# VINAYAKA MISSIONS UNIVERSITY

**SALEM, TAMILNADU, INDIA**

## FACULTY OF ENGINEERING AND TECHNOLOGY

## REGULATIONS - 2016

**CURRICULUM AND SYLLABUS**

**FROM**

**I TO VI SEMESTERS**

**FOR**

## M.E. POWER SYSTEMS ENGINEERING (PART TIME)

# VINAYAKA MISSIONS UNIVERSITY, SALEM

# M.E. POWER SYSTEMS ENGINEERING (PART-TIME)

## REGULATION – 2015 - CURRICULUM

## YEAR-I

### SEMESTER – I

| Sl.No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1. | Applied Mathematics for Electrical Engineers (Common to M.E – PSE & PED) | 3 | 1 | 0 | 4 |
| 2 | Power Electronics in Power Systems | 3 | 0 | 0 | 3 |
| 3 | Elective – I | 3 | 0 | 0 | 3 |
| | **TOTAL** | **9** | **1** | **0** | **10** |

### SEMESTER – II

| Sl.No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1. | Power System Control | 3 | 0 | 0 | 3 |
| 2. | Transients in Power System | 3 | 0 | 0 | 3 |
| 3. | Elective – II | 3 | 0 | 0 | 3 |
| 4. | Power System Simulation – I Lab | 0 | 0 | 3 | 2 |
| | **TOTAL** | **9** | **0** | **0** | **11** |

## YEAR-II

### SEMESTER – III

| Sl.No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1. | Power System Analysis | 3 | 1 | 0 | 4 |
| 2. | Power System Protection | 3 | 0 | 0 | 3 |
| 3. | Elective –III | 3 | 0 | 0 | 3 |
| 4. | Power System Simulation – II Lab | 0 | 0 | 3 | 2 |
| | **TOTAL** | **9** | **1** | **3** | **12** |

### SEMESTER – IV

| Sl.No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1. | Power System Operation | 3 | 1 | 0 | 4 |
| 2 | High Voltage Switch gear | 3 | 1 | 0 | 4 |
| 3 | Elective -IV | 3 | 0 | 0 | 3 |
| | **TOTAL** | **9** | **1** | **0** | **11** |

**YEAR-III**

## SEMESTER – V

| Sl.No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1. | Elective -V | 3 | 0 | 0 | 3 |
| 2 | Elective –VI | 3 | 0 | 0 | 3 |
| 3 | Elective -VII | 3 | 0 | 0 | 3 |
| 4 | Project Work- Phase -I | 0 | 0 | 12 | 6 |
| | **TOTAL** | 9 | 0 | 12 | 15 |

## SEMESTER – VI

| Sl.No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1 | Project Work - Phase -II | 0 | 0 | 24 | 12 |
| | **TOTAL** | 0 | 0 | 24 | 12 |

**TOTAL CREDITS : 71**

# LIST OF ELECTIVES

| Sl.No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1. | Power System Dynamics | 3 | 0 | 0 | 3 |
| 2. | Soft Computing Techniques | 3 | 0 | 0 | 3 |
| 3. | Modelling and Analysis of Electrical Machines | 3 | 0 | 0 | 3 |
| 4. | EHV Power Transmission | 3 | 0 | 0 | 3 |
| 5. | Optimal Control Filtering | 3 | 0 | 0 | 3 |
| 6. | Power Quality | 3 | 0 | 0 | 3 |
| 7. | Power System Restructuring and Deregulation | 3 | 0 | 0 | 3 |
| 8. | Advanced Digital Signal Processing | 3 | 0 | 0 | 3 |
| 9. | Control System Design | 3 | 0 | 0 | 3 |
| 10. | Special Electrical Machines | 3 | 0 | 0 | 3 |
| 11. | Advanced Power System Dynamics | 3 | 0 | 0 | 3 |
| 12. | System Identification and Adaptive Control | 3 | 0 | 0 | 3 |
| 13. | Industrial Power System Analysis and Design | 3 | 0 | 0 | 3 |
| 14. | High Voltage Direct Current Transmission | 3 | 0 | 0 | 3 |
| 15. | Wind Energy Conversion Systems | 3 | 0 | 0 | 3 |
| 16. | Power Electronics for Renewable Energy | 3 | 0 | 0 | 3 |
| 17. | Applications of MEMS Technology | 3 | 0 | 0 | 3 |
| 18. | Flexible AC Transmission System | 3 | 0 | 0 | 3 |
| 19. | Digital Signal Processing | 3 | 0 | 0 | 3 |
| 20. | Artificial Intelligence Applications to Power Systems | 3 | 0 | 0 | 3 |
| 21. | Intelligent Control | 3 | 0 | 0 | 3 |
| 22. | Computer Networks Engineering | 3 | 0 | 0 | 3 |

# SYLLABUS

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| I | I | **APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS** (Common to M.E – PSE & PED) | 3 | 1 | 4 |
| **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.<br>➢ Understand the concept of probability space, and different interpretations of probability.<br>➢ Understand the modeling of physical systems using the tools of multivariate random processes.<br>➢ Understand and characterize the output of linear systems excited by random processes.<br>➢ Understand how the slope of the objective function relates to the solution. | | | | |

**UNIT I - ADVANCED MATRIX THEORY** **9**

Matrix norms – Jordan canonical form – Generalised eigenvectors – Singular value decomposition – Pseudo inverse – Least square approximations – QR algorithm.

**UNIT II - CALCULUS OF VARIATIONS** **9**

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** **9**

Basic concepts – Graphical and Simplex methods –Transportation problem – Assignment problem.

**UNIT IV - DYNAMIC PROGRAMMING** **9**

Elements of the dynamic programming model – optimality principle – Examples of dynamic programming models and their solutions.

**UNIT V - RANDOM PROCESSES** **9**

Classification – Stationary random processes – Auto Correlation – Cross Correlations – Power spectral density – Linear system with random input – Gaussian Process.

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

**REFERENCES**

1.Lewis.D.W.,Matrix Theory ,Allied Publishers, Chennai 1995.
2.Bronson, R, Matrix Operations, Schaums outline Series, McGraw Hill, New York. 1989.
3.Elsgoltis, " Differential Equations and Calculus of Variations ", MIR Publishers, Moscow (1970)
4.Gupta.A.S.,Calculus of Variations with Applications ,Prentice Hall of India, New Delhi, 1999.
5.Taha, H.A., "Operations research - An Introduction ", Mac Millan publishing Co., (1982).
6.Gupta, P.K.and Hira, D.S., "Operations Research ", S.Chand & Co., New Delhi, (1999).
7.Ochi, M.K. "Applied Probability and Stochastic Processes ", John Wiley & Sons (1992).
8.Peebles Jr., P.Z., "Probability Random Variables and Random Signal Principles ", McGraw Hill Inc., (1993).

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| 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.<br>➢ To Study about the converters used in R, RL and RLE loads.<br>➢ To Study about the voltage and current sources inverters.<br>➢ To Understand the concept of static reactive power compensation in FACTS Technology.<br>➢ To Study about the basics of power quality. | | | | |

**UNIT I - INTRODUCTION** **9**

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** **9**

Single Phase and three phase bridge rectifiers, half controlled and Fully Controlled Converters with R, RL, AND RLE loads. Free Wheeling Diodes, Dual Converter, Sequence Control of Converters – inverter operation , Input Harmonics and Out put Ripple ,Smoothing Inductance – Power Factor Improvement effect of source impedance, Overlap, Inverter limit.

**UNIT III - DC TO AC CONVERTERS** **9**

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** **9**

Shunt Reactive Power Compensation – Fixed Capacitor Banks, Switched Capacitors, Static Reactor Compensator, Thyristor Controlled Shunt Reactors (TCR) – Thyristor Controlled Transformer - FACTS Technology-Applications of static thyristor Controlled Shunt Compensators for load compensation ,Static Var Systems for Voltage Control, Power Factor Control and Harmonic Control of Converter Fed Systems.

**UNIT V - POWER QUALITY** **9**

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**


1. N.Mohan,T.M.Undeland and W.P.Robbins, Power Electronics : Converter, Applications and Design , John Wiley and Sons , 1989.
2. M.H.Rashid, Power Electronics, Prentice Hall of India, 1994.
3. B.K.Bose ,Power Electronics and A.C. Drives , Prentice Hall ,1986.
4. Roger C.Dugan , Mark .F. Mc Granaghan, Surya Santaso, H.Wayne Beaty, "Electrical Power Systems Quality", Second Edition, Mc Graw Hill, 2002.
5. T.J.E. Miller, Static Reactive Power Compensation, John Wiley and Sons, Newyork, 1982.
6. Mohan Mathur.R., Rajiv.K.Varma, "Thyristor Based FACTS controllers for Electrical Transmission Systems", IEEE press .1999.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| I | II | **POWER SYSTEM CONTROL** | 3 | 0 | 3 |
| **AIM** | To Study about the control of generation and voltages in power system . | | | | |
| **OBJECTIVE** | To Study about the fundamentals of speed governing in generators, modeling of AVR loops, system operating states of security control , concepts of state estimation and power system control under deregulated environment. | | | | |

**1. AUTOMATIC GENERATION CONTROL** **9**

Fundamentals of speed governing - control of generating unit Power output – composite regulating characteristic of Power Systems – Response rates of turbine – governing systems – fundamentals of automatic generation control – Implementation of AGC -development of state variable model for a two area Power System for use in simulation of AGC. Underfrequency Load Shedding and computation of settings for underfrequency relays.

**2. REACTIVE POWER AND VOLTAGE CONTROL** **9**

Modelling of AVR loops : Components – stability compensation - Production and absorption of reactive Power – methods of voltage control - shunt reactors – shunt capacitors – series capacitors – synchronous condensers – static var systems – Principle of transmission system compensation – modeling of reactive compensating devices – Application of tap changing transformers to transmission systems – distribution system voltage regulation – modeling of transformer ULTC control systems .

**3. SECURITY CONTOL OF POWER SYSTEMS** **9**

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** **9**

Maximum likelihood Weighted Least - Squares Estimation :- Concepts - matrix formulation - Example for Weighted Least - Squares state estimation ; State estimation of an AC network: development of method , Typical results of state estimation on an AC network, State Estimation by Orthogonal Decomposition algorithm – Introduction to Advanced topics : Detection and Identification of Bad Measurements , Estimation of Quantities Not Being Measured , Network Observability and Pseudo-measurements - Application of Power Systems State Estimation .

**5. POWER SYTEM CONTROL UNDER DEREGULATED ENVIRONMENT** **9**

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. Elgerd O.I, "Electric Energy System Theory - an Introduction" - Tata McGraw Hill, New Delhi – 2002.
2. Kundur .P; "Power System Stability and Control" EPRI Publications, California, 1994.
3. Allen J.Wood and Bruce .F. Woolenberg, "Power Generation Operation and Control", John Wiley & sons New York, 1996.
4. Mahalanabis A.K., Kothari. D.P. and Ahson.S.I., "Computer Aided Power System Analysis and Control", Tata McGraw Hill publishing Ltd , 1984.
5. Marija Ilic, F.Galiana, L.Fink, "Power System Restructuring : Engineering and Economics" Kluwer Academic Publishers, 2000.
6. Vaibhav Donde, M.A. Pai & Ian A.Hiskens - "Simulation & Optimization in an AGC system after deregulation" IEEE transactions on Power Systems Vol:16, No.3, Aug 2001.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| **I** | **II** | **TRANSIENTS IN POWER SYSTEMS** | **3** | **0** | **3** |
| **AIM** | To Study about the concepts of transients in power system . | | | | |
| **OBJECTIVE** | To understand the concepts of lightning surges and effect of transients , concepts of switching surges , computation of transmission in conversion equipment , idea of insulation co ordination and case studies using simulation of electromagnetic transients. | | | | |

**1.INTRODUCTION AND LIGHTNING SURGES** **9**

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** **9**

Closing and reclosing of lines – load rejection – fault initiation – fault clearing – short line faults – FerroResonance – isolator switching surges – temporary over voltages – surges on an integrated systems – switching – harmonics.

**3. COMPUTATION OF TRANSIENTS IN CONVERSION EQUIPMENT** **9**

Traveling wave method – Beweley's Lattice diagram – analysis in time and frequency domain – eigenvalue approach – Z-transform.

**4. INSULATION CO ORDINATION** **9**

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

**5. CASE STUDIES-SIMULATION OF ELECTROMAGNETIC TRANSIENTS** **9**

(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**


1. Allan Greenwood, "Electrical Transients in Power Systems", Willey Interscience, New York, 1971.
2. Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York,1980.
3. Diesendorf, W., "Over Voltage on High Voltage Systems", Renselaer Bookstore, Troy New York, 1971.
4. Peterson,H.A., "Transient in Power Systems", Dover Publication, New York, 1963.
5. Rakosh das Begamudre, "Extra High Voltage AC Transmission Engineering", Wiley Eastern Ltd, New Delhi, 1990.
6. C.S.Indulkar, DP Kothari, "Power System Transients" - A Statistical approach , Prentice Hall 1996.

| YEAR | SEMESTER | TITLE OF PAPER | P | T | C |
|---|---|---|---|---|---|
| **I** | **II** | **POWERSYSTEM SIMULATION – I LAB** | **3** | **0** | **2** |
| **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<br>➢ To obtain the solutions of power flow using Gauss seidel method,Newton-Raphson method and Fast decoupled method.<br>➢ To obtain the symmetrical fault and unsymmetrical fault analysis. | | | | |

1. Computation of parameters and modeling of transmission lines.
2. Formation of bus admittance and bus impedance matrices and solution of networks.
3. Solution of power flow using Gauss - Seidel method.
4. Solution of power flow using Newton - Raphson method.
5. Solution of power flow using fast decoupled method.
6. Symmetrical fault analysis.
7. Unsymmetrical fault analysis.

**Total Hours = 45**

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| II | III | POWER SYSTEM ANALYSIS | 3 | 1 | 4 |
| AIM | The aim is to introduce the study of power system analysis in planning and operation of power system. | | | | |
| OBJECTIVE | ➢ To understand the concepts of Sparse matrix techniques for large scale power systems, optimal ordering schemes and gauss elimination methods.<br>➢ To understand the designing of new power system and concepts of Gauss seidel method, Newton Raphson method and Fast Decoupled load flow method.<br>➢ To understand the concepts of fault analysis under Balanced and Unbalanced Faults.<br>➢ To understand the concepts of optimal power flow.<br>➢ To understand the concept of voltage stability and steady-state analysis. | | | | |

**UNIT I - SOLUTION TECHNIQUE** **9**

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** **9**

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** **9**

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** **9**

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** **9**

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**


1. Stagg G W., El. Abiad A.H. “Computer Methods in Power System Analysis ”, McGraw Hill, 1968.
2. Elgerd O.I., “Electrical Energy Systems Theory – An Introduction”, Tata McGraw, 2002.
3. Kundur.P., “P.S. Stability and Control”, McGraw Hill, 1994.
4. T.V. Cutsem and C.Vournas,” Voltage Stability of Electric Power Systems”, Kluwer Publishers, 1998.
5. A.J.Wood and B.F.Wollenberg,”Power Generation Operation and Control”, John Wiley and sons, New York, 1996.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| II | III | POWER SYSTEM PROTECTION | 3 | 0 | 3 |
| **AIM** | To study about the protection of various power systems and construction of protective Relays. | | | | |
| **OBJECTIVE** | ➢ To Understand the concept of protective relay and its terminology.<br>➢ To Understand about the Protection of Power Apparatus.<br>➢ To Study about Protection of Transmission lines.<br>➢ To Study about the placement of reactor, booster and capacitor in power system.<br>➢ To Study the concepts of Digital protection. | | | | |

**UNIT I - INTRODUCTION** **9**

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** **9**

Protection of generators stator phase fault protection –loss of excitation protection, generator off-line protection – Transformer protection – factors affecting differential protection – magnetizing inrush current – Application and connection of transformer differential relays – transformers over current protection – Example motor protection.

**UNIT III - PROTECTION OF TRANSMISSION SYSTEMS** **9**

Bus protection – typical bus arrangements – transformer – bus combination – bus differential systems-line protection – classification of lines and feeders – Techniques applicable for line protection – distance protection for phase faults – Fault resistance and relaying – long line protection – Backup remote local and Breaker failure.

**UNIT IV - PROTECTION OF REACTORS, BOOSTERS & CAPACITORS** **9**

Placement of reactors in power system – Types of reactor – reactor rating application and protection – booster in the power system – transformer tap changing – protection of boosters – capacitors in an interconnected power system – series – shunt – series shunt connections – protection of capacitors.

**UNIT V - DIGITAL PROTECTION** **9**

Digital signal processing – Digital filtering in protection relays – digital data transmission – Numeric relay hardware – relay algorithms – distance relays – direction comparison relays – differential relays – software considerations – numeric relay testing – concepts of modern coordinated control system.

**Total Hours = 45**

**REFERENCES**:


1. Stanley H.Horowitz (Ed), “Protecting relaying for power systems”, IEEE Press, 1980.
2. Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”, Prentice -Hall of India, 2003
3. Y.G. Paithankar, “Principles of Power System Protection”, Marcel Dekker Inc., 1998.
4. P.Kundur, “Power System Stability and Control”, McGraw-Hill, 1993.
5. Badri Ram and D.N. Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw- Hill Publishing Company, 2002.
6. J.L.Blackburn, “Power System Protection: Principles and Applications”, Marcel Dekker, New York, 1998

| YEAR | SEMESTER | TITLE OF PAPER | P | T | C |
|---|---|---|---|---|---|
| **II** | **III** | **POWER SYSTEM SIMULATION – II LAB** | **0** | **3** | **2** |
| **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.<br>➢ To study about the economic dispatch , Unit commitment solution method, co ordination of over current and distance relays.<br>➢ 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**

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| II | IV | POWER SYSTEM OPERATION | 3 | 1 | 4 |
| 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 inter change of power and energy. | | | | |

**1.LOAD FORECASTING** **9**

Introduction – Estimation of Average and trend terms – Estimation of periodic components – Estimation of Stochastic components : Time series approach – Auto- Regressive Model, Auto-Regressive Moving – Average Models – Kalman Filtering Approach – On- line techniques for non stationary load prediction.

**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 λ.

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

The Economic dispatch problem – Thermal system dispatching with networklosses considered – The Lambda –iteration method – Gradient method ofeconomic dispatch – economic dispatch with Piecewise Linear cost functions-economic dispatch using dynamic programming – transmission system effects -A two generator system , coordination equations, incremental losses and penalty factors.

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

Long Range Hydro – Scheduling – Short Range Hydro Scheduling - Hydro Electric plant models – Scheduling problems – The Short term Hydothermal Scheduling problem – Short term hydro-scheduling : A Gradient Approach- Hydro units in series (hydraulically coupled) – Pumped –Storage Hydro- Scheduling with a λ-γ iteration – Dynamic programming solution to the Hydro Thermal scheduling problem.

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

Economy interchange between interconnected utilities – interchange evaluation with unit commitment – Multiple – utility interchange transactions – Power Pools: The Energy Broker system, Allocating pool savings – Transmission Effects and Issues : Transfer limitations, wheeling, rates for transmission services in multiparty utility transactions – Transactions involving Nonutility Parties.

**Total Hours = 45**

**REFERENCES**

1.Allen J.Wood and Bruce F Wollenberg, “Power Generation, Operation and Control”,John Wiley and sons, Newyork, 1996.

2.A.K.Mahalanabis, D.P.Kothari, S.I.Ahson, “Computer Aided Power System Analysis and Control”, Tata Mcgraw Hill Publishing Co. Ltd., NewDelhi 1988.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| **II** | **IV** | **HIGH VOLTAGE SWITCH GEAR** | **3** | **1** | **4** |
| **AIM** | To study about the constructions and operation of high voltage switchgear. | | | | |
| **OBJECTIVE** | ➢ To understand the concepts of operations of switchgear , switchgear terminology in circuit interruption , short circuit calculations and rating of circuit breakeras , classification of circuit breakers and testing of circuit breakers. | | | | |

**1. INTRODUCTION** **7**

Insulation of switchgear - rated and tested voltage coordination between inner and external insulation. Insulation clearances in air, oil $SF_6$ and vacuum, bushing insulation, solid insulating materials – dielectric and mechanical strength consideration.

**2. CIRCUIT INTERRUPTION** **10**

Switchgear terminology – Arc characteristics – direct and alternating current interruption – arc quenching phenomena – computer simulation of arc models – transient re-striking voltage – RRRV-recovery voltage-current chopping-capacitive current breaking-auto re-closing.

**3. SHORT CIRCUIT CALCULATIONS AND RATING OF CIRCUI BREAKERS** **10**

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** **10**

Classification of circuit breakers-design, construction and operating principles of bulk oil, minimum oil, airblast, $SF_6$ and vacuum circuit breakers – Comparison of different types of circuit breakers.

**5. TESTING OF CIRCUIT BREAKERS** **8**

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

**Total Hours = 45**

**REFERENCES**


1. Chunikhin, A. and Zhavoronkov, M., “High Voltage Switchgear Analysis and Design”, Mir Publishers, Moscow, 1989.
2. Kuffel, E., Zaengl, W.S., and Kuffel J., High Voltage Engineering Fundamentals, Newness, Second Edition, Butterworth-Heinemann Publishers, New Delhi, 2000
3. Flursscheim, C.H. (Editor), Power circuit breaker-theory and design, IEE Monograph Series 17, Peter Peregrinus Ltd., Southgate House, Stevenage, Herts, SC1 1HQ, England, 1977.
4. Ananthakrishnan S and Guruprasad K.P., Transient Recovery Voltage and Circuit Breakers, Tata McGraw-Hill Publishing Compa ny Ltd., New Delhi, 1999.
5. IEEE Standard Collection, Surge Protectino C62, 1995 Editions, (Institute of Electrical and Electronics Engineers, Inc.), USA.
6. Funio Nakanishi, Switching Phenomena in high voltage circuit breakers, Marcel Dekker Inc., New York, 1991.

| YEAR | SEMESTER | TITLE OF PAPER | L | P | C |
|---|---|---|---|---|---|
| **III** | **V** | **PROJECT WORK PHASE - I** | **0** | **12** | **6** |
| **OBJECTIVE** | To impart the practical knowledge to the students and also to make them to carry out the technical procedures in their project work. To provide an exposure to the students to refer, read and review the research articles, journals and conference proceedings relevant to their project work and placing this as their beginning stage for their final presentation | | | | |
| METHODOLOGY | ➢ Three reviews have to be conducted by the committee of minimum of three members one of which should be the guide<br>➢ Problem should be selected<br>➢ Students have to collect about 20 papers related to their work<br>➢ Report has to be prepared by the students as per the format<br>➢ Preliminary implementation can be done if possible<br>➢ Internal evaluation has to be done for 200 marks | | | | |

<table>
<tr><th>YEAR</th><th>SEMESTER</th><th>TITLE OF PAPER</th><th>L</th><th>P</th><th>C</th></tr>
<tr><td>III</td><td>VI</td><td>PROJECT WORK PHASE - II</td><td>0</td><td>24</td><td>12</td></tr>
<tr><td>OBJECTIVE</td><td colspan="5">This enables and strengthens the students to carry out the project on their own and to implement their innovative ideas to forefront the risk issues and to retrieve the hazards by adopting suitable assessment methodologies and stating it to global.</td></tr>
<tr><td>METHODOLOGY</td><td colspan="5">➢ Three reviews have to be conducted by the committee of minimum of three members one of which should be the guide<br>➢ Each review has to be evaluated for 400 marks.<br>➢ Attendance is compulsory for all reviews. If a student fails to attend review for Some valid reason, one or more chance may be given.<br>➢ They should publish the paper preferably in the journals/conferences.<br>➢ Final review will be done by the committee that consists of minimum of three members one of which should be the guide (if possible include one external expert Examiner within the college).<br>➢ The report should be submitted by the students around at the end of May.</td></tr>
</table>

# ELECTIVE PAPERS

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **POWER SYSTEM DYNAMICS** | **3** | **0** | **3** |
| **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<br>➢ Discuss the basic definitions ,concepts and tools for stability studies for power system<br>➢ To study the modeling of synchronous machines & speed governing system<br>➢ To study the analysis of small signal stability with controllers<br>➢ To study the analysis of small signal stability without controllers | | | | |

**1. SYNCHRONOUS MACHINE MODELLING 9**

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 9**

Excitation System Requirements; Elements of an Excitation System; Types of Excitation System;Control and protective functions;IEEE (1992) block diagram for simulation of excitation systems. Turbine and Governing System Modelling: Functional Block Diagram of Power Generation and Control, Schematic of a hydroelectric plant, classical transfer function of a hydraulic turbine (no derivation), special characteristic of hydraulic turbine, electrical analogue of hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Steam turbine modelling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; generic speed-governing system model for normal speed/load control function.

**3. SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS 9**

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: State-space representation, stability of dynamic system, Linearisation, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects 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 9**

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 9**

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

**Total Hours = 45**

**REFERENCES**


1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
2. IEEE Committee Report, "Dynamic Models for Steam and Hydro Turbines in Power System Studies", IEEE Trans., Vol.PAS-92, pp 1904-1915, November/December, 1973. on Turbine-Governor Model.
3. P.M Anderson and A.A Fouad, "Power System Control and Stability", Iowa State University Press, Ames, Iowa, 1978.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **SOFT COMPUTING TECHNIQUES** | **3** | **0** | **3** |
| **AIM** | To study about the concepts of Soft Computing Techniques. | | | | |
| **OBJECTIVE** | ➢ To Understand about the intelligent control and also AI approach.<br>➢ To Study about the concepts of Artificial Neural Networks.<br>➢ To Understand about the Fuzzy Logic System, Genetic Algorithm and also GA application to power system optimization problem. | | | | |

**1. INTRODUCTION** **9**

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

**2.ARTIFICIAL NEURAL NETWORKS** **9**

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. FUZZY LOGIC SYSTEM** **9**

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** **9**

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 anD-colony search techniques for solving optimization problems.

**5. APPLICATIONS** **9**

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

**Total Hours = 45**

**REFERENCES**

1. Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
3. KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.
4. Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **MODELLING AND ANALYSIS OF ELECTRICAL MACHINES** | **3** | **0** | **3** |
| **AIM** | To study about the concepts of Modelling & Analysis of Machines | | | | |
| **OBJECTIVE** | ➢ To understand about Modelling of DC Machines<br>➢ To study about the Modelling of Induction Machines<br>➢ To study the various controlling techniques of Induction Machines | | | | |

**UNIT - I MODELING OF DC MACHINES** (9)

Equivalent circuit and Electro magnetic torque-Electromechanical modeling-Field excitation: separate, shunt, series and compound excitation-commutator action. Effect of armature mmf-Analytical fundamentals: Electric circuit aspects-magnetic circuit aspects-inter poles.

**UNIT - II DYNAMIC MODELING OF INDUCTION MACHINES** (9)

Equivalent circuits- steady state performance equations-Dynamic modeling of induction machines: Real time model of a two phase induction machines, Three phase to two phase transformation-Electromagnetic torque-generalized model in arbitrary reference frames-stator reference frames model-rotor reference frames model-synchronously rotating reference frame model.

**UNIT - III PHASE CONTROLLED AND FREQUENCY CONTROLLED INDUCTION MACHINES** (9)

Stator voltage control: Steady state analysis-approximate analysis-slip power recovery scheme: principle of operation-steady state analysis range of slip equivalent circuit-performance-static scherbius drive. Constant Volts/Hz controls implementation-steady state performance-dynamic simulation. PWM Voltages: Generation-machine model-steady state performance.

**UNIT - IV VECTOR CONTROLLED INDUCTION MACHINES** (9)

Principle of vector control-direct vector control: flux and torque processor-DVC in stator reference frames with space vector modulation. Indirect vector control scheme: Derivation and implementation. Flux weakening operation: principle-flux weakening in stator flux linkage and rotor flux linkage.

**UNIT - V SPECIAL MACHINES** (9)

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..

**Total Hours = 45**

**REFERENCES**

1 R.Krishnan.”Electric motor & Drives: Modeling, Analysis and Control”, Prentice Hall of India, 2001.
2 Charles kingsley, Jr., A.E.Fityzgerald, Stephen D.Umans “Electric Machinery”, Tata McGraw Hill, Sixth Edition, 2002.
3 Miller, T.J.E.”Brushless permanent magnet and reluctance motor drives”,Oxford, 2005.
4 C.V.Jones, ”The Unified Theory of ElectricalMachines:,Butterworth,London,1967
P.S.Bhimbra, ”Generalised theory of electrical machines”, Khanna Publishers
5 P.S.Bhimbra,”Generalised theory of electrical machines”, Khanna Publishers, 4thEdition, 1993.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **EHV POWER TRANSMISSION** | **3** | **0** | **3** |
| **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.<br>➢ To Obtain the calculation of resistance, inductance and capacitance on line parameters.<br>➢ To Study about the charge potential in voltage gradient of conductors.<br>➢ To Study about the Power losses and audible losses and also Radio Interference.<br>➢ To understand the concept of electrostatic field of EHV lines for a long object. | | | | |

**1. INTRODUCTION** **6**

Standard Transmission Voltages – Average Values of Line Parameters – Power Handling Capacity and Line Loss – Costs of Transmission Lines and Equipment – Mechanical Considerations in Line Performance.

**2. CALCULATION OF LINE PARAMETERS** **8**

Calculation of Resistance, Inductance and Capacitance – Calculation of sequence inductances and capacitances – Line parameters for Modes of propagation.

**3. VOLTAGE GRADIENTS OF CONDUCTORS** **9**

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** **12**

Power losses and audible losses : $I^2R$ Loss and Corona Loss -Attenuation of Traveling Waves Due to Corona Loss - Audible Noise Generation and Characteristics - Limits for Audible Noise - Day-Night Equivalent Noise Level.

Radio Interference **:** corona pulse generation and properties - Limits for Radio Interference Fields - The CIGRE Formula - The RI Excitation Function -Measurement of RI, RIV and Excitation Function - Design of Filter.

**5. ELECTROSTATIC FIELD OF EHV LINES** **10**

Capacitance of Long Object - Calculation of Electrostatic Field of AC Lines Effect of High Field on Humans, Animals, and Plants - Meters and Measurement of Electrostatic Fields - Electrostatic Induction in Unenergised Circuit of a D/C Line - Induced Voltages in Insulated Ground Wires - Electromagnetic Interference.

**Total Hours = 45**

**REFERENCE**

1.Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, New Age International Pvt. Ltd., 1990, Second Edition.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **OPTIMAL CONTROL AND FILTERING** | **3** | **0** | **3** |
| **AIM** | The aim is to introduce about the Optimal control and Filtering. | | | | |
| **OBJECTIVE** | ➢ To study about the Statement of optimal control problem, Problem formulation and also State inequality constraints.<br>➢ To understand about the LQ control problems and Dynamic programming.<br>➢ To understand about the Numerical Techniques for optimal control, Filtering and Estimation, Kalman Filter and its properties. | | | | |

**1. INTRODUCTION** **9**

Statement of optimal control problem – Problem formulation and forms of optimal Control – Selection of performance measures. Necessary conditions for optimal control – Pontryagin's minimum principle – State inequality constraints – Minimum time problem.

**2. LQ CONTROL PROBLEMS AND DYNAMIC PROGRAMMING** **9**

Linear optimal regulator problem – Matrix Riccatti equation and solution method – Choice of weighting matrices – Steady state properties of optimal regulator – Linear tracking problem – LQG problem – Computational procedure for solving optimal control problems – Characteristics of dynamic programming solution – Dynamic programming application to discrete and continuous systems – Hamilton Jacobi Bellman equation.

**3. NUMERICAL TECHNIQUES FOR OPTIMAL CONTROL** **9**

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** **9**

Filtering – Linear system and estimation – System noise smoothing and prediction –Gauss Markov discrete time model – Estimation criteria – Minimum variance estimation – Least square estimation – Recursive estimation.

**5. KALMAN FILTER AND PROPERTIES** **9**

Filter problem and properties – Linear estimator property of Kalman Filter – Time invariance and asymptotic stability of filters – Time filtered estimates and signal to noise ratio improvement – Extended Kalman filter.

**Total Hours = 45**

**REFERENCES**:


1. KiRk D.E., 'Optimal Control Theory – An introduction', Prentice hall, N.J., 1970.
2. Sage, A.P., 'Optimum System Control', Prentice Hall N.H., 1968.
3. Anderson, BD.O. and Moore J.B., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
4. S.M. Bozic, "Digital and Kalman Filtering", Edward Arnould, London, 1979.
5. Astrom, K.J., "Introduction to Stochastic Control Theory", Academic Press, Inc, N.Y., 1970.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **POWER QUALITY** | **3** | **0** | **3** |
| **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.<br>➢ To Understand about the Non-Linear loads, Measurement and Analysis Methods, Analysis and Conventional Mitigation methods and also Power Quality improvement. | | | | |

**1. 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.

**2. NON-LINEAR LOADS** **9**

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** **9**

Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

**4. ANALYSIS AND CONVENTIONAL MITIGATION METHODS** **9**

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** **9**

Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters –Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: P-Q theory, Synchronous detection method – Custom power park –Status of application of custom power devices.

**Total Hours = 45**

**TEXT BOOKS**


1.Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002

2.G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition)

3. Power Quality - R.C. Duggan

4. Power system harmonics –A.J. Arrillga

5. Power electronic converter harmonics –Derek A. Paice

<table>
<tr><th>YEAR</th><th>SEMESTER</th><th>TITLE OF PAPER</th><th>L</th><th>T</th><th>C</th></tr>
<tr><td></td><td></td><td>ADVANCED DIGITAL SIGNAL PROCESSING</td><td>3</td><td>0</td><td>3</td></tr>
<tr><td>AIM</td><td colspan="5">To enumerating the theoretical and practical aspects of modern signal processing in digital environment.</td></tr>
<tr><td>OBJECTIVE</td><td colspan="5">➢ To provide an understanding of the advanced concepts of Signal processing in digital.<br><br>➢ To study the Estimation, Prediction Techniques, Digital Signal Processor, Application of DSP and also implementation of VLSI.</td></tr>
</table>

**1. INTRODUCTION** **9**

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** **9**

Discrete Random Processes – Ensemble averages, Stationary processes, Autocorrelation and Auto covariance matrices. Parseval's Theorem, Wiener-Khintchine Relation – Power Spectral Density**.** AR, MA, ARMA model based spectral estimation. Parameter Estimation, Linear prediction – Forward and backward predictions, Least mean squared error criterion – Wiener filter for filtering and prediction, Discrete Kalman filter.

**3. DIGITAL SIGNAL PROCESSOR** **9**

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** **9**

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

**5. VLSI IMPLEMENTATION** **9**

Basics on DSP sytem architecture design using VHDL programming, Mapping of DSP algorithm onto hardware, Realisation of MAC & Filter structure.

**Total Hours = 45**

**REFERENCES:**


1. Bernard Widrow, Samuel D. Stearns, "Adaptive Signal Processing", Pearson Education, third edition, 2004.
2. Dionitris G. Manolakis, Vinay K. Ingle, Stepen M. Kogon,"Statistical & Adaptive signal processing, spectral estimation, signal modeling, Adaptive filtering & Array processing", McGraw-Hill International edition 2000.
3. Monson H. Hayes, "Statistical Digital Signal Processing and Modelling", John Wiley and Sons, Inc.,
4. John G. Proaks, Dimitris G. Manolakis, "Digital Signal Processing", Pearson Education 2002.
5. S. Salivahanan, A. Vallavaraj and C. Gnanapriya "Digital Signal Processing", TMH,2000.
6. Avatar Sing, S. Srinivasan, "Digital Signal Processing- Implementation using DSP Microprocessors with Examples from TMS320C54xx", Thomson India, 2004.
7. Lars Wanhammer, "DSP Integrated Circuits", Academic press, 1999,New York.
8. Ashok Ambardar,"Digital Signal Processing: A Modern Introduction",Thomson India edition, 2007.
9. Lars Wanhammer, "DSP Integrated Circuits", Academic press, 1999,New York.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **CONTROL SYSTEM DESIGN** | **3** | **0** | **3** |
| **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<br>➢ To study the design in discrete domain<br>➢ To study the analysis in optimal control<br>➢ To study the discrete state variable design in control system design<br>➢ To study the state estimation design and problem in control system design. | | | | |

**1. CONVENTIONAL DESIGN METHODS** **9**

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

**2. DESIGN IN DISCRETE DOMAIN** **9**

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** **9**

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** **9**

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

**5. STATE ESTIMATION** **9**

State Estimation Problem -State estimation- Luenberger's observer-noise characteristics- Kalman-Bucy filter-Separation Theorem-Controller Design-Wiener filter-Design examples.

**Total Hours = 45**

***REFERENCES***


1. M. Gopal "Modern control system Theory" New Age International, 2005.
2. Benjamin C. Kuo "Digital control systems", Oxford University Press, 2004.
3. G. F. Franklin, J. D. Powell and A. E. Naeini "Feedback Control of Dynamic Systems", PHI (Pearson), 2002.
4. Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado "Control system Design", PHI (Pearson), 2003.
5. G. F. Franklin, J. D. Powell and M Workman, "Digital Control of Dynamic Systems", PHI (Pearson), 2002.
6. B.D.O. Anderson and J.B. Moore., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
7. Loan D. Landau, Gianluca Zito," Digital Control Systems, Design, Identification and Implementation", Springer, 2006.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **SPECIAL ELECTRICAL MACHINES** | **3** | **0** | **3** |
| **AIM** | To Study about the Special Electrical Machines. | | | | |
| **OBJECTIVE** | ➢ To Understand about the Operating principle and Phasor diagram of Synchronous Reluctance motors.<br>➢ To Understand about the Constructional features and principle of operation of Stepping motors, Switched Reluctance motors.<br>➢ 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 9**

Constructional features: axial and radial air gap Motors. Operating principle, reluctance torque – phasor diagram, motor characteristics – Linear induction machines.

**2. STEPPING MOTORS 9**

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 9**

Constructional features-principle of operation-Torque equation-Power Controllers-Characteristics and control Microprocessor based controller.

**4. PERMANENT MAGNET SYNCHRONOUS MOTORS 9**

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 9**

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**

1. Miller, T.J.E. “Brushless permanent magnet and reluctance motor drives ", Clarendon Press, Oxford, 1989.
2. Kenjo, T, “Stepping motors and their microprocessor control ", Clarendon Press, Oxford, 1989.
3. LIM

**REFERENCES**

1. Kenjo, T and Naganori, S “Permanent Magnet and brushless DC motors ", Clarendon Press, Oxford, 1989.

2. Kenjo, T. Power Electronics for the microprocessor Age, 1989.

3. B.K. Bose, “Modern Power Electronics & AC drives”

4. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice-Hall of India Pvt. Ltd., New Delhi, 2003

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **ADVANCED POWER SYSTEM DYNAMICS** | **3** | **0** | **3** |
| **AIM** | To Study about the Various advanced Power Systems Dynamics in Power Systems | | | | |
| **OBJECTIVE** | ➢ To provide an understanding of the advanced concepts of power system dynamics<br>➢ To study the transient stability analysis in power system<br>➢ To study the analysis of sub synchronous oscillation& subsysnchronous resonance (SSR)<br>➢ To study the analysis of transmission, generation and load aspects of voltage<br>➢ Enhancement Of Transient Stability And Counter Measures for sub synchronous resonance | | | | |

**1. TRANSIENT STABILITY ANALYSIS [1,2,3] 9**

Review of numerical integration methods: Euler and Fourth Order Runge-Kutta methods, Numerical stability and implicit methods, Simulation of Power System Dynamic response: Structure of Power system Model, Synchronous machine representation: equations of motion, rotor circuit equations, stator voltage equations, Thevenin's and Norton's equivalent circuits, Excitation system representation, Transmission network and load representation, Overall system equations and their solution: Partitioned – Explicit and Simultaneous-implicit approaches, treatment of discontinuities, Simplified Transient Stability Simulation using implicit integration method.

**2. SUBSYNCHRONOUS OSCILLATIONS [1] 9**

Introduction – Turbine Generator Torsional Characteristics: Shaft system model – Examples of torsional characteristics – Torsional Interaction with Power System Controls: Interaction with generator excitation controls – Interaction with speed governors – Interaction with nearby DC converters.

**3. SUBSYSNCHRONOUS RESONANCE (SSR) [1,4] 9**

Subsysnchronous Resonance (SSR): Characteristics of series –**C**ompensated transmission systems – Self-excitation due to induction generator effect – Torsional interaction resulting in SSR – Analytical Methods – Numerical examples illustrating instability of subsynchronous oscillations – Impact of Network-Switching Disturbances: Steady-state switching – Successive network-Switching disturbances – Torsional Interaction Between Closely Coupled Units; time-domain simulation of subsynchronous resonance – EMTP with detailed synchronous machine model

**4. TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS [5] 9**

Review of transmission aspects – Generation Aspects: Review of synchronous machine theory – Voltage and frequency controllers – Limiting devices affecting voltage stability – Voltage-reactive power 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.

**5 . ENHANCEMENT OF TRANSIENT STABILITY AND COUNTER MEASURES FOR SUB SYNCHRONOUS RESONANCE [1] 9**

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

1. P. Kundur, Power System Stability and Control, McGraw-Hill, 1993.

2. H.W. Dommel and N.Sato, "Fast Transient Stability Solutions," IEEE Trans., Vol. PAS-91, pp, 1643-1650, July/August 1972.

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

4. H. W. Dommel, EMTP THEORY BOOK, Microtran Power System Analysis Corporation, Second Edition, 1996.

5. T.V. Cutsem and C.Vournas, “Voltage Stability of Electric Power Systems”, Kluwer publishers,1998.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL** | **3** | **0** | **3** |
| **AIM** | To Study about the system identification and adaptive control | | | | |
| **OBJECTIVE** | ➢ To provide an models for identification in various system identification and adaptive control<br>➢ To study the analysis in non-parametric and parametric identification<br>➢ To study the analysis in non-linear identification and model validation<br>➢ To study the analysis of adaptive control and adaptation techniques<br>➢ To study the case studies in system identification and adaptive control | | | | |

**1.MODELS FOR INDENTIFICATION** 9

Models of LTI systems: Linear Models-State space Models-OE model- Model sets, Structures and Identifiability-Models for Time-varying and Non-linear systems: Models with Nonlinearities – Non-linear state-space models-Black box models, Fuzzy mode**ls'.**

**2.NON-PARAMETRIC AND PARAMETRIC IDENTIFICATON** **9**

Transient response and Correlation Analysis – Frequency response analysis – Spectral Analysis – Least Square – Recursive Least Square –Forgetting factor- Maximum Likelihood – Instrumental Variable methods.

**3.NON-LINEAR IDENTIFICATION AND MODEL VALIDATION** **9**

Open and closed loop identification: Approaches – Direct and indirect identification – Joint input-output identification – Non-linear system identification – Wiener models – Power series expansions - State estimation techniques – Non linear identification using Neural Network and Fuzzy Logic.

**4. ADAPTIVE COTROL AND ADAPTATION TECHNIQUES** **9**

Introduction – Uses – Auto tuning – Self Tuning Regulators (STR) – Model Reference Adaptive Control (MRAC) – Types of STR and MRAC – Different approaches to self-tuning regulators – Stochastic Adaptive control – Gain Scheduling.

**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**


1. Ljung," System Identification Theory for the User", PHI, 1987.
2. Torsten Soderstrom, Petre Stoica, "System Identification", prentice Hall ` International (UK) Ltd,1989.
3. Astrom and Wittenmark," Adaptive Control ", PHI
4. William S. Levine, " Control Hand Book".
5. Narendra and Annasamy," Stable Adaptive Control Systems, Prentice Hall, 1989.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN** | **3** | **0** | **3** |
| **AIM** | To study about the industrial power system analysis and design. | | | | |
| **OBJECTIVE** | ➢ To understand about the motor starting studies, power factor correction studies.<br>➢ To study the harmonic analysis, flicker analysis and ground grid analysis | | | | |

**1. MOTOR STARTING STUDIES** **9**

Introduction-Evaluation Criteria-Starting Methods-System Data-Voltage Drop Calculations-Calculation of Acceleration time-Motor Starting with Limited-Capacity Generators-Computer-Aided Analysis-Conclusions.

**2. POWER FACTOR CORRECTION STUDIES**

Introduction-System Description and Modeling-Acceptance Criteria-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Overvoltages-Switching Surge Analysis-Back-to-Back Switching-Summary and Conclusions.

**3. HARMONIC ANALYSIS** **9**

Harmonic Sources-System Response to Harmonics-System Model for Computer-Aided Analysis-Acceptance Criteria-Harmonic Filters-Harmonic Evaluation-Case Study-Summary and Conclusions.

**4. FLICKER ANALYSIS** **9**

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** **9**

Introduction-Acceptance Criteria-Ground Grid Calculations-Computer-Aided Analysis - Improving the Performance of the Grounding Grids-Conclusions.

**Total Hours = 45**

**REFERENCES**


1. Ramasamy Natarajan, ”Computer-Aided Power System Analysis”, Marcel Dekker Inc., 2002.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **HIGH VOLTAGE DIRECT CURRENT TRANSMISSION** | **3** | **0** | **3** |
| **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** 9

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** **9**

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** **9**

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** **9**

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

5. **SIMULATION OF HVDC SYSTEMS** **9**

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

**Total Hours = 45**

**REFERENCES**

**1.** Padiyar, K.R., "HVDC Power Transmission System", Wiley Eastern Limited, New Delhi 1990. First edition.

2. Edward Wilson Kimbark, "Direct Current Transmission", Vol. I, Wiley interscience, New York, London, Sydney, 1971

3. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering" New Age International (P) Ltd., New Delhi, 1990.

4. Arrillaga, J., "High Voltage Direct Current Transmission", Peter Pregrinus, London, 1983.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **WIND ENERGY CONVERSION SYSTEMS** | **3** | **0** | **3** |
| **AIM** | To Study about basic concept in wind energy conversion system | | | | |
| **OBJECTIVE** | ➢ To Study about concept in wind energy conversion system<br>➢ To study the analysis in wind turbines<br>➢ To study the analysis of Fixed Speed System in WECS<br>➢ To study the variable speed system in WECS<br>➢ To study the analysis in grid connected system | | | | |

## 1. INTRODUCTION 9

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

## 2. 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.

## 3. 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.

## 4. 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.

## 5. GRID CONNECTED SYSTEMS 9

Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side & Grid side controllers-WECS in various countries

**Total Hours = 45**

## REFERENCES


1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
3. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge,1976.
4. 4.S.Heir "Grid Integration of WECS", Wiley 1998.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS** | **3** | **0** | **3** |
| **AIM** | To Study about power electronic for renewable energy system | | | | |
| **OBJECTIVE** | ➢ To Study about basic concept in renewable energy system<br>➢ To study the analysis in electrical machines for renewable energy conversion<br>➢ To study the analysis of power converter<br>➢ To study the analysis in variable wind and PV system<br>➢ To study the analysis in hybrid renewable energy system | | | | |

**1. INTRODUCTION** **9**

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** **9**

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

**3. POWER CONVERTERS** **9**

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** **9**

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** **9**

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

**Total Hours = 45**

**REFERENCES:**


1. Rashid .M. H “power electronics Hand book”, Academic press, 2001.
2. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
3. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
4. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
5. Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **APPLICATIONS OF MEMS TECHNOLOGY** | **3** | **0** | **3** |
| **AIM** | To Study about the Applications of MEMS Technology. | | | | |
| **OBJECTIVE** | ➢ To Understand about the concepts of Micro-Fabrication, Materials and Electro-Mechanical.<br>➢ 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 9**

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 9**

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

**3. THERMAL SENSING AND ACTUATION 9**

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

**4. PIEZOELECTRIC SENSING AND ACTUATION 9**

Piezoelectric effect-cantilever piezo electric actuator model-properties of piezoelectric materials-Applications.

**5. CASE STUDIES 9**

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

**Total Hours = 45**

**REFERENCES**


1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou , “Fundamentals of microfabrication”,CRC Press, 1997.
3. Boston , “Micromachined Transducers Sourcebook”,WCB McGraw Hill, 1998.
4. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **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 9**

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 9**

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 9**

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

**4. DESIGN OF FACTS CONTROLLERS 9**

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 9**

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

**Total Hours = 45**

**REFERENCES**


1. Narin G.Hingorani, " Flexible AC Transmission ", IEEE Spectrum, April 1993, pp 40- 45.
2. Narin G. Hingorani, " High Power Electronics and Flexible AC Transmission Systems " IEEE High Power Engineering Review, 1998.
3. Narin G.Hingorani, " Power Electronics in Electric Utilities : Role of Power Electronics in future power systems ", Proc. of IEEE, Vol.76, no.4, April 1988.
4. Einar V.Larsen, Juan J. Sanchez-Gasca, Joe H.Chow, " Concepts for design of FACTS Controllers to damp power swings ", IEEE Trans On Power Systems, Vol.10, No.2, May 1995.
5. Gyugyi L., " Unified power flow control concept for flexible AC transmission ", IEEE Proc-C Vol.139, No.4, July 1992.

| YEAR | SEMESTE R | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **DIGITAL SIGNAL PROCESSING** | **3** | **0** | **3** |
| **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** 9

Representation of discrete time signal – classifications – Discrete time – system – Basic operations on sequence – linear – Time invariant – causal – stable – solution to difference equation – convolution sum – correlation – Discrete time Fourier series – Discrete time Fourier transform.

**2. FOURIER AND STRUCTURE REALIZATION** 9

Discrete Fourier transform – properties – Fast Fourier transform – Z-transform – structure realization – Direct form – lattice structure for FIR filter – Lattice structure for IIR Filter

.

**3.FILTERS** 9

FIR Filter – windowing technique – optimum equiripple linear phase FIR filter – IIR filter – Bilinear transformation technique – impulse invariance method – Butterworth filter – Tchebyshev filter.

**4.MULTISTAGE REPRESENTATION** 9

Sampling of band pass signal – antialiasing filter – Decimation by a n integer factor – interpolation by an integer factor – sampling rate conversion – implementation of digital filter banks – sub-band coding – Quadrature mirror filter – A/D conversion – Quantization – coding – D/A conversion – Introduction to wavelets.

**5.DIGITAL SIGNAL PROCESSORS** 9

Fundamentals of fixed point DSP architecture – Fixed point number representation and computation – Fundamentals of floating point DSP architecture – floating point number representation and computation – study of TMS 320 C 50 processor – Basic programming – addition – subtraction – multiplication – convolution – correlation – study of TMS 320 C 54 processor – Basic programming – addition – subtraction – multiplication – convolution – correlation**.**

**Total Hours = 45**

**REFERENCES**


1. John G.Proakis, Dimitris G.Manolakis, “Digital Signal Processing: Principles, Algorithms and Applications”, PHI.
2. S.Salivahanan, A.Vallavaraj and C.Gnanapriya “Digital Signal Processing”, TMH, 2000.
3. A.V. Oppenheim and R.W.Schafer, Englewood “Digital Signal Processing”, Prentice-Hall, Inc, 1975.
4. Rabiner and Gold, “Theory and Application of Digital Signal Processing”, A comprehensive, Industrial – Strength DSP reference book.
6. B.Venkatramani & M.Bhaskar, “Digital Signal Processors Architecture, Programming and Applications”, TMH, 2002.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **ARTIFICIAL INTELLIGENCE APPLICATION TO POWER SYSTEMS** | **3** | **0** | **3** |
| **AIM** | To Study about the Artificial Intelligence application to Power Systems. | | | | |
| **OBJECTIVE** | ➢ To Understand about the Introduction of Neural networks.<br>➢ 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 9**

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 9**

Application of Neural Networks to load forecasting, Contingency Analysis-VAR control, Economic Load Dispatch.

**3. INTRODUCTION TO FUZZY LOGIC 9**

Crispness-Vagueness-Fuzziness-Uncertainty-Fuzzy set theory Fuzzy sets-Fuzzy set operations-fuzzy measures-fuzzy relations-fuzzy function. Structure of fuzzy logic controller- fuzzification models-data base-rule base-inference engine defuzzification module.

**4. APPLICATIONS TO POWER SYSTEMS 9**

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 9**

Introduction – Simple Genetic Algorithm – Reproduction,. Crossover, Mutation, Advanced Operators in Genetic Search – Applications to voltage Control and Stability Studies.

**Total Hours = 45**

## *REFERENCES*


1. James.A.Freeman and B.M.Skapura "Neural Networks, Algorithms Applications and Programming techniques"- Addison Wesley,1990.
2. George Klir and Tina Folger,.A., "Fuzzy sets, Uncertainty and Information", Prentice Hall of India Pvt.Ltd.,1993 .
3. Zimmerman,H.J. "Fuzzy Set Theory and its Applications", Kluwer Academic Publishers,1994.
4. IEEE tutorial on "Application of Neural Network to Power Systems", 1996
5. Loi Lei Lai , "Intelligent System Applications in Power Engineering", John Wiley and Sons Ltd., 1998.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **INTELLIGENT CONTROL** | **3** | **0** | **3** |
| **AIM** | The aim is to introduce about the Intelligent control. | | | | |
| **OBJECTIVE** | ➢ To Understand about the intelligent control and also AI approach.<br>➢ To Study about the concepts of Artificial Neural Networks.<br>➢ To Understand about the Fuzzy Logic System, Genetic Algorithm and also GA application to power system optimization problem. | | | | |

**1. INTRODUCTION** **9**

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

**2.ARTIFICIAL NEURAL NETWORKS** **9**

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** **9**

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** **9**

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** **9**

GA application to power system optimisation problem, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox.

Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. Stability analysis of fuzzy control systems.

**Total Hours = 45**

## REFERENCES


1. Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
2. KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
3. KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice- Hall of India Pvt. Ltd., 1993.
4. Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
5. Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers.

| YEAR | SEMESTER | TITLE OF PAPER | L | T | C |
|---|---|---|---|---|---|
| | | **COMPUTER NETWORK ENGINEERING** | **3** | **0** | **3** |
| **AIM** | To Study about the Computer Network Engineering. | | | | |
| **OBJECTIVE** | ➢ To discuss about the Protocols and Architecture.<br>➢ 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**

Protocols-layered approach-OSI model-DoD model-Hierarchical Approach-Local Network Technology- Bus/Tree topology-Ring topology-medium access protocols -Details of IEEE 802 standards.

**2. NETWORK ACCESS PROTOCOL & INTERNETWORKING 9**

Circuit Switched Network Access-Packet Switched Network Access-Broadcast Network Access-Principle of Internetworking-Bridges, Gateways-X, 75-internet protocols-ISO Internet protocol standard.

**3. TRANSPORT PROTOCOL & ROUTING TECHNIQUES 9**

Transport Service protocol Mechanisms-Network Service-Transport standards-Internet Transport protocols-Wireless UDP-Overview of routing techniques.

**4. PRESENTATION/APPLICATION PROTOCOLS 9**

File Transfer Protocols-World Wide Web-Electronic Mail-Overview of ISDN-ISDN Protocols.

**5. NETWORK MANAGEMENT 8**

Architecture of network management-Fault management-Congestion Control Algorithms

Security Management.

**Total Hours = 45**

**TEXT BOOKS**

1. Stallings, " Data and Computer Communication ", Maxwell and Macmillan, 1988.

2. Andrew Tannenbaum S., " Computer Networks ", 3rd Edition, Prentice Hall of India, 1997.

**REFERENCES**

1. Stallings, “Data and Computer Communication: Architectures, Protocols and Standards", IEEE Computer Society, 1987.

2. Kernel Texpian A.S., " Communication Network Management ", Prentice Hall, 1992.

3. " Network Management ", Standards, Uylers Black, McGraw Hill, 1995.

4. Commer and Stevens, " Internetworking with TCP/IP Vol.III: Client Server Programming and application ", Prentice Hall , USA, 1994.