FACULTY OF ENGINEERING AND TECHNOLOGY

REGULATIONS - 2017

CURRICULUM AND SYLLABUS

FROM

I TO IV SEMESTERS

FOR

M.TECH. POWER SYSTEMS ENGINEERING (REGULAR)
# FACULTY OF ENGINEERING AND TECHNOLOGY
## M.TECH. POWER SYSTEMS ENGINEERING (REGULAR)
### REGULATION 2017

## YEAR-I

### SEMESTER – I

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<tr>
<th>Sl.No.</th>
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<tr>
<td>1.</td>
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## LIST OF ELECTIVES

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SYLLABUS

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<td>I</td>
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<td>APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS (Common to M.E – PED &amp; PSE)</td>
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AIM
The aim of this course is to introduce students to the types of problems encountered in matrix theory, to provide techniques to analyze and solve these problems, and to provide examples of where these techniques are used in practice.

OBJECTIVE
- Develop their understanding of random processes particularly as they apply to electrical systems.
- Understand the concept of probability space, and different interpretations of probability.
- Understand the modeling of physical systems using the tools of multivariate random processes.
- Understand and characterize the output of linear systems excited by random processes.
- Understand how the slope of the objective function relates to the solution.

UNIT I - ADVANCED MATRIX THEORY

UNIT II - CALCULUS OF VARIATIONS
Variation and its properties – Euler’s equation – Functionals dependent on first and higher order derivatives – Functionals dependent on functions of several independent variables – Some applications – Direct methods: Ritz and Kantorovich methods.

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

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

UNIT V - RANDOM PROCESSES

L=45; T = 15 : Total Hours=60

REFERENCES
To study about the protection of various power systems and construction of protective relays.

To Understand the concept of protective relay and its terminology.
To Understand about the Protection of Power Apparatus.
To Study about Protection of Transmission lines.
To Study about the placement of reactor, booster and capacitor in power system.
To Study the concepts of Digital protection.

UNIT I - INTRODUCTION

General philosophy of protection – Characteristic function of protective relays – basic relay elements and relay terminology – basic construction of static relays – non-critical switching circuits.

UNIT II - PROTECTION OF POWER APPARATUS


UNIT III - PROTECTION OF TRANSMISSION SYSTEMS


UNIT IV - PROTECTION OF REACTORS, BOOSTERS & CAPACITORS


UNIT V - DIGITAL PROTECTION


Total hours = 45

REFERENCES

YEAR | SEMESTER | TITLE OF PAPER | L | T | C
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I | I | POWER ELECTRONICS IN POWER SYSTEMS | 3 | 0 | 3

AIM
To Study about the various power electronics devices used in power systems.

OBJECTIVE
- To Study about the basic concept of different types of power electronics devices.
- To Study about the converters used in R, RL and RLE loads.
- To Study about the voltage and current sources inverters.
- To Understand the concept of static reactive power compensation in FACTS Technology.
- To Study about the basics of power quality.

UNIT I - INTRODUCTION
Basic Concept of Power Electronics, Different types of Power Electronic Devices – Diodes, Transistors and SCR, MOSFET, IGBT and GTO’s.

UNIT II - AC TO DC CONVERTERS

UNIT III - DC TO AC CONVERTERS
General Topology of single Phase and three phase voltage source and current source inverters - Need for feedback diodes in anti parallel with switches – Multi Quadrant Chopper viewed as a single phase inverter- Configuration of Single phase voltage source inverter: Half and Full bridge, Selection of Switching Frequency and Switching Device. Voltage Control and PWM strategies.

UNIT IV - STATIC REACTIVE POWER COMPENSATION

UNIT V - POWER QUALITY
Power Quality – Terms and Definitions – Transients – Impulsive and Oscillatory Transients – Harmonic Distortion – Harmonic Indices – Total Harmonic Distortion – Total Demand Distortion- Locating Harmonic Sources Harmonic s from commercial and industrial Loads – Devices for Controlling Harmonics – Passive and Active Filters -Harmonic Filter Design-

Total hours = 45

REFERENCES
The aim is to introduce the study of power system analysis in planning and operation of power system.

- To understand the concepts of Sparse matrix techniques for large scale power systems, optimal ordering schemes and gauss elimination methods.
- To understand the designing of new power system and concepts of Gauss seidel method, Newton Raphson method and Fast Decoupled load flow method.
- To understand the concepts of fault analysis under Balanced and Unbalanced Faults.
- To understand the concepts of optimal power flow.
- To understand the concept of voltage stability and steady-state analysis.

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 model in real variable form; Newton’s method for solution; Adjustment of P-V buses; Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment; Net Interchange power control in Multi-area power flow analysis: Assessment of Available Transfer Capability (ATC) using Power Flow method; Continuation Power Flow method.

UNIT III - SHORT CIRCUIT ANALYSIS
Review of 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 012 frame and abc frame using Thevenin’s Equivalent and \( Z_{BUS} \) matrix for different faults.

UNIT IV - OPTIMAL POWER FLOW
Introduction: 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 V - VOLTAGE STABILITY ANALYSIS, STEADY-STATE
Transmission system aspects: SLIB system, maximum deliverable power, power-voltage relationship, generator reactive power requirement, network versus load P-V characteristics, Instability scenario, effect of compensation and series, shunt, SVC, V-Q curves, effect of adjustable transformer ratios.

L= 45  T=15  TOTAL = 60
REFERENCES

AIM
To study about the concepts of power system simulation laboratory.

OBJECTIVE
- To compute the parameters and modeling of transmission lines and formation of bus admittance and bus impedance matrices.
- To obtain the solutions of power flow using Gauss seidel method, Newton-Raphson method and Fast decoupled method.
- To obtain the symmetrical fault and unsymmetrical fault analysis.

1. Computation of parameters and modeling of transmission lines.
5. Solution of power flow using fast decoupled method.
7. Unsymmetrical fault analysis.

Total hours = 45
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<td>POWER SYSTEM OPERATION</td>
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**AIM**

To study about the operation of power system mainly in thermal and hydro power plant.

**OBJECTIVE**

- Study about the concepts and its operation of load forecasting, unit commitment, generation scheduling of thermal system and hydrothermal system and interchange of power and energy.

1. **LOAD FORECASTING**
   9

2. **UNIT COMMITMENT**
   9
   Constraints in unit commitment – Spinning reserve, thermal unit constraints, other constraints – Solution using Priority List method, Dynamic programming method - Forward DP approach, Lagrangian relaxation method – adjusting $\lambda$.

3. **GENERATION SCHEDULING – THERMAL SYSTEM**
   9

4. **GENERATION SCHEDULING – HYDRO THERMAL SYSTEMS**
   9

5. **INTERCHANGE OF POWER AND ENERGY**
   9

**REFERENCES**

1. AUTOMATIC GENERATION CONTROL

2. REACTIVE POWER AND VOLTAGE CONTROL

3. SECURITY CONTROL OF POWER SYSTEMS
   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.

4. STATE ESTIMATION

5. POWER SYSTEM CONTROL UNDER Deregulated ENVIRONMENT
   New system structures under competition – Classification of operational tasks in today’s power industry – Temporal decomposition within the real time operation – classification of operational tasks in the competitive industry – meeting predicted demand in today’s industry – meeting demand in the new industry – balancing supply and demand in real time - Load frequency control under deregulated environment.

Total Hours = 45
REFERENCES

1. INTRODUCTION AND LIGHTNING SURGES

Review of various types of power system transients – effect of transients on power systems- relevance of the study and computation of power system transients. Electrification of thunderclouds – lightning current stages – lightning current parameters and their values – stroke to tower and midspan – induced lightning surges.

2. SWITCHING SURGES


3. COMPUTATION OF TRANSIENTS IN CONVERSION EQUIPMENT


4. INSULATION COORDINATION

Over voltage protective devices – shielding wires, rods gaps, surge diverters, principles of insulation coordination – recent advancements in insulation coordination – Design of EHV system – Insulation coordination as applied to transformer, substations.

5. CASE STUDIES-SIMULATION OF ELECTROMAGNETIC TRANSIENTS

(i) Energisation of a single phase 0.95 pf load from a non ideal source and a realistic line representation.
(ii) Energisation of a single phase 15 mile long line from an ideal voltage source (equivalent-Π) – lumped and distributed parameter representation.
(iii) Energisation of a 3 phase, 15 mile distributed parameter line connected to a transformer and RL load, (three phase closure simulations).
(iv) Same as above but only one phase closed.
(v) Energisation of a 120 mile transposed line from an ideal voltage source. (Adequate model needed)

Total Hours = 45

REFERENCES

### OBJECTIVE

- To understand the concepts of operations of switchgear, switchgear terminology in circuit interruption, short circuit calculations and rating of circuit breakers, classification of circuit breakers and testing of circuit breakers.

### 1. INTRODUCTION

Insulation of switchgear - rated and tested voltage coordination between inner and external insulation. Insulation clearances in air, oil SF₆ and vacuum, bushing insulation, solid insulating materials – dielectric and mechanical strength consideration.

### 2. CIRCUIT INTERRUPTION


### 3. SHORT CIRCUIT CALCULATIONS AND RATING OF CIRCUIT BREAKERS

Types of faults in power systems-short circuit current and short circuit MVA calculations for different types of faults-rating of circuit breakers – symmetrical and asymmetrical ratings.

### 4. CIRCUIT BREAKERS

Classification of circuit breakers-design, construction and operating principles of bulk oil, minimum oil, airblast, SF₆ and vacuum circuit breakers – Comparison of different types of circuit breakers.

### 5. TESTING OF CIRCUIT BREAKERS

Type tests and routine tests – short circuit testing-synthetic testing of circuit breakers-recent advancements in high voltage circuit breakers-diagnosis.

L = 45 \hspace{1cm} T = 15 \hspace{1cm} \text{Total Hours} = 60

### REFERENCES

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**AIM**

To study about the concepts of power system simulation laboratory.

**OBJECTIVE**

- To study about the Contingency analysis, Small signal stability analysis, transient stability analysis, analysis of switching surge using EMTP.
- To study about the economic dispatch, Unit commitment solution method, co ordination of over current and distance relays.
- To study about the concept of induction motor starting analysis.

**LIST OF EXPERIMENTS**

1. Contingency analysis: Generator shift factors and line outage distribution factors
2. Small signal stability analysis: SMIB and Multi machine configuration
3. Transient stability analysis of Multi – machine configuration
4. Economic dispatch with line flow constraints
5. Unit commitment: Priority-list schemes and dynamic programming
6. Co-ordination of over current and distance relays for radial line protection
7. Induction motor starting analysis
8. Analysis of switching surge using EMTP.

Total Hours = 45
ELECTIVE PAPERS
### POWER SYSTEM DYNAMICS

**AIM**
To Study about the Various Power Systems Dynamics Devices Used in Power Systems.

**OBJECTIVE**
- To provide an understanding of the advanced concepts of dynamics
- Discuss the basic definitions, concepts and tools for stability studies for power systems
- To study the modeling of synchronous machines & speed governing system
- To study the analysis of small signal stability with controllers
- To study the analysis of small signal stability without controllers

1. **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 \( p\Psi \) terms and speed variations, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical model.

2. **MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS**


3. **SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS**

of Field Circuit Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example,

4. 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.

5. ENHANCEMENT OF SMALL SIGNAL STABILITY


Total Hours = 45

REFERENCES

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**AIM**

To study about the concepts of Soft Computing Techniques.

**OBJECTIVE**

- To Understand about the intelligent control and also AI approach.
- To Study about the concepts of Artificial Neural Networks.
- To Understand about the Fuzzy Logic System, Genetic Algorithm and also GA application to power system optimization problem.

1. **INTRODUCTION**  


2. **ARTIFICIAL NEURAL NETWORKS**


3. **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. Self-organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system.

4. **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 and an D-colony search techniques for solving optimization problems.

5. **APPLICATIONS**


Total Hours = 45
REFERENCES

AIM
To study about the concepts of Modelling & Analysis of Machines

OBJECTIVE
➢ To understand about Modelling of DC Machines
➢ To study about the Modelling of Induction Machines
➢ To study the various controlling techniques of Induction Machines

UNIT - I MODELING OF DC MACHINES

UNIT - II DYNAMIC MODELING OF INDUCTION MACHINES

UNIT - III PHASE CONTROLLED AND FREQUENCY CONTROLLED INDUCTION MACHINES

UNIT - IV VECTOR CONTROLLED INDUCTION MACHINES

UNIT - V SPECIAL MACHINES
Permanent magnet and characteristics-synchronous machines with PMs: Machine configuration-flux density distribution-types of PMSM-Variable Reluctance Machines: Basics-analysis-practical configuration-circuit wave forms for torque production stepping motors..

REFERENCES
4 C.V.Jones, ”The Unified Theory of ElectricalMachines:,Butterworth,London,1967
5 P.S.Bhimbra, ”Generalised theory of electrical machines”, Khanna Publishers
AIM
To Study about the importance and its use of Extra high voltage in power transmission.

OBJECTIVE
➢ To Study about the concept of standard transmission voltage and its power handling technique.
➢ To Obtain the calculation of resistance, inductance and capacitance on line parameters.
➢ To Study about the charge potential in voltage gradient of conductors.
➢ To Study about the Power losses and audible losses and also Radio Interference.
➢ To understand the concept of electrostatic field of EHV lines for a long object.

1. INTRODUCTION

2. CALCULATION OF LINE PARAMETERS
Calculation of Resistance, Inductance and Capacitance – Calculation of sequence inductances and capacitances – Line parameters for Modes of propagation.

3. 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.

4. CORONA EFFECTS

5. ELECTROSTATIC FIELD OF EHV LINES

Total Hours = 45

REFERENCE
The aim is to introduce about the Optimal control and Filtering. 

To study about the Statement of optimal control problem, Problem formulation and also State inequality constraints. 

To understand about the LQ control problems and Dynamic programming. 

To understand about the Numerical Techniques for optimal control, Filtering and Estimation, Kalman Filter and its properties. 

1. INTRODUCTION 

2. LQ CONTROL PROBLEMS AND DYNAMIC PROGRAMMING 

3. NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL 
Numerical solution of 2-point boundary value problem by steepest descent and Fletcher Powell method solution of Ricatti equation by negative exponential and interactive Methods. 

4. FILTERING AND ESTIMATION 

5. KALMAN FILTER AND PROPERTIES 

REFERENCES: 
AIM

To Study about the concepts of Power Quality.

OBJECTIVE

➢ To Understand about the Characterisation of Electric Power Quality, Short duration and long duration voltage variations, Voltage imbalance, Voltage fluctuations.

➢ To Understand about the Non-Linear loads, Measurement and Analysis Methods, Analysis and Conventional Mitigation methods and also Power Quality improvement.

1. 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.

2. NON-LINEAR LOADS

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.

3. MEASUREMENT AND ANALYSIS METHODS


4. 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: Detorit 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.

5. POWER QUALITY IMPROVEMENT


Total Hours = 45

TEXT BOOKS

3. Power Quality - R.C. Duggan
5. Power electronic converter harmonics – Derek A. Paice
### AIM
To enumerate the theoretical and practical aspects of modern signal processing in digital environment.

### OBJECTIVE
- To provide an understanding of the advanced concepts of Signal processing in digital.
- To study the Estimation, Prediction Techniques, Digital Signal Processor, Application of DSP and also implementation of VLSI.

### 1. INTRODUCTION
Mathematical description of change of sampling rate – Interpolation and Decimation, Filter implementation for sampling rate conversion – direct form FIR structures, DTFT, FFT, Wavelet transform and filter bank implementation of wavelet expansion of signals

### 2. ESTIMATION AND PREDICTION TECHNIQUES

### 3. DIGITAL SIGNAL PROCESSOR
Basic Architecture – Computational building blocks, MAC, Bus Architecture and memory, Data Addressing, Parallelism and pipelining, Parallel I/O interface, Memory Interface, Interrupt, DMA.

### 4. APPLICATION OF DSP
Design of Decimation and Interpolation Filter, FFT Algorithm, PID Controller, Application for Serial Interfacing, DSP based Power Meter, Position control.

### 5. VLSI IMPLEMENTATION
Basics on DSP system architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realisation of MAC & Filter structure.

Total Hours = 45

### REFERENCES:
AIM
To enumerating the theoretical and practical aspects of Control System Design

OBJECTIVE
- To study the conventional design methods in the concepts of control system design
- To study the design in discrete domain
- To study the analysis in optimal control
- To study the discrete state variable design in control system design
- To study the state estimation design and problem in control system design.

1. CONVENTIONAL DESIGN METHODS

Design specifications- PID controllers and compensators- Root locus based design- Bode based design-Design examples

2. DESIGN IN DISCRETE DOMAIN

Sample and Hold-Digital equivalents-Impulse and step invariant transformations-Methods of discretisation-Effect of sampling- Direct discrete design – discrete root locus
Design examples

3. OPTIMAL CONTROL

Formation of optimal control problems-results of Calculus of variations- Hamiltonian formulation-solution of optimal control problems- Evaluation of Riccati’s equation
State and output Regulator problems-Design examples

4. DISCRETE STATE VARIABLE DESIGN

Discrete pole placement- state and output feedback-estimated state feedback-discrete optimal control- dynamic programming-Design examples

5. STATE ESTIMATION


Total Hours = 45

REFERENCES

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**AIM**

To Study about the Special Electrical Machines.

**OBJECTIVE**

- To Understand about the Operating principle and Phasor diagram of Synchronous Reluctance motors.
- To Understand about the Constructional features and principle of operation of Stepping motors, Switched Reluctance motors.
- To Understand about the Principle of operation and Phasor diagram of Permanent Magnet synchronous motors and study about the Permanent Magnet brushless DC motors.

1. **SYNCHRONOUS RELUCTANCE MOTORS**

2. **STEPPING MOTORS**
   - Constructional features, principle of operation, modes of excitation torque production in Variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor.

3. **SWITCHED RELUTANCE MOTORS**
   - Constructional features-principle of operation-Torque equation-Power Controllers-Characteristics and control Microprocessor based controller.

4. **PERMANENT MAGNET SYNCHRONOUS MOTORS**
   - Principle of operation, EMF, power input and torque expressions, Phasor diagram, Power controllers, Torque speed characteristics, Self control, Vector control, Current control schemes.

5. **PERMANENT MAGNET BRUSHLESS DC MOTORS**
   - Commutation in DC motors, Difference between mechanical and electronic commutators, Hall sensors, Optical sensors, Multiphase Brushless motor, Square wave permanent magnet brushless motor drives, Torque and emf equation, Torque-speed characteristics, Controllers-Microprocessor based controller.

Total Hours = 45

**TEXT BOOKS**

3. LIM

**REFERENCES**

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**AIM**

To Study about the Various advanced Power Systems Dynamics in Power Systems

**OBJECTIVES**

- To provide an understanding of the advanced concepts of power system dynamics
- To study the transient stability analysis in power system
- To study the analysis of sub synchronous oscillation & subsynchronous resonance (SSR)
- To study the analysis of transmission, generation and load aspects of voltage
- Enhancement Of Transient Stability And Counter Measures for sub synchronous resonance

1. **TRANSIENT STABILITY ANALYSIS [1,2,3]**


2. **SUBSYNCHRONOUS OSCILLATIONS [1]**


3. **SUBSYNCHRONOUS RESONANCE (SSR) [1,4]**


4. **TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS [5]**


5. **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.

Total Hours = 45
REFERENCES


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


AIM
To Study about the system identification and adaptive control

OBJECTIVE
- To provide an models for identification in various system identification and adaptive control
- To study the analysis in non-parametric and parametric identification
- To study the analysis in non-linear identification and model validation
- To study the analysis of adaptive control and adaptation techniques
- To study the case studies in system identification and adaptive control

1. MODELS FOR IDENTIFICATION
9

2. NON-PARAMETRIC AND PARAMETRIC IDENTIFICATION
9

3. NON-LINEAR IDENTIFICATION AND MODEL VALIDATION
9

4. ADAPTIVE CONTROL AND ADAPTATION TECHNIQUES
9

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

Total Hours = 45
REFERENCES

3. Astrom and Wittenmark,” Adaptive Control”, PHI
AIM
To study about the industrial power system analysis and design.

OBJECTIVE
➢ To understand about the motor starting studies, power factor correction studies.
➢ To study the harmonic analysis, flicker analysis and ground grid analysis

1. MOTOR STARTING STUDIES


2. POWER FACTOR CORRECTION STUDIES


3. HARMONIC ANALYSIS


4. FLICKER ANALYSIS

Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis-Case Study-Arc Furnace Load-Minimizing the Flicker Effects-Summary.

5. GROUND GRID ANALYSIS


Total Hours = 45

REFERENCES

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**AIM**

To Study about the needs of high voltage direct current transmission in todays

**OBJECTIVE**

To Study about the concepts and its importance of DC power transmission technology, analysis of HVDC converters, Converters and HVDC system control, harmonics and filters and simulation of HVDC system.

1. **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.

2. **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.

3. **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.

4. **HARMONICS AND FILTERS**

   Introduction-generation of harmonics-design of AC filters-DC filters-carrier frequency and RI noise.

5. **SIMULATION OF HVDC SYSTEMS**

   Introduction-system simulation: Philosophy and tools-HVDC system simulation-modeling of HVDC systems for digital dynamic simulation.

   **Total Hours = 45**

**REFERENCES**


1. INTRODUCTION  
Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine

2. 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.

3. 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.

4. 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.

5. GRID CONNECTED SYSTEMS
Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side & Grid side controllers-WECS in various countries

Total Hours = 45

REFERENCES
1. 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.

2. ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

3. 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.

4. 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

5. HYBRID RENEWABLE ENERGY SYSTEMS

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV-Maximum Power Point Tracking (MPPT).

REFERENCES:

AIM
To Study about the Applications of MEMS Technology.

OBJECTIVE
- To understand about the concepts of Micro-Fabrication, Materials and Electro-Mechanical.
- To study about the Electrostatic Sensors and Actuation, Thermal Sensing and Actuation, Piezoelectric Sensing and Actuation and also case studies of MEMS Technology.

1. 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.

2. ELECTROSTATIC SENSORS AND ACTUATION
Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-

3. THERMAL SENSING AND ACTUATION
Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-

4. PIEZOELECTRIC SENSING AND ACTUATION
Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-

5. CASE STUDIES
Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.

Total Hours = 45

REFERENCES
YEAR | SEMESTER | TITLE OF PAPER | L | T | C  
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 | | FLEXIBLE AC TRANSMISSION SYSTEMS | 3 | 0 | 3  
AIM | To understand the use of thyristors in flexible AC transmission systems.  
OBJECTIVE | ➢ To study the operations and control of thyristors in FACTS toolkit and concepts of static VAR compensator, series compensation schemes, Unified power flow control, Design of FACTS controllers, and static VAR compensation.  

1. **INTRODUCTION**  
FACTS-a toolkit, Basic concepts of Static VAR compensator, Resonance damper, Thyristor controlled series capacitor, Static condenser, Phase angle regulator, and other controllers.  

2. **SERIES COMPENSATION SCHEMES**  
Sub-Synchronous resonance, Torsional interaction, torsional torque, Compensation of conventional, ASC, NGH damping schemes, Modelling and control of thyristor controlled series compensators.  

3. **UNIFIED POWER FLOW CONTROL**  
Introduction, Implementation of power flow control using conventional thyristors, Unified power flow concept, Implementation of unified power flow controller.  

4. **DESIGN OF 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.  

5. **STATIC VAR COMPENSATION**  
Basic concepts, Thyristor controlled reactor (TCR), Thyristors switched reactor (TSR), Thyristor switched capacitor (TSC), saturated reactor (SR), Fixed Capacitor (FC).  

**Total Hours = 45**  

REFERENCES  
AIM
To Study about the concepts of digital signal processing.

OBJECTIVE
➢ To understand the operation of discrete time signal and system, Fourier and structure realization, filters, multistage representation and Digital signal processor.

1. DISCRETE TIME SIGNALS AND SYSTEMS

2. FOURIER AND STRUCTURE REALIZATION

3. FILTERS

4. MULTISTAGE REPRESENTATION

5. DIGITAL SIGNAL PROCESSORS

REFERENCES

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<td>ARTIFICIAL INTELLIGENCE APPLICATION TO POWER SYSTEMS</td>
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<tr>
<td>AIM</td>
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<td>To Study about the Artificial Intelligence application to Power Systems.</td>
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| OBJECTIVE |          | ➢ To Understand about the Introduction of Neural networks.  
            |          | ➢ To Understand about the Application of Neural networks to Power System problems, Application of Fuzzy logic to Power Systems, Genetic Algorithm and its applications to power systems. |   |   |   |

1. **INTRODUCTION TO NEURAL NETWORKS**  
Basics of ANN-Perceptron-Delta learning rule-Back Propagation Algorithm-Multilayer Feed forward network-Memory models-Bi-directional associative memory-Hopfield network

2. **APPLICATIONS TO POWER SYSTEM PROBLEMS**  
Application of Neural Networks to load forecasting, Contingency Analysis-VAR control, Economic Load Dispatch.

3. **INTRODUCTION TO FUZZY LOGIC**  

4. **APPLICATIONS TO POWER SYSTEMS**  
Decision making in Power system Control through fuzzy set theory-Use of fuzzy set models of LP in Power systems scheduling problems-Fuzzy logic based power system stabilizer.

5. **GENETIC ALGORITHM AND ITS APPLICATIONS TO POWER SYSTEMS**  

**Total Hours = 45**

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**AIM**
The aim is to introduce about the Intelligent control.

**OBJECTIVE**
- To Understand about the intelligent control and also AI approach.
- To Study about the concepts of Artificial Neural Networks.
- To Understand about the Fuzzy Logic System, Genetic Algorithm and also GA application to power system optimization problem.

1. INTRODUCTION

2. ARTIFICIAL NEURAL NETWORKS
Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis and wavelet transformations. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

3. 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 and ant-colony search techniques for solving optimization problems.

4. 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. Self-organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system.

5. APPLICATIONS

Total Hours = 45

REFERENCES
AIM
To Study about the Computer Network Engineering.

OBJECTIVE
➢ To discuss about the Protocols and Architecture.
➢ To Understand the concepts of Network Access Protocol, Internetworking Transport protocol, Overview of Routing techniques, Presentation/Application Protocols and also Network Management.

1. PROTOCOLS AND ARCHITECTURES
10

2. NETWORK ACCESS PROTOCOL & INTERNETWORKING
9

3. TRANSPORT PROTOCOL & ROUTING TECHNIQUES
9

4. PRESENTATION/APPLICATION PROTOCOLS
9

5. NETWORK MANAGEMENT
8
Architecture of network management-Fault management-Congestion Control Algorithms
Security Management.

Total Hours = 45

TEXT BOOKS

REFERENCES