DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

Regulations Curriculum
and Syllabus
2013
Semester I - IV

M.Tech.
(POWER SYSTEMS ENGINEERING)
Objective of the Programme:

This Programme will enable the students to understand the concept of power generation, transmission, distribution and utilization. This course provides an insight into the sophisticated methods of power system control and operation using simulation tools. The students can pursue their research in the field of power quality, power system planning, power system reliability and application of power electronics to power systems. The students will also be exposed to renewable energy sources.

### SEMESTER I

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*Common to M.Tech(PED)/M.Tech(ELS)

** Common to M.Tech (PED)

# Common to M.Tech(ELS)

### SEMESTER II

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**ELECTIVES FOR POWER SYSTEM ENGINEERING**

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*Common to M.Tech(PED)/M.Tech(ELS)
# Common to M.Tech(ELS)

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 82
Goal
To equip the students with knowledge of advanced mathematical techniques required for the analytical study of the technical subjects under power electronics.

Objectives
1. To know about probability theory useful for power system
2. To know about dynamic programming for optimization techniques
3. To know about differential calculus

Outcome
1. Getting idea about basic fundamentals of probability
2. Getting idea about optimization techniques
3. Getting idea about differential calculus

UNIT I ADVANCED MATRIX THEORY

UNIT II NUMERICAL SOLUTION OF ALGEBRAIC EQUATIONS
Solutions of large systems of equations using Gauss Elimination method; principle behind sparsity and optimal ordering; relevance of the solution technique for engineering applications.

UNIT III NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS

UNIT IV LINEAR PROGRAMMING
Basic concepts – Graphical and Simplex methods – Transportation problem – Assignment problem.

UNIT V DYNAMIC PROGRAMMING
Elements of the dynamic programming model – optimality principle – Examples of dynamic programming models and their solutions.

L = 60 TOTAL = 60
REFERENCES

PPS101 POWER SYSTEM OPERATION AND CONTROL
Common to M.Tech (ELS) L T P C
3 1 0 4

Objective
(1) To know the various techniques for optimizing unit operation according to load demand.
(2) To know about latest power frequency control , SCADA operation, economic dispatching.

Outcome
(1) To get idea about load forecasting ,optimizing unit operation
(2) To get an idea about power frequency control, SCADA operation, economic dispatching.

UNIT I LOAD FORECASTING

UNIT II UNIT COMMITMENT

UNIT III GENERATION SCHEDULING

UNIT IV CONTROL OF POWER SYSTEMS
Review of AGC and reactive power control –System operating states by security control functions – Monitoring, evaluation of system state by contingency analysis – Corrective controls (Preventive, emergency and restorative) – Energy control center – SCADA system – Functions – monitoring , Data acquisition and controls – EMS system.

UNIT V STATE ESTIMATION
Estimation by Orthogonal Decomposition algorithm – Introduction to Advanced topics: Detection and Identification of Bad Measurements, Estimation of Quantities Not Being Measured
Goal
To provide an insight into the various methods of analyzing a power system for ensuring normal operation of the power system.

Objective
The course will enable the students to:
(1) Study the sparse matrix solution techniques for large scale power systems
(2) study the various method of load flow solution and the concept of ATC.
(3) Study the concept of optimal power flow ant the solution methods .
(4) give an insight into the types of unsymmetrical faults and symmetrical components.
(5) have an insight into the transient stability analysis and the explicit and implicit methods of solution for finding stability.

Outcome
After completion of the course, the students are expected to:
(1) Get the knowledge to understand the storage schemes for sparse matrices and the solution methods.
(2) Get a clear idea of the solution methods of load flow problem and the importance of ATC calculation and the methods.
(3) Get an idea for carrying out optimal power flow analysis and the methods of analysis.
(4) Learn the Zbus building algorithm and the solution of unsymmetrical faults using symmetrical components.
(5) Understand the numerical integration methods for determining 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 – 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; Net Interchange power control in Multi-area power flow analysis: ATC,
Assessment of Available Transfer Capability (ATC) using Repeated Power Flow method; Continuation Power Flow method.
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

Fault calculations using sequence networks for different types of faults. Bus impedance matrix (Z_{BUS}) construction using Building Algorithm for lines with mutual coupling; Simple numerical problems. 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 domain using Thevenin’s equivalent and Z_{BUS} matrix for different faults.

UNIT V TRANSIENT STABILITY ANALYSIS


REFERENCES:


PPS703 POWER SYSTEM PLANNING AND RELIABILITY
Common to M.Tech(PSE)

Goal
To provide the basic knowledge in load forecasting and perform reliability analysis of generation and transmission systems.

Objective
The course will enable the students to:

(1) understand the importance of system planning and to study the forecasting methodology.
(2) study the various methods of analyzing generator system reliability.
(3) study the various methods of analyzing transmission system reliability.
(4) study the distribution system planning concepts and reliability analysis.
(5) have an insight into the basic concepts on expansion planning.

Outcome
After completion of the course, the students are expected to:

1. understand the importance of system planning and the need for load forecasting and the methodology.
2. get a clear idea to carryout reliability analysis of isolated and inter connected generation systems.
3. get an idea of evaluating performance reliability indices of distribution system networks
4. Understand the current practices of expansion planning in India and the problems in

UNIT I SYSTEM PLANNING

Objectives of system planning: Long term and short term planning-stages in planning
Load forecasting: Classification and characteristics of loads- Forecast methodology- Energy forecasting- Non weather sensitive forecasting- Weather sensitive forecasting- Total forecasting- Annual and monthly peak load forecasting- Use of AI in load forecasting.

UNIT II GENERATION SYSTEM RELIABILITY ANALYSIS


UNIT III TRANSMISSION SYSTEM RELIABILITY ANALYSIS

Transmission system reliability model analysis – Capacity state classification- Average Interruption rate method – LOLP method- frequency & duration approach - weather effects on system studies. Two plant single load system-t two plant two load system - load forecasting uncertainly interconnections benefits.

UNIT IV DISTRIBUTION SYSTEM PLANNING AND RELIABILITY ANALYSIS

Basic Concepts- Distribution planning- Sub transmission lines and distribution substations- Design primary and secondary systems - Evaluation of performance reliability indices of radial system networks.

UNIT V EXPANSION PLANNING

Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placement problem in transmission system and radial distributions system.

L = 45 T=15 TOTAL = 60

REFERENCES:
5. Proceeding of work shop on energy systems planning & manufacturing CI.

PPD 708 ADVANCED POWER ELECTRONICS

Common to M.Tech (PSE)

Prerequisite
Power Electronics

Goal
To provide knowledge about the structure and functioning of different converter circuits
Objective

The course will enable the students to:

1. get exposed to the construction, working and performance calculation of various types of single and three phase AC voltage controllers.
2. To familiarize the students with the working of AC-DC converters with different types of loads.
3. To familiarize the students with power factor correction circuits.
4. To get exposed to the construction, working and performance calculation of various types of single and three phase half and full bridge inverters.
5. To familiarize the students with multi-level inverters.

Outcome

After completion of the course the students are expected to be able to:

1. Explain the theory and working of different types of single phase and three phase AC voltage controllers.
2. Explain the working of AC-DC converters for different load conditions.
3. Gain knowledge about Power factor correction circuits.
4. Explain the functioning of different types of single and three phase inverters.
5. Gain knowledge about multi-level inverters.

UNIT I AC VOLTAGE CONTROLLERS

Single Phase AC Voltage Controllers with Rand RL loads - Effects of source and load inductances – Three Phase AC Voltage Controllers – Analysis of controllers with Star and delta connected resistive loads – Application.

UNIT II AC-DC CONVERTERS


UNIT III SINGLE PHASE INVERTERS

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.

UNIT IV 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.

UNIT V CURRENT SOURCE INVERTERS

Operation of six-step thyristor inverter - inverter operation modes - load - commutated inverters - Auto sequential current source inverter (ASCI) - current pulsations - comparison of current source inverter and voltage source inverters

Text Books


Reference Books:

Objective
To provide the idea about
(1) Electromagnetic energy conversion in various system.
(2) Modeling of Stationary circuits in various Reference Frame.
(3) Modeling of different Electrical machines.
(4) Analysis of machines under Steady state and transient conditions.

Outcome
To get a knowledge about
(1) Calculation of MMF and machine inductance
(2) State equations and Time domain block diagram
(3) Modeling of AC machines and DC machines in various reference frames like arbitrary and Parks Transformation.
(4) Analysis under Steady state and transient conditions for different machines.
(5) Analyse Dynamic performance with the help of simulation

UNIT I  PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION  9
General expression of stored magnetic energy, co-energy and force/ torque - example using single and doubly excited system –AC machines :Calculation of air gap mmf and per phase machine inductance using physical machine data.

UNIT II  REFERENCE FRAME THEORY  9
Static and rotating reference frames - transformation of variables - reference frames - transformation between reference frames - transformation of a balanced set -balanced steady state phasor and voltage equations - variables observed from several frames of reference.

UNIT III  DC MACHINES  9
Voltage and torque equations - dynamic characteristics of permanent magnet and shunt DC motors – Time domain block diagram and state equations .

UNIT IV  INDUCTION MACHINES  9

UNIT V  SYNCHRONOUS MACHINES  9

L = 45 T = 15 TOTAL = 60

TEXT BOOKS

REFERENCES

PPS206 POWER SYSTEM SIMULATION LABORATORY-I

Goal
1. To have hands on experience on various system studies and different techniques used for system planning using Software packages.
2. To perform the dynamic analysis of power system

Objective
The course will enable the students to

(1) Do computer simulation programs that focus on the operation of electrical power systems.
(2) Emulate response of protective devices
(3) Evaluate protection & control systems
(4) Get online data on-demand
(5) View & analyze initial & post-disturbance actions
(6) Determine Device Coordination & Selectivity
(7) Evaluate economic power transfer capability.
(8) Emulate dynamic response in relay co-ordination
(9) Stabilise power system devices

Outcome
(1) Accurate analysis with actual operating values
(2) Virtual operation of power systems
(3) Improve system planning & design
(4) Recognize & correct potential hidden problems
(5) Avoid "unforeseen" errors
(6) Prevent system interruption
(7) Determine under-utilization of system resources
(8) Identify the cause of operation problems
(9) Reduce design & commissioning time
(10) Design more efficient & reliable power systems
LIST OF EXPERIMENTS

2. Power flow analysis by Fast decoupled method.
3. Unit commitment: Priority-list schemes and dynamic programming.
5. Analysis of switching surge: Energisation of a long distributed-parameter line.
7. Co-ordination of over-current and distance relays for radial line protection.
8. Digital Over Current Relay Setting and Relay Coordination.
9. Reliability Assessment on Power system.

List of equipments

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SEMESTER II

PPD204 LINEAR AND NON LINEAR SYSTEM THEORY
Common to M.Tech(PED)

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Goal:
To provide an insight theory on linear and non linear control systems

Objectives
The course should enable the students to:

1. Study the concept of state space representation of dynamic systems.
2. Study about solution of state equations of linear, nonlinear, time invariant and time varying systems and also about systems modes.
3. Know about the concepts of controllability, observability, detectability, stabilizability and reducability of time invariant and time varying systems.
4. Have an in-depth knowledge about stability of linear and nonlinear systems using Liapunov's criterion.
5. Study the concept of observable and controllable companion forms and pole placement by feedback for SISO and MIMO systems.

Outcome

1. At the end of the course the student should be able to
2. Derive state space equations and draw state diagrams for physical systems.
(3) Solve state equations of linear, nonlinear, time invariant and time varying systems,
(4) Verify if a given system is controllable, observable, detectable, stabilizable and reducable.
Verify if a given system is stable using Liapunov's criterion.
Develop observable and controllable companion forms for a given system.

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

UNIT II   SOLUTION OF STATE EQUATION

UNIT III  CONTROLLABILITY AND OBSERVABILITY
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

UNIT V    MODAL CONTROL
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.

REFERENCES:

PPS201 ELECTRICAL TRANSIENTS IN POWER SYSTEMS

Objective
1. To know about high voltage transient Behavior travelling on line.
2. To know about voltage solutions under transient conditions using lattice diagram
3. To know about lightning and switching voltage travelling behavior using EMTP
4. To know about insulation coordination under transients.

Outcome
1. To get knowledge about high voltage Transient behavior travelling on line.
2. To get knowledge about voltage solutions under transient conditions using lattice diagram
To get knowledge about lightning and switching voltage travelling behavior using EMTP
To get knowledge about insulation coordination under transients.

UNIT I TRAVELLING WAVES ON TRANSMISSION LINE
Lumped and Distributed Parameters - Wave Equation - Reflection, Refraction, Standing waves. Behaviour of Travelling waves at the line terminations - Lattice Diagrams - Attenuation and Distortion - Multi-conductor system and Velocity wave.

UNIT II COMPUTATION OF POWER SYSTEM TRANSIENTS

UNIT III LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES
Lightning: Physical phenomena of lightning - Interaction between lightning and power system - Factors contributing to line design - Switching: Short line or kilometric fault - Energizing transients – closing and re-closing of lines - load dropping, load rejection - Ferro resonance - Double frequency transients, Voltage induced by fault - Very Fast Transient Overvoltage (VFTO)

UNIT IV BEHAVIOUR OF WINDING UNDER TRANSIENT CONDITION
Initial and Final voltage distribution - Winding oscillation - traveling wave solution - Behaviour of the transformer core under surge condition - Rotating machine - Surge in generator and motor

UNIT V INSULATION CO-ORDINATION
Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level - overvoltage protective devices – types of surge diveters-lightning arresters, substation earthing.

L = 45 T = 15 TOTAL = 60

REFERENCES
Objective
To know about different protection schemes in digital advancement.

Outcome
To get an idea about different digital protection Schemes in transmission systems

UNIT I  EQUIPMENT PROTECTION  9
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- Incipient faults in transformers - Phenomenon of over-fluxing in transformers - Transformer protection application chart-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  9
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  9
Drawback of Over Current protection - Introduction to distance relay - Simple impedance relay - Reactance relay - mho relays comparison of distance relay - Three stepped distance protection - Trip contact configuration for the three - Impedance seen from relay side - Three-stepped protection of double end fed lines-need for carrier - Aided protection-Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying-numerical example for a typical distance protection scheme for a transmission line.

UNIT IV  BUSBAR PROTECTION  9
Introduction - Differential protection of bus bars-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 - Internal fault - Stability ratio of high impedance bus bar differential scheme - Supervisory relay-protection of three - Phase bus bars-Numerical examples on design of high impedance bus bar differential scheme.

UNIT V  NUMERICAL PROTECTION  9
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

REFERENCES
Goal

To provide an insight into the small signal stability analysis of power system with and without Controllers

Objectives

The course will enable the students to:

(1) understand the modeling of synchronous machine for small signal stability analysis
(2) study the modeling of excitation systems, turbine and speed governing systems for small signal stability analysis.
(3) study the stability of dynamic system using classical machine model.
(4) give an insight into the stability analysis of dynamic system with AVR and PSS.
(5) have an insight into the enhancement of small signal stability using PSS.

Outcome

After completion of the course, the students are expected to

(1) get the knowledge to model a synchronous machine for small signal stability analysis
(2) get a clear idea of the types of excitation systems, turbines and their modeling for small signal analysis.
(3) understand the classical machine stability analysis using state space representation.
(4) realize the effects of excitation system on small signal stability with AVR and PSS.
(5) study the use of power system stabilizers for the enhancement of small signal stability.

UNIT I SYNCHRONOUS MACHINE MODELLING

Physical Description: armature and field structure, machines with multiple pole pairs, mmf waveforms, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine, dq0 Transformation, Per Unit Representations: Park’s transformation; Equivalent Circuits for direct and quadrature axes, Steady-state Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Steady-state equivalent circuit, Computation of steady-state values.

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, 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.

UNIT V  ENHANCEMENT OF SMALL SIGNAL STABILITY

Power System Stabilizer: Stabilizer based on shaft speed signal (Delta- omega) – Delta P- Omega stabilizer-Frequency-based stabilizers - Digital Stabilizer - Excitation control design - Exciter gain - Phase lead compensation - Stabilizing signal washout- stabilizer gain - Stabilizer limits.

L= 45 T=15 TOTAL =60

REFERENCES

PPS205 POWER SYSTEM SIMULATION LABORATORY II

Objective
To know about the computational methods for power load flow solutions

Outcome
To get the knowledge about the computational methods for power load flow solutions.

LIST OF EXPERIMENTS
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
4. Co-ordination of over-current and distance relays for radial line protection
5. Induction motor starting analysis
6. Load flow analysis of two-bus system with STATCOM
7. Transient analysis of two-bus system with STATCOM
8. Available Transfer Capability calculation using an existing load flow program

TOTAL = 45

List of equipments

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ELECTIVES FOR POWER SYSTEM ENGINEERING

PPD702 INTELLIGENTCONTROL
Common to M.Tech(PED)/M.Tech(ELS)

Goal
To equip the students with a knowledge of modern intelligent control techniques and their applications.

Objectives
The course should enable the students to:

1. Study the concept of approaches and architecture for intelligent control, knowledge representation and expert systems.
2. Study various concepts about artificial neural networks, types of ANN and neural network based controller.
4. Study the various concepts of fuzzy logic control and its applications.
5. Study the applications of expert systems, fuzzy logic control, ANN and genetic algorithm.

Outcome
At the end of the course the student should be able to:

1. Understand the concepts of intelligent control and their comparisons.
2. Understand the concepts of artificial neural network, types of ANN and to design ANN based controller.
3. Understand the concept of genetic algorithm and its applications to optimization techniques.
4. Design fuzzy logic controller.
5. Understand various intelligent control applications.

UNIT I INTRODUCTION

UNIT II ARTIFICIAL NEURAL NETWORKS

UNIT III GENETIC ALGORITHM
Basic concept of Genetic algorithm, algorithmic steps, adjustment of free parameters. Solution of control problems using genetic algorithm. Tabu search and ant-colony search techniques for solving optimization problems.

UNIT IV FUZZY LOGIC SYSTEM
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems.
organizing fuzzy logic control. Fuzzy logic control of nonlinear time-delay system.
UNIT V  APPLICATIONS

GA application to power system optimisation problem, Case studies: Identification and control of linear and nonlinear dynamic systems.
Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller. Stability analysis of fuzzy control system

REFERENCES


PPD703 FLEXIBLE AC TRANSMISSION SYSTEMS

Common to M.Tech (PED)/M.Tech (ELS)

Goal
To provide a knowledge of application of power electronics in the efficient design and operation of power systems.

Objectives
The course will enable the students:

1. To get introduced to basic concepts of FACTS controllers.
2. To familiarize the students with the working of series compensation.
3. To familiarize the students with the working of Unified Power Flow Controller.
4. To expose the students to the designing of FACTS controllers.
5. To familiarize the students with static VAR compensators

Outcome
After completion of the course the students are expected to be able to:

1. Explain the basic compensators used in power systems.
2. Explain how series compensation is done in power system
3. Explain the working of Unified Power Flow Controller.
4. Design variable structure of FACTS controllers for power system
5. Explain the working of static VAR compensators and their applications in power system

UNIT I  INTRODUCTION

FACTS-a toolkit, basic concepts of static VAR compensator, resonance damper, thyristor controlled series capacitor, static condenser, phase angle regulator, and other controllers.

UNIT II  SERIES COMPENSATION SCHEMES
Sub-Synchronous resonance, Torsional interaction, torsional torque, compensation of conventional,
ASC, NGH damping schemes, modeling and control of thyristor controlled series compensators.

UNIT III U N I F I E D POWER FLOW CONTROL

Introduction, Implementation of power flow control using conventional thyristors, unified power flow concept, Implementation of unified power flow controller.

UNIT IV D E S I G N O F FACTS CONTROLLERS

Approximate multi-model decomposition, Variable structure FACTS controllers for Power system transient stability, Non-linear variable-structure control, variable structure series capacitor control, and variable structure resistor control.

UNIT V S T A T I C V A R C O M P E N S A T I O N

Basic concepts, Thyristor controlled reactor (TCR), Thyristor switched reactor (TSR), Thyristor switched capacitor (TSC), saturated reactor (SR), Fixed Capacitor (FC).

REFERENCES


PPD705 HIGH VOLTAGE DIRECT CURRENT TRANSMISSION
Common to M.Tech(PED)/M.Tech(ELS)

Goal
To impart knowledge on design, simulation and analysis of HVDC converters and associated control system.

Objective
The course should enable the students to:
1. Study the basics of dc power transmission technology and its modern trends,
2. Study the analysis of Graetz circuits for 6-pulse & 12-pulse converter characteristics,
3. Study the system control hierarchy and firing angle control ,
4. Study the characteristics and non-characteristics harmonics in HVDC system and types of Filters
5. Study about the simulation of converter station using HVDC Simulator software.

Outcome
At the end of the course the student should be able to:
1. Know the comparison of AC and DC transmission and application of HVDC transmission systems,
2. One can learn about the applications of different converter bridges,
3. Know the HVDC system control and start-stop DC link,
4. Know the different types of harmonics in HVDC system Filters to remove them,
5. One can learn about the modeling and analysis of HVDC system using HVDC simulator.

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.

UNIT II  ANALYSIS OF 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.

UNIT III  CONVERTER AND HVDC SYSTEM CONTROL
General principles 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  HARMONICS AND FILTERS
Introduction-generation of harmonics-design ofAC filters-DC filters-carrier frequency and RI noise.

UNIT V  SIMULATION OF HVDC SYSTEMS
Introduction-system simulation: Philosophy and tools-HVDC system simulation-modeling of HVDC systems for digital dynamic simulation.

REFERENCES

PPD707 POWER QUALITY
(COMMON TO M.Tech. (PED) / M.Tech (ELS)

Objective
To provide the knowledge about improving quality techniques in power supply under Linear and non linear loads.

Outcome
Gain the knowledge about improving quality techniques in power supply under linear and non linear loads.

UNIT I  INTRODUCTION
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.
Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

UNIT III MEASUREMENT AND ANALYSIS METHODS


UNIT IV ANALYSIS AND CONVENTIONAL MITIGATION METHODS

Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On-line extraction of fundamental sequence components from measured samples - Harmonic indices - Analysis of voltage sag: Detroit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI) - Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

UNIT V POWER QUALITY IMPROVEMENT


TEXT BOOKS

5. Power system harmonics - A.J. Arrilaga

PPS701 ELECTRO MAGNETIC FIELD COMPUTATION AND MODELLING

Objective
The course should enable the students
(1) To study the basic Field theory and it’s equations
(2) To study the basic analytical methods like Finite difference method and variable separable method and to find the solutions of field equations
(3) To study the advanced methods like 1D and 2D planar and axial symmetry problem.
(4) To compute the Force, Torque, Energy equations for basic configurations
(5) To study the various design applications

Outcome
At the end of the course the students should be able
(1) To design equations for any given systems.
(2) To find the solutions for different systems using analytical methods.
(3) To calculate Force and torque for different systems.
(4) To design new applications.
UNIT I  INTRODUCTION
9
Review of basic field theory - electric and magnetic fields - Maxwell's equations - Laplace, Poisson and Helmholtz equations - principle of energy conversion - force/torque calculation

UNIT II  SOLUTION OF FIELD EQUATIONS I
9
Limitations of the conventional design procedure, need for the field analysis based design, problem definition, solution by analytical methods - direct integration method - variable separable method - method of images, solution by numerical methods - Finite Difference Method.

UNIT III  SOLUTION OF FIELD EQUATIONS II
9
Finite element method (FEM) - Differential/integral functions - Variational method - Energy minimization - Discretisation - Shape functions - Stiffness matrix - 1D and 2D planar and axial symmetry problem.

UNIT IV  FIELD COMPUTATION FOR BASIC CONFIGURATIONS
9
Computation of electric and magnetic field intensities - Capacitance and Inductance - Force, Torque, Energy for basic configurations.

UNIT V  DESIGN APPLICATIONS
9
Insulators - Cylindrical magnetic actuators - Transformers - Rotating machines.

L=45  T=15  TOTAL=60

REFERENCES
5. User manuals of MAGNET, MAXWELL & ANSYS software.
Objective

1. To know about best optimum pricing Methods by refer US market conditions
2. To know about price forecasting methods.

Outcome

1. To get the knowledge about best optimum Pricing methods by refer US market Conditions
2. To get the knowledge about price forecasting methods.

UNIT I OVERVIEW OF KEY ISSUES IN ELECTRIC UTILITIES RESTRUCTURING


UNIT II ELECTRIC UTILITY MARKETS IN THE UNITED STATES:


UNIT III OASIS: OPEN ACCESS SAME-TIME INFORMATION SYSTEM:


UNIT IV ELECTRIC ENERGY TRADING:


UNIT V ELECTRICITY PRICING - VOLATILITY, RISK AND FORECASTING:

REFERENCES


PPS704 ADVANCED POWER SYSTEM DYNAMICS

Objective
To provide the basic idea about advanced synchronous machine models under transient and steady state conditions and with resonance effects.

Outcome
To gain the knowledge about advanced synchronous machine models under transient and steady state conditions and with resonance effects.

UNIT I TRANSIENT STABILITY ANALYSIS


UNIT II SUBSYNCHRONOUS OSCILLATIONS


UNIT III SUBSYNCHRONOUS RESONANCE (SSR)


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

characteristics of synchronous generators - Capability curves - Effect of machine limitation on deliverable
power - Load Aspects - Voltage dependence of loads - Load restoration dynamics - Induction motors - Load tap changers - Thermostatic load recovery - General aggregate load models.

UNIT V ENHANCEMENT OF TRANSIENT STABILITY AND COUNTER MEASURES FOR SUBSYNCHRONOUS RESONANCE

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.

L = 45 T = 15 TOTAL = 60

REFERENCES
3. AU Power Lab Laboratory Manuals, Anna University, pp: 7-1 to 7-12, May 2004.

PPS705 WIND ENERGY CONVERSION SYSTEMS

Common to M.Tech(ELS)

Objective
The course will enable the students to
(1) To introduce the principle of wind turbines and wind energy conversion systems.
(2) To learn the design and control principles of Wind turbine.
(3) To understand the concepts of fixed speed and variable speed, wind energy conversion systems.
(4) To analyze the grid integration issues.

Outcome
To gain the knowledge about wind energy conversion system that connected to the grid.

UNIT I INTRODUCTION
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
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
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
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.

L=45 T=15 Total =60

REFERENCES

5. N. Jenkins, "Wind Energy Technology" John Wiley & Sons, 1997

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: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

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 - Principle of operation: 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).
PPS707 ENERGY AUDITING AND MANAGEMENT
CommontoM.Tech(PED)/M.Tech(ELS)

Objective
The course will enable the students to:
(1) Emphasize the energy management on various electrical equipments and metering.
(2) Adopt Conservation methods in various systems.
(3) Learn various technically proven ways to conserve Energy and then prioritize them based on the cost benefit analysis
(4) Illustrate the concept of lighting systems and cogeneration..
(5) Apply Tools for energy audit and recommend measures for energy conservation

Outcome
(1) At the end of this course students will be able to work as supervisor /Energy Auditor/
    Cost Analyzer in industry/Power utility/Public sector
(2) Assess energy conservation potential in various systems

UNIT I INTRODUCTION
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
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
Energy efficient motors , factors affecting efficiency, loss distribution , constructional details , characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-
   voltage unbalance- over motoring- motor energy audit. Transformer Loading/Efficiency
   analysis, Feeder/cable loss evaluation, case study.Reactive Power management-Capacitor
   Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance.

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 –
Objective
The course will enable the students to:

1. Have a working knowledge of the emerging power generation technologies such as photovoltaic arrays, wind turbines, and fuel cells.
2. Model renewable electrical energy systems for analysis and design.
3. Calculate the basic performance parameters of these systems, such as efficiency and cost.
4. Perform basic assessment and design of a renewable electrical energy system for a given application.
5. Determine the requirements for interconnecting a renewable electrical energy system to the utility electric power grid.

Outcome
At the end of the course, the student should be able to
1. Understand power generation by various technologies such as PV arrays, wind turbines and fuel cells.
2. Analysis and Design of renewable electrical energy systems
3. Analysis the performance parameters of various systems
4. Design of renewable electrical energy system
5. Understanding interconnection of renewable electrical energy to utility electric power grid

UNIT I DISTRIBUTED GENERATION INTRODUCTION
Distributed Generation Definition, Distributed generation advantages, challenges and needs.- Non conventional and renewable energy sources

UNIT II WIND POWER GENERATION
Wind Power- wind turbine and rotor types, wind speed –power curve, power coefficient, tip speed ratio, wind energy distribution, environmental impact.
UNIT III PV POWER GENERATION
Photovoltaic and Thermo-solar power –Solar cell technology, Photovoltaic power characteristics and Thermo-solar power generation.

UNIT IV OTHER RENEWABLES SOURCES AND TURBINES
Biomass Power, Fuel cells types, types of Tidal power generation schemes, mini and micro hydro power schemes, and Micro turbines for DG, bulb and tubular turbines.

UNIT V ENERGY STORAGE AND CONTROL TECHNIQUES

L=45 T=15 TOTAL=60

REFERENCES:
2. “Renewable energy power for a sustainable future” by Godfrey Boyle ,2004 Oxford University Press in association with the Open university.