Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying - Carrier aided distance schemes for acceleration of zone II.; numerical example for a typical distance protection scheme for a transmission line.

UNIT IV BUSBAR PROTECTION

Introduction – Differential protection of busbars-external and internal fault - Actual behaviors of a protective CT - Circuit model of a saturated CT - External fault with one CT saturation :need for high impedance – Minimum internal fault that can be detected by the high – Stability ratio of high impedance busbar differential scheme - Supervisory relay-protection of three – Phase busbars-Numerical examples on design of high impedance busbar differential scheme.
UNIT V  NUMERICAL PROTECTION

Introduction – Block diagram of numerical relay - Sampling theorem- Correlation with a reference wave – Least error squared (LES) technique - Digital filtering-numerical over - Current protection – Numerical transformer differential protection-Numerical distance protection of transmission line

TOTAL : 45 PERIODS

TEXTBOOKS

REFERENCES

PS8202  POWER SYSTEM DYNAMICS  L T P C
3 0 0 3

COURSE OBJECTIVES
• To impart knowledge on dynamic modelling of a synchronous machine in detail
• To describe the modeling of excitation and speed governing system in detail.
• To understand the fundamental concepts of stability of dynamic systems and its classification
• To understand and enhance small signal stability problem of power systems.

UNIT I  SYNCHRONOUS MACHINE MODELLING

Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, mmf waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation, Per Unit Representations: L_{ad}-reciprocal per unit system and that from power-invariant form of Park’s transformation; Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Rotor angle, Steady-state equivalent circuit, Computation of steady-state values, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Simplifications for large-scale studies : Neglect of stator \rho \Psi terms and speed
variations, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical model.

UNIT II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS


UNIT III SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS


UNIT IV SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System Stabiliser: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical a example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example. Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers.

UNIT V ENHANCEMENT OF SMALL SIGNAL STABILITY


TOTAL : 45 PERIODS
TEXT BOOKS:

REFERENCES:

PS8253 FLEXIBLE AC TRANSMISSION SYSTEMS L T P C
3 0 0 3

COURSE OBJECTIVES
- To emphasis the need for FACTS controllers.
- To learn the characteristics, applications and modelling of series and shunt FACTS controllers.
- To analyze the interaction of different FACTS controller and perform control coordination

UNIT I INTRODUCTION
Review of basics of power transmission networks-control of power flow in AC transmission line- Analysis of uncompensated AC Transmission line- Passive reactive power compensation: Effect of series and shunt compensation at the mid-point of the line on power transfer- Need for FACTS controllers- types of FACTS controllers.

UNIT II STATIC VAR COMPENSATOR (SVC)
Configuration of SVC- voltage regulation by SVC- Modelling of SVC for load flow analysis- Modelling of SVC for stability studies-Design of SVC to regulate the mid-point voltage of a SMIB system- Applications: transient stability enhancement and power oscillation damping of SMIB system with SVC connected at the mid-point of the line.

UNIT III THYRISTOR AND GTO THYRISTOR CONTROLLED SERIES CAPACITORS (TCSC and GCSC)
Concepts of Controlled Series Compensation – Operation of TCSC and GCSC- Analysis of TCSC-GCSC – Modelling of TCSC and GCSC for load flow studies-modeling TCSC and GCSC for stability studied- Applications of TCSC and GCSC
UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS 9
Static synchronous compensator (STATCOM) - Static synchronous series compensator (SSSC) - Operation of STATCOM and SSSC - Power flow control with STATCOM and SSSC - Modelling of STATCOM and SSSC for power flow and transient stability studies – operation of Unified and Interline power flow controllers (UPFC and IPFC) - Modelling of UPFC and IPFC for load flow and transient stability studies - Applications.

UNIT V CONTROLLERS AND THEIR COORDINATION 9

TOTAL : 45 PERIODS

TEXT BOOKS

REFERENCES:

PS8254 RESTRUCTURED POWER SYSTEM L T P C 3 0 0 3

COURSE OBJECTIVES
- To Introduce the restructuring of power industry and market models.
- To impart knowledge on fundamental concepts of congestion management.
- To analyze the concepts of locational marginal pricing and financial transmission rights.
- To Illustrate about various power sectors in India

UNIT I INTRODUCTION TO RESTRUCTURING OF POWER INDUSTRY 9
Introduction: Deregulation of power industry, Restructuring process, Issues involved in deregulation, Deregulation of various power systems – Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production – Market models: Market models based on Contractual
arrangements, Comparison of various market models, Electricity vis – a – vis other commodities, Market architecture, Case study.

UNIT II  TRANSMISSION CONGESTION MANAGEMENT  9

UNIT III  LOCATIONAL MARGINAL PRICES AND FINANCIAL TRANSMISSION RIGHTS  9

UNIT IV  ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK  9
Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - How to obtain ancillary service –Co-optimization of energy and reserve services - International comparison Transmission pricing – Principles – Classification – Rolled in transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Merits and demerits of different paradigm.

UNIT V  REFORMS IN INDIAN POWER SECTOR  9

TOTAL : 45 PERIODS

TEXTBOOKS

REFERENCES
1. Sally Hunt,” Making competition work in electricity”, , John Willey and Sons Inc. 2002
Course objectives

1. To analyze the effect of FACTS controllers by performing steady state analysis.
2. To have hands on experience on different wind energy conversion technologies.

1. Small-signal stability analysis of single machine-infinite bus system using classical machine model
2. Small-signal stability analysis of multi-machine configuration with classical machine model
3. Induction motor starting analysis
4. Load flow analysis of two-bus system with STATCOM
5. Transient analysis of two-bus system with STATCOM
6. Available Transfer Capability calculation using an existing load flow program
7. Study of variable speed wind energy conversion system- DFIG
8. Study of variable speed wind energy conversion system- PMSG
9. Computation of harmonic indices generated by a rectifier feeding a R-L load
10. Design of active filter for mitigating harmonics.

TOTAL: 45 PERIODS

COURSE OBJECTIVES

- To perform transient stability analysis using unified algorithm.
- To impart knowledge on sub-synchronous resonance and oscillations.
- To analyze voltage stability problem in power system.
- To familiarize the methods of transient stability enhancement.

UNIT I TRANSIENT STABILITY ANALYSIS


UNIT II UNIFIED ALGORITHM FOR DYNAMIC ANALYSIS OF POWER SYSTEMS

Need for unified algorithm- numerical integration algorithmic steps-truncation error-variable step size – handling the discontinuities- numerical stability- application of the algorithm for transient. Mid-term and long-term stability simulations
UNIT III  SUBSYNCHRONOUS RESONANCE (SSR) AND OSCILLATIONS  

UNIT IV  TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS  

UNIT V  ENHANCEMENT OF TRANSIENT STABILITY AND COUNTER MEASURES FOR SUBSYNCHRONOUS RESONANCE [1]
Principle behind transient stability enhancement methods: high-speed fault clearing, reduction of transmission system reactance, regulated shunt compensation, dynamic braking, reactor switching, independent pole-operation of circuit-breakers, single-pole switching, fast-valving, high-speed excitation systems; NGH damper scheme.

TEXT BOOKS:

REFERENCES
COURSE OBJECTIVES

- To introduce the objectives of Load forecasting.
- To study the fundamentals of Generation system, transmission system and Distribution system reliability analysis
- To illustrate the basic concepts of Expansion planning

UNIT I LOAD FORECASTING 9
Objectives of forecasting - Load growth patterns and their importance in planning - Load forecasting Based on discounted multiple regression technique - Weather sensitive load forecasting - Determination of annual forecasting - Use of AI in load forecasting.

UNIT II GENERATION SYSTEM RELIABILITY ANALYSIS 9
Probabilistic generation and load models - Determination of LOLP and expected value of demand not served - Determination of reliability of iso and interconnected generation systems.

UNIT III TRANSMISSION SYSTEM RELIABILITY ANALYSIS 9
Deterministic contingency analysis - probabilistic load flow - Fuzzy load flow probabilistic transmission system reliability analysis - Determination of reliability indices like LOLP and expected value of demand not served.

UNIT IV EXPANSION PLANNING 9
Basic concepts on expansion planning - procedure followed for integrate transmission system planning, current practice in India - Capacitor placer problem in transmission system and radial distributions system.

UNIT V DISTRIBUTION SYSTEM PLANNING OVERVIEW 9
Introduction, sub transmission lines and distribution substations - Design primary and secondary systems - Distribution system protection and coordination of protective devices.

TOTAL: 45 PERIODS

TEXT BOOK:

REFERENCES:
CO8072 ROBUST CONTROL L T P C 3 0 0 3

COURSE OBJECTIVES
- To introduce norms, random spaces and robustness measures
- To educate on H2 optimal control and estimation techniques
- To educate on Hinfinity optimal control techniques
- To educate on the LMI approach of Hinfinity control
- To educate on synthesis techniques for robust controllers and illustrate through case studies

UNIT I INTRODUCTION 9

UNIT II H2 OPTIMAL CONTROL 9
Linear Quadratic Controllers – Characterization of H2 optimal controllers – H2 optimal estimation-Kalman Bucy Filter – LQG Controller

UNIT III H-INFINITY OPTIMAL CONTROL-RICCATI APPROACH 9
Formulation – Characterization of H-infinity sub-optimal controllers by means of Riccati equations – H-infinity control with full information – Hinfinity estimation

UNIT IV H-INFINITY OPTIMAL CONTROL- LMI APPROACH 9

UNIT V SYNTHESIS OF ROBUST CONTROLLERS & CASE STUDIES 9
Synthesis of Robust Controllers – Small Gain Theorem – D-K –iteration- Control of Inverted Pendulum- Control of CSTR – Control of Aircraft – Robust Control of Second-order Plant-Robust Control of Distillation Column

TOTAL : 45 PERIODS

REFERENCES
COURSE OBJECTIVES

- To introduce various model structures for system identification
- To impart knowledge on parametric and non-parametric identification
- To introduce non-linear identification techniques
- To introduce the concept of adaptation techniques and control
- To illustrate the identification and adaptive control techniques through case studies

UNIT I MODELS FOR IDENTIFICATION
9

UNIT II NON-PARAMETRIC AND PARAMETRIC IDENTIFICATION
9

UNIT III NON-LINEAR IDENTIFICATION
9

UNIT IV ADAPTIVE CONTROL AND ADAPTATION TECHNIQUES
9

UNIT V CASE STUDIES
9
Inverted Pendulum, Robot arm, process control application: heat exchanger, Distillation column, application to power system, Ship steering control.

TOTAL : 45 PERIODS

REFERENCES
5. William S. Levine, " Control Hand Book".
COURSE OBJECTIVES

- To educate on modeling and representing systems in state variable form
- To educate on solving linear and non-linear state equations
- To illustrate the role of controllability and observability
- To educate on stability analysis of systems using Lyapunov’s theory
- To educate on modal concepts and design of state and output feedback controllers and estimators

UNIT I  STATE VARIABLE REPRESENTATION  9
Introduction-Concept of State-State equation for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model-State Diagrams - Physical System and State Assignment.

UNIT II  SOLUTION OF STATE EQUATIONS  9

UNIT III  CONTROLLABILITY AND OBSERVABILITY  9
Controllability and Observability-Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV  STABILITY  9

UNIT V  MODAL CONTROL  9
Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems-The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

TOTAL : 45 PERIODS

REFERENCES:
PROGRAM OBJECTIVES

- To review the fundamentals of ANN and fuzzy set theory
- To make the students understand the use of ANN for modeling and control of non-linear system and to get familiarized with the ANN tool box.
- To impart knowledge of using Fuzzy logic for modeling and control of non-linear systems and get familiarized with the FLC tool box.
- To make the students to understand the use of optimization techniques.
- To familiarize the students on various hybrid control schemes, P.S.O and get familiarized with the ANFIS tool box.

UNIT I  OVERVIEW OF ARTIFICIAL NEURAL NETWORK (ANN) & FUZZY LOGIC


UNIT II  NEURAL NETWORKS FOR MODELLING AND CONTROL

Modeling of non linear systems using ANN- NARX,NNSS,NARMAX - Generation of training data - optimal architecture – Model validation- Control of non linear system using ANN- Direct and Indirect neuro control schemes- Adaptive neuro controller – Case study - Familiarization of Neural Network Control Tool Box.

UNIT III  FUZZY LOGIC FOR MODELLING AND CONTROL


UNIT IV  GENETIC ALGORITHM

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like Tabu search, Ant-colony search and Particle Swarm Optimization.

UNIT V  HYBRID CONTROL SCHEMES


TOTAL : 45+30 = 75 PERIODS

Soft Computing Techniques - Lab

To implement adaline and madaline with bipolar inputs and outputs using NN toolbox.
To implement back propagation for a given input pattern using NN toolbox.
To implement discrete hopfield network and test for given input pattern using NN toolbox.
To implement fuzzy set operation and properties using FUZZY toolbox.
To perform max-min composition of two matrices obtained from Cartesian product using ‘m file’ in MATLAB.
Write a program to verify the various laws associated with fuzzy set using FUZZY toolbox.
Write a Matlab program for maximizing \( f(x) = x^2 \) using GA, where \( x \) is ranges from 0 to 31 (Perform only 5 iterations). Find the objective function and ‘x’ value.

Design FLC for a FOPDT process using FUZZY toolbox.

Design a Neuro model for an inverted pendulum using NN toolbox.

Design Fuzzy model for an inverted pendulum using FUZZY toolbox.

REFERENCES


ET8072 MEMS TECHNOLOGY  L T P C  3 0 0 3
Pre-requisites: Basic Instrumentation, Material Science, Programming

COURSE OBJECTIVES

- To teach the students properties of materials, microstructure and fabrication methods.
- To teach the design and modeling of Electrostatic sensors and actuators.
- To teach the characterizing thermal sensors and actuators through design and modeling.
- To teach the fundamentals of piezoelectric sensors and actuators.
- To give exposure to different MEMS and NEMS devices.

UNIT I MEMS: MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress-resonant frequency and quality factor.

UNIT II ELECTROSTATIC SENSORS AND ACTUATION

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications.

UNIT III THERMAL SENSING AND ACTUATION

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.
UNIT IV  PIEZOELECTRIC SENSING AND ACTUATION  
Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

UNIT V  CASE STUDIES  
Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

TOTAL : 45 PERIODS

REFERENCES

ET8152 MICROCONTROLLER BASED SYSTEM DESIGN  LT P C
3 0 0 3

Pre-requisites: Basics of Processor Architecture & Programming in 8085/8051

COURSE OBJECTIVES
• To expose the students to the fundamentals of microcontroller based system design.
• To teach I/O and RTOS role on microcontroller.
• To impart knowledge on
• PIC Microcontroller based system design.
• To introduce Microchip PIC 8 bit peripheral system Design
• To give case study experiences for microcontroller based applications.

UNIT I  8051 ARCHITECTURE  

UNIT II  8051 PROGRAMMING  

UNIT III  PIC MICROCONTROLLER  
UNIT IV PERIPHERAL OF PIC MICROCONTROLLER

UNIT V SYSTEM DESIGN – CASE STUDY
Interfacing LCD Display – Keypad Interfacing - Generation of Gate signals for converters and Inverters - Motor Control – Controlling DC/ AC appliances – Measurement of frequency - Stand alone Data Acquisition System.

TOTAL : 45 PERIODS

REFERENCES:

ET8351 DISTRIBUTED EMBEDDED COMPUTING

Pre-requisites: Basics in Programming, Embedded System & operating systems

OBJECTIVES
- To expose the students to the fundamentals of Network communication technologies.
- To teach the fundamentals of Internet
- To study on Java based Networking
- To introduce network routing Agents
- To study the basis for network on-chip technologies

UNIT I THE HARDWARE INFRASTRUCTURE

UNIT II INTERNET CONCEPTS
Capabilities and limitations of the internet – Interfacing Internet server applications to corporate databases HTML and XML Web page design and the use of active components.

UNIT III DISTRIBUTED COMPUTING USING JAVA
UNIT IV EMBEDDED AGENT

UNIT V EMBEDDED COMPUTING ARCHITECTURE

TOTAL : 45 PERIODS

REFERENCES:

HV8071 APPLICATIONS OF HIGH ELECTRIC FIELDS

OBJECTIVE:
To impart knowledge on,
- different HV applications in industry and food preservation.
- different HV applications in cancer treatments and microbial inactivation.
- the awareness on safety and hazard issues.

UNIT I APPLICATION IN INDUSTRY

UNIT II APPLICATION IN MICROBIAL INACTIVATION
Introduction-definitions, descriptions and applications-mechanisms of microbial in-activations-electrical breakdown-electroporation-inactivation models -Critical factors-analysis of process, product and microbial factors-pulse generators and treatment chamber design-Research needs.

UNIT III APPLICATION IN FOOD PRESERVATION
Processing of juices, milk, egg, meat and fish products- Processing of water and waste – Industrial feasibility, cost and efficiency analysis.
UNIT IV  APPLICATION IN CANCER TREATMENT  

UNIT V  SAFETY AND ELECTROSTATIC HAZARDS  

TOTAL : 45 PERIODS

REFERENCES

HV8251  EHV POWER TRANSMISSION  L T P C  3 0 0 3

OBJECTIVES:
To impart knowledge on,
• various parameters and voltage gradients of transmission line conductors.
• effect of electric fields and various losses on EHV transmission line due to corona effects
• the design requirements of EHV AC and DC lines.

UNIT I  INTRODUCTION  
Standard transmission voltages – different configurations of EHV and UHV lines – average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance.

UNIT II  CALCULATION OF LINE PARAMETERS  
Calculation of resistance, inductance and capacitance for multi-conductor lines – calculation of sequence inductances and capacitances – line parameters for different modes of propagation – resistance and inductance of ground return.

Attested

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UNIT III  VOLTAGE GRADIENTS OF CONDUCTORS  
Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on sub conductors of bundle - voltage gradients on conductors in the presence of ground wires on towers.

UNIT IV  CORONA EFFECTS  

UNIT V  ELECTROSTATIC FIELD AND DESIGN OF EHV LINES  
Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields - electrostatic Induction in unenergised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference, Design of EHV lines.

TOTAL : 45 PERIODS

REFERENCES

PE8072 NON LINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS  L T P C
3 0 0 3

OBJECTIVES:
- To understand the non linear behavior of power electronic converters.
- To understand the techniques for investigation on non linear behavior of power electronic converters.
- To analyse the non linear phenomena in DC to DC converters.
- To analyse the non linear phenomena in AC and DC Drives.
- To introduce the control techniques for control of non linear behavior in power electronic systems.

UNIT I  BASICS OF NONLINEAR DYNAMICS  
Basics of Nonlinear Dynamics: System, state and state space model, Vector field-Modeling of Linear, nonlinear and Linearized systems, Attractors , chaos, Poincare map, Dynamics of Discrete time system, Lyapunov Exponent, Bifurcations, Bifurcations of
smooth map, Bifurcations in piece wise smooth maps, border crossing and border collision bifurcation.

UNIT II  TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA  9
Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analyzing stability.

UNIT III  NONLINEAR PHENOMENA IN DC-DC CONVERTERS  9
Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Nonlinear phenomenon in the inverter under tolerance band control

UNIT IV  NONLINEAR PHENOMENA IN DRIVES  9
Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives.

UNIT V  CONTROL OF CHAOS  9
Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives.

TOTAL : 45 PERIODS

TEXT BOOKS:
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, Westview Press

PE8073  POWER QUALITY  LT P C
3 0 0 3

OBJECTIVES :
• To understand the various power quality issues.
• To understand the concept of power and power factor in single phase and three phase systems supplying non linear loads
• To understand the conventional compensation techniques used for power factor correction and load voltage regulation.
• To understand the active compensation techniques used for power factor correction.
• To understand the active compensation techniques used for load voltage regulation.

UNIT I  INTRODUCTION  9
Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.
UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM


UNIT III CONVENTIONAL LOAD COMPENSATION METHODS


UNIT IV LOAD COMPENSATION USING DSTATCOM

Compensating single – phase loads – Ideal three phase shunt compensator structure – generating reference currents using instantaneous PQ theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in Voltage control mode

UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM


TOTAL : 45 PERIODS

TEXT BOOKS

3. Power Quality - R.C. Duggan
5. Power Electronic Converter Harmonics –Derek A. Paice
OBJECTIVES:

- To provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
- To equip with required skills to derive the criteria for the design of power converters for UPS, Drives etc.
- Ability to analyse and comprehend the various operating modes of different configurations of power converters.
- Ability to design different single phase and three phase inverters.

UNIT I SINGLE PHASE INVERTERS

Introduction to self commutated switches: MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated Thyristor inverters – Design of UPS

UNIT II THREE PHASE VOLTAGE SOURCE INVERTERS

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – Application to drive system

UNIT III CURRENT SOURCE INVERTERS


UNIT IV MULTILEVEL & BOOST INVERTERS


UNIT V RESONANT INVERTERS

Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters.

TOTAL: 45 PERIODS

TEXT BOOKS

REFERENCES

PE8351 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS  L T P C
3 0 0 3

OBJECTIVES:
• To Provide knowledge about the stand alone and grid connected renewable energy systems.
• To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
• To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.
• To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
• To develop maximum power point tracking algorithms.

UNIT I INTRODUCTION
Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems : operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION
Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III POWER CONVERTERS
Solar: Block diagram of solar photo voltaic system : line commutated converters (inversion-mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing.
Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS
Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS-Grid Integrated solar system
UNIT V HYBRID RENEWABLE ENERGY SYSTEMS
Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV-Maximum Power Point Tracking (MPPT).

TEXT BOOK

REFERENCES:

HV8073 DESIGN OF SUBSTATIONS LT P C 3 0 0 3

OBJECTIVES:
• To provide in-depth knowledge on design criteria of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS).
• To study the substation insulation co-ordination and protection scheme.
• To study the source and effect of fast transients in AIS and GIS.

UNIT I INTRODUCTION TO AIS AND GIS
Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation.

UNIT II MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS
Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design.

UNIT III INSULATION COORDINATION OF AIS AND GIS

UNIT IV GROUNDING AND SHIELDING
Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by wires and masts.

UNIT V FAST TRANSIENTS PHENOMENON IN AIS AND GIS
REFERENCES
   “Power Engineer’s handbook”, TNEB Association.

PS8072 DISTRIBUTED GENERATION AND MICRO GRID L T P C
3 0 0 3

OBJECTIVES
- To illustrate the concept of distributed generation
- To analyze the impact of grid integration.
- To study concept of Microgrid and its configuration

UNIT I INTRODUCTION

UNIT II DISTRIBUTED GENERATIONS (DG)
Concept of distributed generations, topologies, selection of sources, regulatory standards/framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants

UNIT III IMPACT OF GRID INTEGRATION
Requirements for grid interconnection, limits on operational parameters: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV BASICS OF A MICROGRID
Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids,
UNIT V  CONTROL AND OPERATION OF MICROGRID  9
Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

TOTAL : 45 PERIODS

REFERENCES

PS8073  ENERGY MANAGEMENT AND AUDITING  L T P C
3 0 0 3

COURSE OBJECTIVES
- To study the concepts behind economic analysis and Load management.
- To emphasize the energy management on various electrical equipments and metering.
- To illustrate the concept of lighting systems and cogeneration.

UNIT I  INTRODUCTION  9
Need for energy management - energy basics- designing and starting an energy management program – energy accounting -energy monitoring, targeting and reporting- energy audit process.

UNIT II  ENERGY COST AND LOAD MANAGEMENT  9
Important concepts in an economic analysis - Economic models-Time value of money-Utility rate structures- cost of electricity-Loss evaluation
Load management: Demand control techniques-Utility monitoring and control system-HVAC and energy management-Economic justification

UNIT III  ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT  9
Systems and equipment- Electric motors-Transformers and reactors-Capacitors and synchronous machines
UNIT IV METERING FOR ENERGY MANAGEMENT
Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements- Metering techniques and practical examples

UNIT V LIGHTING SYSTEMS & COGENERATION
Concept of lighting systems - The task and the working space -Light sources - Ballasts - Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

TEXT BOOKS

REFERENCES

COURSE OBJECTIVES
• To impart knowledge on operation, modelling and control of HVDC link.
• To perform steady state analysis of AC/DC system.
• To expose various HVDC simulators.

UNIT I DC POWER TRANSMISSION TECHNOLOGY
Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system - Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables, VSC based HVDC.

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL
Pulse number, choice of converter configuration – Simplified analysis of Graetz circuit - Converter bridge characteristics – characteristics of a twelve pulse converter- detailed analysis of converters.
UNIT III      MULTITERMINAL DC SYSTEMS
Introduction – Potential applications of MTDC systems - Types of MTDC systems - Control and protection of MTDC systems - Study of MTDC systems.

UNIT IV      POWER FLOW ANALYSIS IN AC/DC SYSTEMS
Per unit system for DC Quantities - Modelling of DC links - Solution of DC load flow - Solution of AC-DC power flow – Unified, Sequential and Substitution of power injection method.

UNIT V      SIMULATION OF HVDC SYSTEMS
Introduction – DC LINK Modelling, Converter Modeling and State Space Analysis, Philosophy and tools – HVDC system simulation, Online and OFFline simulators — Dynamic interactions between DC and AC systems.

TOTAL: 45 PERIODS

TEXT BOOKS

REFERENCES

PS8075 OPTIMISATION TECHNIQUES L T P C 3 0 0 3

COURSE OBJECTIVES
- To introduce the different optimization problems and techniques
- To study the fundamentals of the linear and non-linear programming problem.
- To understand the concept of dynamic programming and genetic algorithm technique

UNIT I      INTRODUCTION
Definition, Classification of optimization problems, Classical Optimization Techniques, Single and Multiple Optimization with and without inequality constraints.

UNIT II      LINEAR PROGRAMMING (LP)
Simplex method of solving LPP, revised simplex method, duality, Constrained optimization, Theorems and procedure, Linear programming, mathematical model, solution technique, duality.
UNIT III  NON LINEAR PROGRAMMING  9
Steepest descent method, conjugates gradient method, Newton’s Method, Sequential
quadratic programming, Penalty function method, augmented Lagrange multiplier
method.

UNIT IV  DYNAMIC PROGRAMMING (DP)  9
Multistage decision processes, concept of sub-optimization and principle of optimality,
Recursive relations, Integer Linear programming, Branch and bound algorithm

UNIT V  GENETIC ALGORITHM  9
Introduction to genetic Algorithm, working principle, coding of variables, fitness function,
GA operators; Similarities and differences between Gas and traditional methods;
Unconstrained and constrained optimization using genetic Algorithm, real coded gas,
Advanced Gas, global optimization using GA, Applications to power system.

TEXT BOOKS:
2. G.Luenberger,” Introduction of Linear and Non-Linear Programming” , Wesley

REFERENCE BOOKS:

PS8076  SOLAR AND ENERGY STORAGE SYSTEM  L T P C
3 0 0 3

COURSE OBJECTIVES
• To Study about solar modules and PV system design and their applications
• To Deal with grid connected PV systems
• To Discuss about different energy storage systems

UNIT I  INTRODUCTION  9
Characteristics of sunlight – semiconductors and P-N junctions –behavior of solar cells –
cell properties – PV cell interconnection

UNIT II  STAND ALONE PV SYSTEM  9
Solar modules – storage systems – power conditioning and regulation - protection –
stand alone PV systems design – sizing

UNIT III  GRID CONNECTED PV SYSTEMS  9
PV systems in buildings – design issues for central power stations – safety – Economic
aspect – Efficiency and performance - International PV programs

TOTAL : 45 PERIODS

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UNIT IV  ENERGY STORAGE SYSTEMS  9
Impact of intermittent generation – Battery energy storage – solar thermal energy storage – pumped hydroelectric energy storage

UNIT V  APPLICATIONS  9

TEXT BOOKS:

REFERENCES:

TOTAL : 45 PERIODS

PS8077  WIND ENERGY CONVERSION SYSTEM  L T P C
3 0 0 3

COURSE OBJECTIVES
- To learn the design and control principles of Wind turbine.
- To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
- To analyze the grid integration issues.

UNIT I  INTRODUCTION  9
Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin’s theory-Aerodynamics of Wind turbine

UNIT II  WIND TURBINES  9
HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction.

UNIT III  FIXED SPEED SYSTEMS  9
Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model-Generator model for Steady state and Transient stability analysis.

UNIT IV  VARIABLE SPEED SYSTEMS  9
Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.
UNIT V GRID CONNECTED SYSTEMS
Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TEXT BOOKS

REFERENCES

PS8255 SMART GRIDS L T P C 3 0 0 3

COURSE OBJECTIVES
- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications.

UNIT I INTRODUCTION TO SMART GRID
Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Concept of Resilient & Self Healing Grid, Present development & International policies in Smart Grid, Diverse perspectives from experts and global Smart Grid initiatives.

UNIT II SMART GRID TECHNOLOGIES
Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE
Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor.
Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

UNIT IV  POWER QUALITY MANAGEMENT IN SMART GRID

UNIT V  HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS
Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

TEXT BOOKS:

REFERENCES:
2. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey”, IEEE Transaction on Smart Grids,