NALLA MALLA REDDY ENGINEERING COLLEGE
Autonomous Institution
Accredited by **NAAC** with **'A'** Grade, **NBA** Accredited B.Tech Programs
Sponsored by **Nalla Malla Reddy Education Society**
Website: www.nmrec.edu.in

R21

Department of Electrical & Electronics Engineering
Course Curriculum: R21 for M. Tech. (EPE)

I Year - Semester I

Sl.	Course Title	L	T	P	Credits
1	Power System Analysis	3	0	0	3
2	Economic Operation of Power Systems	3	0	0	3
3	1. HVDC Transmission 2. Renewable Energy Systems 3. Smart Grid Technologies **4.** Modern Control Theory	3	0	0	3
4	1. Electrical Power Distribution System 2. Reactive Power Compensation and Management 3. Mathematical Methods for Power Engineering **4.** Hybrid Electric Vehicles	3	0	0	3
5	Research Methodology and IPR	2	0	0	2
6	Power Systems Computation Lab-I	0	0	4	2
7	Advanced Power Systems Lab	0	0	4	2
8	Audit Course - I	2	0	0	0
	Total Credits	**16**	**0**	**8**	**18**

I Year - Semester II

Sl.	Course Title	L	T	P	Credits
1	Digital Protection of Power System	3	0	0	3
2	Power System Dynamics	3	0	0	3
3	1. Restructured Power Systems 2. EHV AC Transmission 3. Swarm Intelligence Techniques in Power Systems 4. Industrial Load Modeling and Control	3	0	0	3
4	1. AI Techniques in Power Systems 2. Power Quality 3. Power Apparatus Design 4. Power System Reliability and Planning	3	0	0	3
5	Mini Project with Seminar	0	0	4	2
6	Power Systems Computation Lab-II	0	0	4	2
7	Power System Protection Lab	0	0	4	2
8	Audit Course - II	2	0	0	0
	Total Credits	**14**	**0**	**12**	**18**

II Year - Semester I

Sl.	Course Title	L	T	P	Credits
1	1. Power System Transients 2. Flexible AC Transmission Systems 3. Gas Insulated Systems 4. SCADA System and Applications	3	0	0	3
2	Open Elective	3	0	0	3
3	Dissertation Work Review - II	0	0	12	6
	Total	**6**	**0**	**12**	**12**

II Year - Semester II

Sl.	Course Title	L	T	P	Credits
1	Dissertation Work Review - III	0	0	12	6
2	Dissertation Viva-Voce	0	0	28	14
	Total	**0**	**0**	**40**	**20**

Audit Course I & II:

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills

POWER SYSTEM ANALYSIS (Professional Core - I)

M. TECH. I Year I Sem. (EPE)

Prerequisite: Computer Methods in Power Systems
Course Objectives: to prepare the students to

- Build the Nodal admittance and Nodal impedance matrices of a practical network.
- Study various methods of load flow.
- Analyse various types of faults in power system.
- Understand power system security concepts
- Understand state estimation and study simple algorithms for state estimation.

Course Outcomes: Students will be able to:

- To build/construct YBUS and ZBUS of any practical network.
- Calculate voltage phasors at all buses, given the data using various methods of load flow.
- Calculate fault currents in each phase.
- Rank various contingencies according to their severity.
- Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps , CB status etc.

UNIT-I: NETWORK MATRICES Introduction, per unit system, Bus Admittance Matrix, Network Solution, Network Reduction(Kron Reduction), YBUS structure and manipulation Bus Impedance matrix, Methods to determine columns of ZBUS.

UNIT-II: LOAD FLOW STUDIES Overview of Gauss-Siedel, Newton-Raphson load flow methods, fast decoupled method, convergence properties, sparsity techniques, handling Qmax violations in constant matrix, inclusion in frequency effects, AVR in load flow, handling of discrete variable in load flow.

UNIT-III: FAULT CALCULATIONS Symmetrical faults-Fault calculations using ZBUS - Fault calculations using ZBUS equivalent circuits, Selection of circuit breakers, symmetrical components, unsymmetrical faults - Problems on various types of faults.

UNIT-IV: CONTINGENCY ANALYSIS Security Analysis: Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, overload index ranking

UNIT-V: STATE ESTIMATION Sources of errors in measurements, Virtual and Pseudo measurements, Observability concepts, Tracking state Estimation, Weighted Least Square method, Bad Data detection and estimation.

TEXT BOOKS:

1. J.J. Grainger & W.D. Stevenson, "Power system analysis", McGraw Hill, 2003.
2. A. R. Bergen & Vijay Vittal, "Power System Analysis", Pearson, 2000.

REFERENCES:

1. L.P. Singh, "Advanced Power System Analysis and Dynamics", New Age International, 2006.
2. G.L. Kusic, "Computer aided power system analysis", Prentice Hall India, 1986.
3. A.J. Wood, " Power generation, operation and control" , John Wiley, 1994.
4. P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995.
5. NPTEL Course, A. K. Sinha, Power System Analysis,
https://www.youtube.com/playlist?list=PL36A60B630E8C7B56
6. Pradeep Yemula, Power System Practice, online course
https://www.youtube.com/playlist?list=PL-uxPiMl0_6GWFPGXgVapb1yjVAZs9YGz

ECONOMIC OPERATION OF POWER SYSTEMS
(Professional Core - II)

M. TECH. I Year I Sem. (EPE)

Prerequisite: Electrical Power Systems

Course Objectives: Students will be able to:
- Understand economic load scheduling problem and unit commitment problem.
- Understand hydro-thermal scheduling problem.
- Understand load frequency control (LFC)
- Understand the optimal power flow (OPF) problem.

Course Outcomes: the student will be able to
- Distinguish between economic load dispatch and unit commitment problem
- Solve economic load scheduling (with and without network losses) and unit commitment problem
- Solve hydro-thermal scheduling problem
- Analyze the single area and two area systems for frequency deviation
- Solve the OPF problem using ac and dc load flow methods.

UNIT-I: ECONOMIC LOAD SCHEDULING Characteristics of Steam Turbine, Variations in steam unit characteristics, Economic dispatch with piecewise linear cost functions, Lambda Iterative method, LP method, Economic dispatch under composite generation production cost function, Base point and Participation factors, Thermal system Dispatching with Network losses.

UNIT-II: UNIT COMMITMENT Unit Commitment – Definition – Constraints in Unit Commitment–Unit Commitment solution methods – Priority–List Methods – Dynamic Programming Solution.

UNIT-III: HYDRO THERMAL SCHEDULING Characteristics of Hydroelectric units, Introduction to Hydrothermal coordination, Long-Range and Short-Range Hydro-Scheduling, Hydroelectric plant models, Hydrothermal scheduling with storage limitations, Dynamic programming solution to hydrothermal scheduling.

UNIT-IV: LOAD FREQUENCY CONTROL Control of generation – models of power system elements – single area and two area block diagrams – generation control with PID controllers – implementation of Automatic Generation control (AGC) – AGC features.

UNIT-V: OPTIMAL POWER FLOW Introduction to Optimal power flow problem, OPF calculations combining economic dispatch and power flow, OPF using DC power flow, Algorithms for solution of the ACOPF, Optimal Reactive Power Dispatch.

TEXT BOOKS:

1. Olle I. Elgerd, “Electric Energy Systems Theory an Introduction”, TMH, 2nd Edition, 1983
2. J.J. Grainger &W.D.Stevenson, “Power system analysis ”, McGraw Hill ,2003

REFERENCES:

1. Allen J. Wood, Bruce F. Wollenberg, Gerald B. Sheblé-Power Generation, Operation and Control-Wiley-Interscience (2013)
2. NPTEL Course, Prof. S. N. Singh, Power System Operation and Control, https://www.youtube.com/playlist?list=PL4BFB13CCDB954BCF

HVDC TRANSMISSION
(Professional Elective - I)

M. TECH. I Year I Sem. (EPE)

Prerequisite: Power Systems and Power Electronics

Course Objectives:
- to prepare the students to understand the state-of-the-art of HVDC technology.
- to enable the students to model and analyse HVDC systems

Course Outcomes: Students will be able to:
- understand the state-of-the-art of HVDC technology.
- model and analye the HVDC system for inter-area power flow regulation.
- analyze the converter and dc grid faults and adopt methods to mitigate them.
- analyse the HVDC converter reactive power requirements and address the issues.

UNIT-I: GENERAL ASPECTS OF DC TRANSMISSION Evolution of HVDC transmission, Comparison of HVDC and HVAC systems, Types of DC links, Components of a HVDC system, Valve characteristics, Properties of converter circuits, assumptions, single phase and Three-phase Converters, Pulse number, choice of best circuit for HVDC converters.

UNIT-II: ANALYSIS OF BRIDGE CONVERTER Analysis of simple rectifier circuits, required features of rectification circuits for HVDC transmission. **Analysis of HVDC converter**: Different modes of converter operation, Output voltage waveforms and DC voltage in rectification, Output voltage waveforms and DC in inverter operation, Thyristor/Valve voltages. Equivalent electrical circuit.

UNIT-III: DC LINK CONTROL Grid control, basic means of control, power reversal, limitations of manual control, Constant current versus Constant Voltage, Desired features of control.
Actual control characteristics: Constant-minimum-ignition-angle control, Constant-current control, Constant-extinction-angle control. Stability of control, tap-changer control**,** Power control and current limits, frequency control.

UNIT-IV: CONVERTER FAULTS & PROTECTION Converter mal-operations, Commutation failure, Starting and shutting down the converter bridge, Converter protection.

UNIT-V: REACTIVE POWER MANAGEMENT Smoothing reactor and DC Lines, Reactive power requirements, Harmonic analysis, Filter design

TEXT BOOKS:
1. J. Arrillaga, “High Voltage Direct Transmission”, Peter Peregrinus Ltd. London, 1983.
2. K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International Publishers, 3rd Edition, 2015.

REFERENCES:
1. High Voltage Direct Current Transmission, NPTEL Lectures by Prof. S. N. Singh, https://www.youtube.com/playlist?list=PL4B78E9972172086A
2. E. W. Kimbark, “Direct Current Transmission”, Vol. I, Wiley Interscience, 1971.
3. Erich Uhlmann, “Power Transmission by Direct Current”, B.S. Publications, 2004.
4. SN Singh, “*Electric Power Generation, Transmission and Distribution*, PHI, New Delhi 2nd edition, 2008.
5. V. Kamaraju, ”HVDC Transmission” Tata McGraw-Hill Education Pvt Ltd,New delhi,2011.

RENEWABLE ENERGY SYSTEMS
(Professional Elective - I)

M. TECH. I Year I Sem. (EPE)
Prerequisite: Power Systems and Electrical Machines
Course Objectives: to prepare the students to

- learn various renewable energy sources
- gain understanding of integrated operation of renewable energy sources
- understand power electronics interface with the grid

Course Outcomes: Students will be able to

- Knowledge about renewable energy
- Understand the working of distributed generation system in autonomous/grid connected modes

UNIT- I: SOLAR ENERGY SYSTEMS: Introduction – solar radiation - solar thermal energy conversion - Flat plate collector - concentric collectors- solar pond - central receiver system- solar pumping - Solar photovoltaic systems - characteristics of PV cell- Photo voltaic modules - Types of Photo voltaic systems.

UNIT-II: WIND ENERGY AND BIO GAS: Basics of wind energy - classification of turbines - wind characteristics - energy extraction - Betz limit - Modes of wind power generation- Bio Mass energy conversion - Anaerobic Digestion - Aerobic Digestion - Gasification-Bio Gas Plants.

UNIT-III: OCEAN ENERGY CONVERSION: Tidal Energy generation - characteristics of Tides - Power generation schemes - Components in Tidal power plant- Wave Energy - Principle of wave energy plant - Wave energy conversion machines - Ocean Thermal Energy conversion - Principle - cycles of operation - Types of OTEC plants - Applications

UNIT-IV: GEO-THERMAL ENERGY AND FUEL CELLS: HYBRID ENERGY SYSTEMS Geothermal Energy - Structure of Earth's interior - Geothermal fields, gradient, resources - Geothermal power generation - Fuel cells – Introduction - Principle of operation - Types of **FUEL CELLS** - State of art fuel cells-energy output of a fuel cell - operating characteristics of fuel cells - thermal efficiency - Need for Hybrid systems - Types of Hybrid systems.

UNIT-V: ENERGY SYSTEMS AND GRIDS Introduction, Energy systems, Distribution technologies, Energy storage for grid electricity, Social and environmental aspects of energy supply and storage. Electricity grids(networks), DC grids, Special challenges and opportunities for renewable electricity, Power Electronic Interface with the Grid

TEXT BOOKS:

1. D.P.Kothari, K.C.Singal, R.Ranjan, "Renewable Energy Resources and emerging technologies " - PHI 2/e 2011.
2. John Twidell and Tony Weir, "Renewable Energy Resources" - 2nd edition, CRC Press.
3. Rakosh Das Begamudre, "Energy conversion systems"- New Age International Publishers, New Delhi - 2000.
4. "Renewable Energy Resources" by John Twidell and Tony Weir, 2nd Edition, Fspon & Co.

REFERENCES:

1. "Understanding Renewable Energy Systems", by Volker Quaschning, 2005, UK.
2. "Renewable Energy Systems-Advanced Conversion, Technologies & Applications" by Faner Lin Luo Honer Ye, CRC press, Taylor & Francis group.
3. NPTEL Course on Non-Conventional Energy Sources, https://www.youtube.com/playlist?list=PL3QMEfkolRFbGhXveCE7RFDBgY0_gRxkh

SMART GRID TECHNOLOGIES
(Professional Elective - I)

M. TECH. I Year I Sem. (EPE)
Prerequisite: Power Systems
Course Objectives: to prepare the students to

- Understand concept of smart grid and its advantages over conventional grid
- Know smart metering techniques
- Learn wide area measurement techniques
- Understand the problems associated with integration of distributed generation & its solution through smart grid.

Course Outcomes: Students will be able to

- Distinguish between conventional grid and smart grid
- Apply smart metering concepts to industrial and commercial installations
- Formulate solutions in the areas of smart substations, distributed generation and wide area measurements
- Develop smart grid solutions using modern communication technologies

UNIT-I: INTRODUCTION TO SMART GRID Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self-Healing Grid Present development & International policies in Smart Grid

UNIT-II: SMART METERS Introduction to Smart Meters, Real Time Pricing, Automatic Meter Reading (AMR), Advanced Metering Infrastructure (AMI), Outage Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Smart Appliances, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation, Wide Area Measurement System (WAMS), Phasor Measurement Unit (PMU)

UNIT-III: INFORMATION AND STORAGE SYSTEMS Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, Pumped Hydro, Compressed Air Energy Storage, fuel-cells

UNIT-IV: MICROGRID Concept of microgrid, need & applications of microgrid, formation of micro-grid, Issues of interconnection, protection & control of microgrid, Plastic & Organic solar cells, thin film solar cells, Variable speed wind generators, micro-turbines, Captive power plants, Integration of renewable energy sources

UNIT-V: POWER QUALITY Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, power quality conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit and communication protocols in grid.

TEXT BOOKS:

1. Ali Keyhani, “Design of smart power grid renewable energy systems”, Wiley IEEE, 2011
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press, 2009

REFERENCES:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, “Smart Grid: Technology and Applications”, Wiley 2012
2. Stuart Borlase, “Smart Grid: Infrastructure, Technology and solutions “ CRC Press
3. A.G.Phadke, “Synchronized Phasor Measurement and their Applications”, Springer
4. S. Chowdhury, S. P. Chowdhury, and P. Crossley, “Microgrids and active distribution networks”, IET, 2009, http://uni-site.ir/khuelec/wp-content/uploads/Microgrids-and-Active- Distribution-Networks.pdf
5. Prof. N. P. Padhy and Prof. Premalatha Jena, NPTEL course – Introduction to Smart Grid https://www.youtube.com/playlist?list=PLLy_2iUCG87D59-Bc8Jqfqt43LvPC0KgC

MODERN CONTROL THEORY
(Professional Elective - I)

M. TECH. I Year I Sem. (EPE)
Prerequisite: Linear Control Systems
Course Objectives:
- To explain the concepts of basics and modern control system for the real time analysis and design of control systems.
- To explain the concepts of state variables analysis.
- To study and analyze nonlinear systems.
- To analyze the concept of stability for nonlinear systems and their categorization.
- To apply the comprehensive knowledge of optimal theory for Control Systems.

Course Outcomes: Upon completion of this course, students should be able to:
- Terms of basic and modern control system for the real time analysis and design of control systems.
- To perform state variables analysis for any real time system.
- Apply the concept of optimal control to any system.
- Able to examine a system for its stability, controllability and observability.
- Implement basic principles and techniques in designing linear control systems.
- Formulate and solve deterministic optimal control problems in terms of performance indices.
- Apply knowledge of control theory for practical implementations in engineering and network analysis.

UNIT I: Mathematical Preliminaries and State Variable Analysis: Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear Transformations and Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear systems – The concept of state – State space model of Dynamic systems – Time invariance and Linearity – Non uniqueness of state model – State diagrams for Continuous-Time State models - Existence and Uniqueness of Solutions to Continuous-Time State Equations – Solutions of Linear Time Invariant Continuous-Time State Equations – State transition matrix and it's properties. Complete solution of state space model due to zero input and due to zero state.

UNIT II: Controllability and Observability: General concept of controllability – Controllability tests, different state transformations such as diagonalization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems – General concept of Observability – Observability tests for Continuous-Time Invariant Systems – Observability of different State transformation forms.

State Feedback Controllers and Observers: State feedback controller design through Pole Assignment, using Ackkermans formula– State observers: Full order and Reduced order observers.

UNIT III: Non-Linear Systems: Introduction – Non Linear Systems - Types of Non-Linearities – Saturation – Dead-Zone - Backlash – Jump Phenomenon etc; Linearization of nonlinear systems, Singular Points and its types– Describing function–describing function of different types of nonlinear elements, – Stability analysis of Non-Linear systems through describing functions. Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method.

UNIT IV: Stability Analysis: Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems - Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

UNIT V: Calculus of Variations:---- optimal control

TEXT BOOKS :
1. M.Gopal, Modern Control System Theory, New Age International - 1984
2. Ogata. K, Modern Control Engineering, Prentice Hall - 1997

REFERENCES:

1. N K Sinha, Control Systems, New Age International – 3^{rd} edition.
2. Donald E.Kirk, Optimal Control Theory an Introduction, Prentice - Hall Network series - First edition.

ELECTRICAL POWER DISTRIBUTION SYSTEM
(Professional Elective - II)

M. TECH. I Year I Sem. (EPE)

Prerequisite: Power Systems

Course Objectives: to prepare the students to
- Learn about load forecasting
- Understand power distribution system reconfiguration and restoration
- Learn control and communication systems
- Understand distribution automation

Course Outcomes: Students will be able to
- understand power distribution system
- explore distribution automation and its application in practice
- learn control and communication systems
- apply optimization techniques for distribution systems
- carryout distribution energy management

UNIT-I: LOAD FORECASTING Distribution of Power, Management, Power Loads, Load Forecasting Short-term & Long-term, Power System Loading, Technological Forecasting.

UNIT-II: DISTRIBUTION AUTOMATION Advantages of Distribution Management System (DMS) Distribution Automation: Definition, Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints, Power Factor Correction

UNIT-III: CONTROL AND COMMUNICATION Interconnection of Distribution, Control & Communication Systems, Remote Metering, Automatic Meter Reading and its implementation. SCADA: Introduction, Block Diagram, SCADA Applied To Distribution Automation. Common Functions of SCADA, Advantages of Distribution Automation through SCADA

UNIT-IV: OPTIMALITY PRINCIPLES Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial, Distribution Systems, Sectionalizing Switches – Types, Benefits, Bellman's Optimality Principle, Remote Terminal Units, Energy efficiency in electrical distribution & Monitoring

UNIT-V: ENERGY MANAGEMENT Maintenance of Automated Distribution Systems, Difficulties in Implementing Distribution. Automation in Actual Practice, Urban/Rural Distribution, Energy Management, AI techniques applied to Distribution Automation

TEXT BOOKS:
1. A.S. Pabla, "Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., Fourth Edition.
2. M.K. Khedkar, G.M. Dhole, "A Text Book of Electrical power Distribution Automation", University Science Press, New Delhi

REFERENCES:
1. Turan Gonen, "Electric Power Distribution Engineering", 3rd Edition CRC Press,
2. Anthony J Panseni, "Electrical Distribution Engineering", CRC Press
3. James Momoh, "Electric Power Distribution, automation, protection & control", CRC Press
4. NPTEL course, Electricial Distribution System Analysis, https://www.youtube.com/playlist?list=PLLy_2iUCG87DxrqJr3dBhSruMiRHK0rNr

REACTIVE POWER COMPENSATION AND MANAGEMENT
(Professional Elective - II)

M. TECH. I Year I Sem. (EPE)

Prerequisite: Power Systems

Course Objectives:

- To identify the necessity of reactive power compensation
- To describe load compensation
- To select various types of reactive power compensation in transmission systems
- To illustrate reactive power coordination system
- To characterize distribution side and utility side reactive power management.

Course Outcomes: Upon the completion of this course, the student will be able to

- Distinguish the importance of load compensation in symmetrical as well as un symmetrical loads
- Observe various compensation methods in transmission lines
- Construct model for reactive power coordination
- Distinguish demand side reactive power management & user side reactive power management

UNIT- I: LOAD COMPENSATION Objectives and specifications – reactive power characteristics – inductive and capacitive approximate biasing – Load compensator as a voltage regulator – phase balancing and power factor correction of unsymmetrical loads- examples.

UNIT- II: STEADY–STATE AND TRANSIENT REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM Uncompensated line – types of compensation – Passive shunt and series and dynamic shunt compensation – examples. Characteristic time periods – passive shunt compensation – static compensations - series capacitor compensation – compensation using synchronous condensers – examples

UNIT- III: REACTIVE POWER COORDINATION Objective – Mathematical modeling – Operation planning – transmission benefits – Basic concepts of quality of power supply – disturbances- steady –state variations – effects of under voltages – frequency –Harmonics, radio frequency and electromagnetic interferences

UNIT- IV DISTRIBUTION SIDE REACTIVE POWER MANAGEMENT: Load patterns, basic methods load shaping, power tariffs- KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels System losses, loss reduction methods, economics planning, capacitor placement, retrofitting of capacitor banks

UNIT- V: USER SIDE REACTIVE POWER MANAGEMENT KVAR requirements for domestic appliances – Purpose of using capacitors – selection of capacitors – deciding factors – types of available capacitor, characteristics and Limitations

Reactive power management in electric traction systems and arc furnaces: Typical layout of traction systems – reactive power control requirements – distribution transformers- Electric arc furnaces – basic operations- furnaces transformer –filter requirements – remedial measures –power factor of an arc furnace

TEXT BOOKS:

1. Reactive power control in Electric power systems by T.J.E.Miller, John Wiley and sons, 1982.
2. Reactive power Management by D.M.Tagare, Tata McGraw Hill, 2004.

REFERENCES:

1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just “Reactive Power Compensation: A Practical Guide, April, 2012, Wiley publication.

MATHEMATICAL METHODS FOR POWER ENGINEERING
(Professional Elective - II)

M. TECH. I Year I Sem. (EPE)

Prerequisite: Mathematics

Course Objectives: to prepare the students to

- understand the relevance of mathematical methods to solve engineering problems.
- understand how to apply these methods for a given engineering problem.

Course Outcomes: Students will be able to

- understand vector spaces, linear transformation, eigenvalues and eigenvectors of linear operators
- learn about linear programming problems and understand the simplex method for solving linear programming problems in various fields of science and technology
- acquire knowledge about nonlinear programming and various techniques used for solving constrained and unconstrained nonlinear programming problems
- understand the concept of random variables, functions of random variable and their probability distribution
- understand stochastic processes and their classification

UNIT- I: Vector spaces, linear transformations, Matrix representation of linear transformation, Eigen values and Eigen vectors of linear operator

UNIT- II: Linear Programming Problems, Simplex Method, Duality, Non Linear Programming problems

UNIT- III: Unconstrained Problems, Search methods, Constrained Problems

UNIT- IV: Lagrange method, Kuhn-Tucker conditions, Random Variables, Marginal and Conditional distributions, Elements of stochastic processes

UNIT- V: Mathematical methods applied to Power Engineering, examples – economic load dispatch, optimal power flow, unit commitment

TEXT BOOKS:

1. Kenneth Hoffman and Ray Kunze, “Linear Algebra”, 2nd Edition, PHI, 1992
2. Erwin Kreyszig, “Introductory Functional Analysis with Applications”, John Wiley & Sons, 2004

REFERENCES:

1. Irwin Miller and Marylees Miller, John E. Freund’s “Mathematical Statistics”, 6th Edn, PHI, 2002
2. J. Medhi, “Stochastic Processes”, New Age International, New Delhi., 1994
3. A Papoulis, “Probability, Random Variables and Stochastic Processes”, 3rd Edition, McGraw Hill, 2002
4. John B Thomas, “An Introduction to Applied Probability and Random Processes”, John Wiley, 2000
5. Hillier F S and Liebermann G J, “Introduction to Operations Research”, 7th Edition, McGraw Hill, 2001
6. Simmons D M, “Non Linear Programming for Operations Research”, PHI, 1975
7. MIT online course, Prof. Gilbert Strang, Linear Algebra, https://www.youtube.com/playlist?list=PL49CF3715CB9EF31D
8. Matpower, Free open-source tools for electric power system simulation and optimization, https://matpower.org/

HYBRID ELECTRIC VEHICLES
(Professional Elective - II)

M. TECH. I Year I Sem. (EPE)

Prerequisite: Power Systems, Electrical Machines and Power Electronics
Course Objectives: to prepare the students to
- understand upcoming technology of hybrid system
- understand different aspects of drives application
- learn the electric Traction

Course Outcomes: Students will be able to
- Acquire fundamental concepts and principles of hybrid electric vehicles (HEV)
- Design and analyse HEVs
- Apply electric drives in vehicles / traction
- Understand energy management in HEVs

UNIT-I: INTRODUCTION TO HYBRID ELECTRIC VEHICLES (HEV) History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization Transmission characteristics, Mathematical models to describe vehicle performance

UNIT-II: HYBRID TRACTION Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis.

UNIT-III: CONTROL OF MOTORS FOR HEV Introduction to electric components used in hybrid and electric Vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives configuration and control of Permanent Magnet Motor drives Configuration and control of Switch Reluctance, Motor drives, drive system efficiency

UNIT-IV: DESIGN OF HEV Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics Selecting the energy storage technology, Communications, supporting subsystems

UNIT-V: ENERGY MANAGEMENT IN HEV Introduction to energy management and their strategies used in hybrid and electric vehicle, Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies

TEXT BOOKS:
1. Sira -Ramirez, R. Silva Ortigoza, “Control Design Techniques in Power Electronics Devices”, Springer.
2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, “Sliding mode control of switching Power Converters”

REFERENCES:
1. NPTEL Course on Electric Vehicles, https://www.youtube.com/playlist?list=PLlYm0-AHZdZRLYSylFinxkspWmcgNvbtl
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design fundamentals, CRC Press, 2003.
3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and
4. Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
5. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

RESEARCH METHODOLOGY AND IPR

M. TECH. I Year I Sem. (EPE)

Prerequisite: None

Course Objectives:

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know the patent rights

Course Outcomes: At the end of this course, students will be able to

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

UNIT- I: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT- II: Effective literature studies approaches, analysis, Plagiarism, Research ethics

UNIT- III: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT- IV: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT- V: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction".

REFERENCES:

1. Ranjit Kumar, 2nd Edition , "Research Methodology: A Step by Step Guide for beginners"
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
3. Mayall , "Industrial Design", McGraw Hill, 1992.
4. Niebel , "Product Design", McGraw Hill, 1974.
5. Asimov , "Introduction to Design", Prentice Hall, 1962.
6. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
7. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

POWER SYSTEMS COMPUTATION LAB – I

(Lab - 1)

M. TECH. I Year I Sem. (EPE)

Prerequisite: power systems

Course Objectives: Students will be able to:

- Construction of Y-bus, z-bus for a n-bus system.
- Analyze various Load flow studies .
- Steady state, transient stability analysis.
- Economic load dispatch problem.
- Unitcommitment problem.
- State estimation of power system.

Course Outcomes: Students will be able to:

- Construct Y-bus and Z-bus
- Compare the different load flow methods
- Analyze the different stability analysis of variety of power systems
- Understood Economic load dispatch and Unit Commitment problems.
- Understood State estimation of power system.

List of Experiments

1. Develop Program for YBUS formation by direct inspection method.
2. Develop Program for YBUS formation by Singular Transformation method.
3. Develop Program for G-S Load Flow Algorithm.
4. Develop Program for N-R Load Flow Algorithm in Polar Coordinates.
5. Develop Program for FDLF Algorithm.
6. Develop Program for DC load Flow Algorithm.
7. Develop Program for ZBUS Building Algorithm.
8. Develop Simulation of Single Phase Full Converter with RLE Load
9. Develop Program model for Closed Loop Speed Control of Separately Excited D.C Motor.
10. Develop Program model for Sinusoidal Pulse Width Modulation.
11. Develop Simulation of RLC Circuit.
12. Develop Program for Transient Stability Analysis for Single Machine connected to Infinite Bus by Point by Point Method.

ADVANCED POWER SYSTEMS LAB
(Lab - 2)

M. TECH. I Year I Sem. (EPE)

Prerequisite: power systems and FACTS

Course Objectives: Students will be able to:
- Determine transmission line parameters
- Determine transmission line regulation and efficiency
- Determine various fault calculations
- Perform load and line compensation

Course Outcomes: Students will be able to:
- Calculate transmission line parameters
- Calculate transmission line regulation and efficiency
- Calculate various fault parameters
- Compare system parameters with and without compensation

List of Experiments
1. Determination of Line Parameters R, L and C.
2. Determination of T/L efficiency and Regulation for a given load.
3. Analysis of Ferranti effect on Transmission Lines under light loadings.
4. Determination of ABDC parameters of a given Transmission Line Network.
5. Fault Analysis:
6. I. Single Line to Ground fault (L-G). II. Line to Line fault (L-L).
   III. Double Line to Ground fault (L-L-G). IV. Triple Line to Ground fault (L-L-L-G).
7. Analysis of Uncompensated lines and their voltage profiles.
8. Shunt compensation of Transmission lines (Capacitor/Reactors)
9. Load Compensation analysis
10. Line Compensation using FACTS devices.
11. Analysis of Transmission lines under Surge Impedance Loading.
12. Determination of Sequence impedance of Transmission Line and SIL analysis.

DIGITAL PROTECTION OF POWER SYSTEM
(Professional Core - III)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Power System Protection
Course Objectives: to prepare the students to:
- Study numerical relays.
- Develop mathematical approach towards protection.
- Study algorithms for numerical protection.

Course Outcomes: Students will be able to:
- understand the importance of Digital Relays.
- apply mathematical approach towards protection.
- develop various protection algorithms.

UNIT-I: Mathematical Background to Digital Protection Overview of static relays, Transmission line protection, Transformer protection, Need for Digital protection. Performance and operational characteristics of Digital protection, Basic structure of Digital relays, Finite difference techniques, Interpolation formulas, Numerical differentiation, Curve fitting and smoothing, Fourier analysis, Walsh function analysis, Relationship between Fourier and Walsh coefficients.

UNIT-II: Basic Elements of Digital Protection Basic components of a digital relay, Signal conditioning subsystems, Conversion subsystem, Digital relay subsystem, The digital relay as a unit.

UNIT-III: Digital Relaying Algorithms-I Sinusoidal-Wave-Based algorithms: Sample and first-derivative methods, First and second-derivative methods, Two-sample technique, Three-sample technique, An early relaying scheme. Fourier analysis based algorithms: Full cycle window algorithm, Fractional-cycle window algorithms, Fourier-transform based algorithm. Walsh-function-based algorithms.

UNIT-IV: Digital Relaying Algorithms-II Least squares based methods: Integral LSQ fit, Power series LSQ fit, Multi-variable series LSQ technique, Determination of measured impedance estimates. Differential equation based techniques: Representation of transmission lines with capacitance neglected, Differential equation protection with selected limits, Simultaneous differential equation techniques.
Travelling-wave based protection: Fundamentals of Travelling-wave based protection, Bergeron's-equation based protection scheme, Ultra-high-speed polarity comparison scheme, Ultra-high-speed wave differential scheme, Discrimination function based scheme, superimposed component trajectory based scheme.

UNIT-V: Digital protection of Transformers and Transmission lines Principles of transformer protection, Digital protection of Transformer using: FIR filter based algorithm, Least squares curve fitting based algorithms, Fourier-based algorithm, and Flux-restrained current differential relay. Digital Line differential protection: Current-based differential schemes, Composite voltage- and current- based scheme.

TEXT BOOKS:

1. A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009.
2. A.T. Johns and S. K. Salman, "Digital Protection of Power Systems", IEEE Press, 1999.

REFERENCES:

1. Gerhard Zeigler, "Numerical Distance Protection", Siemens Publicis Corporate Publishing, 2006.
2. S.R.Bhide "Digital Power System Protection" PHI Learning Pvt.Ltd.2014.

POWER SYSTEM DYNAMICS
(Professional Core - IV)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Power Systems and Electrical Machines
Course Objectives: to prepare students to:
- Develop mathematical models for synchronous machine, Exciter, Governor and Prime mover.
- Study power system dynamic phenomena and the effects of exciter and governor control.
- Understand methods to improve dynamic stability.

Course Outcomes: Students will be able to:
- Understand the modeling of synchronous machine in details
- Understand the modeling of Exciter and Governor control
- Carry out simulation studies of power system dynamics using MATLAB-SIMULINK, MI-POWER
- Carry out stability analysis with and without power system stabilizer (PSS)

UNIT-I:POWER SYSTEM STABILITY: A CLASSICAL APPROACH Introduction, Requirements of a Reliable Electrical Power Service, Swing Equation, Power-Angle Curve, Stability analysis of SMIB system, Equal area criteria, Classical Model of a Multimachine System, Shortcomings of the Classical Model, Block Diagram of One Machine infinite bus system, System Response to Small Disturbances: Types of Problems Studied, The Unregulated Synchronous Machine, Modes of Oscillation of an Unregulated Multimachine System, Regulated Synchronous Machine.
UNIT-II: SYNCHRONOUS MACHINE MODELING-I Introduction, Park's Transformation, Flux Linkage Equations, Voltage Equations, Formulation of State- Space Equations, Current Formulation, Per Unit Conversion, Normalizing the Voltage and Torque Equations, Equivalent Circuit of a Synchronous Machine, The Flux Linkage State-Space Model, Load Equations, Sub-transient and Transient Inductances and Time Constants, Simplified Models of the Synchronous Machine, Turbine Generator Dynamic Models.

UNIT-III: SYNCHRONOUS MACHINE MODELING-II Steady state equations and phasor diagrams, Determining steady state conditions, Evaluation of Initial conditions, Determination of machine parameters, Digital simulation of Synchronous machines, Linearization and Simplified Linear model and state-space representation of simplified model.
UNIT-IV: EXCITATION AND PRIME MOVER CONTROL Simplified view of excitation control, control configurations, typical excitation configurations, excitation control system definitions, voltage regulator, exciter buildup, excitation system response, state-space description of the excitation system, computer representation of excitation systems, Typical system constants, and the effects of excitation on generator power limits, transient stability and dynamic stability of the power system, Prime mover control: Hydraulic turbines and governing systems, Steam turbines and governing systems.
UNIT-V: SMALL SIGNAL STABILITY ANALYSIS Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix, Small-signal stability of a single-machine infinite bus system, Effects of excitation system, Power system stabilizer, System state matrix with amortisseurs, Characteristics of small-signal stability problems.
TEXT BOOKS:
1. P. M. Anderson & A. A. Fouad “Power System Control and Stability”, Galgotia , New Delhi, 1981
2. J Machowski, J Bialek & J. R W. Bumby, “Power System Dynamics and Stability”, John Wiley & Sons, 1997

REFERENCES:
1. P.Kundur, “Power System Stability and Control”, McGraw Hill Inc., 1994.
2. E.W. Kimbark, “Power system stability”, Vol. I & III, John Wiley & Sons, New York 2002
3. L. Leonard Grigsby (Ed.); “Power System Stability and Control”, 2nd edition, CRC Press, 2007
4. NPTEL online course, Prof. A. M. Kulkarni, Power System Dynamics and Control, https://www.youtube.com/playlist?list=PLuv3GM6-gsE2WXbxLSnqKHf5gcnedXCZH

RESTRUCTURED POWER SYSTEMS
(Professional Elective - III)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Power Systems
Course Objectives: to prepare students to

- Understand restructuring of the electricity market
- Understand deregulation of the electricity market
- Understand the money, power & information flow in a deregulated power system

Course Outcomes: Students will be able to

- Know about various types of regulations in power systems.
- Identify the need of regulation and deregulation.
- Understand technical and Non-technical issues in deregulated Power Industry.
- Identify existing electricity markets.
- Classify different market mechanisms and summarize the role of various entities in the market.

UNIT-I: Fundamentals of restructured system, Market architecture, Load elasticity, Social welfare maximization.

UNIT-II: Optimal power flow (OPF): Role in vertically integrated systems and in restructured markets, congestion management.

UNIT-III: Optimal bidding, Risk assessment, Hedging,Transmission pricing,Tracing of power

UNIT-IV: Ancillary services, Standard market design, Distributed generation in restructured markets, renewable energy markets

UNIT-V: Developments in India, IT applications in restructured markets, Working of restructured power systems, Pennsylvania-New Jersey-Maryland Interconnection (PJM) market, Recent trends in Restructuring

TEXT BOOKS:

1. Lorrin Philipson, H. Lee Willis, “Understanding electric utilities and de-regulation”, Marcel Dekker Pub.,1998.
2. Steven Stoft, “Power system economics: designing markets for electricity”, John Wiley and Sons, 2002.

REFERENCES:

1. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, “Operation of restructured power systems”, Kluwer Academic Pub., 2001.
2. Mohammad Shahidehpour, MuwaffaqAlomoush, “Restructured electrical power systems: operation, trading and volatility”, Marcel Dekker.

EHV AC TRANSMISSION
(Professional Elective – III)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Power Systems

Course objectives: to prepare the students to

- identify the different aspects of Extra High Voltage AC Transmission design and analysis
- understand the importance of modern developments of EHV and UHV transmission systems.
- demonstrate EHV AC transmission system components, protection and insulation level for over voltages.

Course Outcomes: Upon the completion of this course, the student will be able to

- Understand the importance of EHV AC transmission
- estimate choice of voltage for transmission, line losses and power handling capability of EHV Transmission.
- apply statistical procedures for line designs, scientific and engineering principles in power systems.

UNIT- I: Extra high voltage (EHV) AC. Transmission line trends and preliminary aspect standard transmission voltages – Estimation at line and ground parameters-Bundle conductor systems-Inductance and Capacitance of EHV lines – positive, negative and zero sequence impedance – Line Parameters for Modes of Propagation.

UNIT- II: Electrostatic field and voltage gradients – calculations of electrostatic field of AC lines – effect of high electrostatic field on biological organisms and human beings - surface voltage gradients and maximum gradients of actual transmission lines – voltage gradients on sub conductor.

UNIT- III:

Electrostatic induction in unenergized lines – measurement of field and voltage gradients for three phase single and double circuit lines – unenergized lines. Power Frequency Voltage control and over- voltages in EHV lines: No load voltage – charging currents at power frequency-voltage control – shunt and series compensation – static VAR compensation.

UNIT - IV: Corona in EHV lines – Corona loss formulae- attention of traveling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits. Measurements of audio noise radio interference due to Corona - properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV.

UNIT- V: Design of EHV lines based on steady state and transient limits - EHV cables and their characteristics.

TEXT BOOKS:

1. R. D. Begamudre, “EHVAC Transmission Engineering”, New Age International (p) Ltd. 3rd Edition.
2. K. R. Padiyar, “HVDC Power Transmission Systems” New Age International (p) Ltd. 2nd revised Ed, 2012.

REFERENCES:

1. S. Rao “EHVAC and HVDC Transmission Engineering. Practice” Khanna publishers.
2. Arrillaga. J “High Voltage Direct Current Transmission” 2nd Ed (London) Peter Peregrines, IEE, 1998.
3. Padiyar. K. R, “FACTS Controllers in Power Transmission and Distribution” New Age International Publishers, 2007.
4. Hingorani H G and Gyugyi. L “Understanding FACTS-Concepts and Technology of Flexible AC Transmission Systems” New York, IEEE Press, 2000.
5. Advances in UHV Transmission and Distribution, online course https://www.youtube.com/channel/UCWKPXSjLRz-TAFgFWCfMmGg/videos

SWARM INTELLIGENCE TECHNIQUES IN POWER SYSTEMS
(Professional Elective - III)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Artificial Intelligence techniques in power systems

Course Objectives: to prepare students to:

- Understand evolutionary algorithms like GA,PSO, ANT COLONY and BEE COLONY etc.
- Apply evolutionary algorithms to solve power systems problems
- understand solution of Multi-Objective optimization using these algorithms

Course Outcomes: Upon the completion of this course, the student will be able to

- Discriminate the capabilities of bio-inspired system and conventional methods in solving optimization problems.
- Examine the importance of exploration and exploitation of swarm intelligent system to attain near global optimal solution.
- Distinguish the functioning of various swarm intelligent systems.
- Employ various bio-inspired algorithms for power systems engineering applications.

UNIT-I: FUNDAMENTALS OF SOFT COMPUTING TECHNIQUES Definition-classification of optimization problems-unconstrained and constrained optimization optimality conditions-Introduction to intelligent systems-soft computing techniques-conventional computing versus swarm computing-classification of meta-heuristic techniques-single solution based and population based algorithms-exploitation and exploration in population based algorithms-Properties of Swarm intelligent Systems-application domain-Discrete and continuous problems-single objective and multi-objective problems.

UNIT-II: GENETIC ALGORITHM AND PARTICLE SWARM OPTIMIZATION Genetic algorithms-Genetic algorithm versus Conventional Optimization Techniques-Genetic representations and selection mechanisms: Genetic operators-different types of crossover and mutation operators-Bird flocking and Fish Schooling-anatomy of a particle-equations based on velocity and positions-PSO topologies-control parameters-GA and PSO algorithms for solving ELD problems.

UNIT-III: ANT COLONY OPTIMIZATION and ARTIFICIAL BEE COLONY ALGORITHMS Biological ant colony system-Artificial ants and assumptions –Stigmergic communications-pheromone updating-local-global-pheromone evaporation-ant colony system-ACO models-Touring ant colony system-max min ant system-concept of elastic ants-Task partitioning in honey bees-Balancing foragers and receivers-Artificial bee colony (ABC) algorithms-binary ABC algorithms-ACO and ABC algorithms for solving Economic Dispatch of thermal units.

UNIT-IV: SHUFFLED FROG-LEAPING ALGORITHM and BAT OPTIMIZATION ALGORITHM Bat algorithm-Echolocation of bats-Behaviour of micro bats-Acoustics of echolocation-Movement of Virtual bats-Loudness and pulse Emission-Shuffled frog algorithm-virtual population of frogs- comparison of memes and genes-memeplex formation-memeplex updation-BA and SFLA algorithms for solving ELD and optimal placement and sizing of the DG problem.

UNIT-V: MULTI OBJECTIVE OPTIMIZATION Multi-Objective optimization introduction-concept of pareto optimality-Non-dominant sorting technique- pareto fronts-best compromise solution-min-max method-NSGA-II algorithm and applications to power systems

TEXT BOOKS:

1. Xin-She Yang, 'Recent Advances in Swarm Intelligence and Evolutionary Computation' Springer International Publishing, Switzerland, 2015.

2. Kalyanmoy Deb 'Multi-Objective Optimization using Evolutionary Algorithms', John Wiley & Sons, 2001.

REFERENCES:

1. James Kennedy and Russel E Eberheart, 'Swarm Intelligence', The Morgan Kaufmann Series in Evolutionary Computation, 2001.
2. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, 'Swarm Intelligence-From natural to Artificial Systems', Oxford university Press, 1999.
3. David Goldberg, 'Genetic Algorithms in Search, Optimization and Machine Learning', Pearson Education, 2007.
4. Konstantinos E. Parsopoulos and Michael N. Vrahatis, ' Particle Swarm Optimization and Intelligence: Advances and Applications', Information Science reference, IGI Global, 2010.
5. N P Padhy, 'Artificial Intelligence and Intelligent Systems', Oxford University Press, 2005.

REFERENCE PAPERS:

1. "Shuffled frog-leaping algorithm: a memetic meta-heuristic for discrete optimization" by Muzaffar eusuff, Kevin lansey and Fayzul pasha, Engineering Optimization, Taylor & Francis, Vol. 38, No. 2, pp.129-154, March 2006.
2. "A New Metaheuristic Bat-Inspired Algorithm" by Xin-She Yang, Nature Inspired Cooperative Strategies for Optimization (NISCO 2010) (Eds. J.R. Gonzalez et al.), Studies in Computational Intelligence, Springer Berlin, 284, Springer, 65-74 (2010).
3. "Firefly Algorithms for Multimodal Optimization" Xin-She Yang, O. Watanabe and T. Zeugmann (Eds.), Springer-Verlag Berlin Heidelberg, pp. 169-178, 2009.

INDUSTRIAL LOAD MODELLING AND CONTROL
(Professional Elective - III)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Power Systems
Course Objectives: to prepare the students to
- understand the energy demand scenario
- model the industrial loads and study load demand
- Study reactive power management in Industries

Course Outcomes: Students will be able to
- gain knowledge about load control techniques in industries and its application.
- understand different types of industrial processes and optimize the process
- apply load management to reduce demand of electricity during peak time
- apply different energy saving opportunities in industries.

UNIT-I: INTRODUCTION TO INDUSTRIAL LOAD MODELING Electric Energy Scenario-Demand Side Management-Industrial Load Management. Load Curves-Load Shaping Objectives-Methodologies. Barriers; Classification of Industrial Loads- Continuous and Batch processes -Load Modeling.

UNIT-II: LOAD CONTROL METHODS Direct load control- Interruptible load control. Bottom up approach- scheduling- Formulation of load models- Optimization and control algorithms - Case studies. Reactive power management in industries- controls-power quality impacts, application of filters, Energy saving in industries.

UNIT-III: COOLING AND HEATING load profiling- Modeling. Cool storage-Types- Control strategies. Optimal operation-Problem formulation- Case studies.

UNIT-IV: CAPTIVE POWER MANAGEMENT Captive power units- Operating and control strategies- Power Pooling- Operation models. Energy banking-Industrial Cogeneration

UNIT-V: OPTIMAL OPERATING STRATEGIES Selection of Schemes Optimal Operating Strategies. Peak load saving-Constraints-Problem formulation Case study. Integrated Load management for Industries

TEXT BOOKS:
1. C.O. Bjork “Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands,1989.
2. C.W. Gellings and S.N. Talukdar, “Load management concepts,” IEEE Press, New York, 1986, pp. 3-28.

REFERENCES:
1. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981.
2. H. G. Stoll, "Least cost Electricity Utility Planning”, Wiley Interscience Publication, USA, 1989.
3. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, New Delhi, 1995.
4. IEEE Bronze Book- “Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities”, IEEE Inc, USA.

AI TECHNIQUES IN POWER SYSTEMS
(Professional Elective - IV)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Power System Analysis
Course Objectives: to prepare students to

- Understand fuzzy logic, artificial neural network (ANN)
- Understand genetic algorithm (GA) & evolutionary programming (EP)

Course Outcomes: Students will be able to

- Learn the concepts of biological foundations of artificial neural networks
- Learn Feedback networks and radial basis function networks and fuzzy logics
- Identifications of fuzzy and neural network
- Acquire the knowledge of GA

UNIT-I: Biological foundations to intelligent Systems, Artificial Neural Networks, Single layer and Multilayer Feed Forward NN, LMS and Back Propagation Algorithm, Feedback networks and Radial Basis Function Networks.

UNIT-II: Fuzzy Logic, Knowledge Representation and Inference Mechanism, Defuzzification Methods. Fuzzy Neural Networks and their learning methods

UNIT-III: System Identification using Fuzzy and Neural Network.

UNIT-IV: Genetic algorithm, Reproduction cross over, mutation, Introduction to evolutionary program.

UNIT-V: Applications of above mentioned techniques to practical problems on power engineering

TEXT BOOKS:

1. J M Zurada , “An Introduction to ANN”, Jaico Publishing House
2. Simon Haykins, “Neural Networks”, Prentice Hall

REFERENCES:

1. Timothy Ross, “Fuzzy Logic with Engg. Applications”, McGraw. Hill
2. Driankov, Dimitra, “An Introduction to Fuzzy Control”, Narosa Publication
3. Golding, “Genetic Algorithms”, Addison-Wesley Publishing Co.
4. NPTEL Course on “Introduction to Soft Computing” by Prof. Debasis Samanta, https://www.youtube.com/playlist?list=PLJ5C_6qdAvBFqAYS0P9INAogIMklG8E-9
5. NPTEL Course on Neural Networks and Applications, https://www.youtube.com/playlist?list=PL53BE265CE4A6C056

POWER QUALITY
(Professional Elective - IV)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Power Systems and Power Electronics

Course Objectives: to prepare students to

- know different terms of power quality.
- illustrate power quality issues for short and long interruptions.
- construct study of characterization of voltage sag magnitude and three phase unbalanced voltage sag.
- know the behavior of power electronics loads, induction motors, synchronous motor etc. by the power quality issues
- know mitigation of power quality problems by using VSI converters.

Course Outcomes: Upon the completion of this course, the student will be able to

- Know the severity of power quality problems in distribution system;
- Understand the concept of voltage sag transformation from up-stream (higher voltages) to down-stream (lower voltage)
- Compute the power quality improvement by using various mitigating custom power devices.

UNIT- I: INTRODUCTION Introduction of the Power Quality (PQ) problem: Terms used in PQ - Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

UNIT- II: LONG & SHORT INTERRUPTIONS Interruptions – Definition – Difference between failures, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

Short interruptions: definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

UNIT - III: SINGLE-PHASE & THREE-PHASE VOLTAGE SAG CHARACTERIZATION Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration. Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

UNIT-IV: POWER QUALITY CONSIDERATIONS IN INDUSTRIAL POWER SYSTEMS Voltage sag – equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

UNIT-V: MITIGATION OF INTERRUPTIONS & VOLTAGE SAGS

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

Power Quality and EMC Standards: Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

TEXT BOOKS:

1. Math H J Bollen “Understanding Power Quality Problems”, IEEE Press.
2. R.C. Dugan, M.F. McGranaghan and H.W. Beaty, “Electric Power Systems Quality.” New York: McGraw-Hill.1996

REFERENCES:

1. G.T. Heydt, ‘Electric Power Quality’, 2nd Edition. (West Lafayette, IN, Stars in a Circle Publications, 1994).
2. Power Quality VAR Compensation in Power Systems, R. Sastry Vedam Mulukutla S. Sarma, CRC Press.
3. A Ghosh, G. Ledwich, Power Quality Enhancement Using Custom Power Devices. Kluwer Academic, 2002

POWER APPARATUS DESIGN
(Professional Elective - IV)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Electrical Machines
Course Objectives: to prepare the students to
- design and model AC and DC rotating machines
- Learn electromagnetic energy conversion
- know about rating of machines

Course Outcomes: Students will be able to
- give a systematic approach for design, modeling and analysis of rotating machines
- design and model special machines.

UNIT-I: Principles of Design of Machines -Specific loadings, choice of magnetic and electric loadings,Real and apparent flux densities, temperature rise calculation, Separation of main dimension for DC machines, Induction machines and synchronous machines, Design of Transformers-General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling.

UNIT-II: Specific loadings, choice of magnetic and electric loadings Real and apparent flux -densities, temperature rise calculation,Separation of main dimension for DC machines,Induction machines and synchronous machines,Heating and cooling of machines, types of ventilation, continuous and intermittent rating.

UNIT-III: General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling tubes,Calculation of losses, efficiency and regulation, Forces winding during short circuit.

UNIT-IV: General considerations, output equation, Choice of specific electric and magnetic loadings, efficiency, power factor, Number of slots in stator and rotor,Elimination of harmonic torques.

UNIT-V: Design of stator and rotor winding, slot leakage flux, Leakage reactance, equivalent resistance of squirrel cage rotor, Magnetizing current, efficiency from design data. Types of alternators, comparison, specific loadings, output co-efficient, design of main dimensions Introduction to Computer Aided Electrical Machine Design Energy efficient machines.

TEXT BOOKS:

1. Clayton A.E, “The Performance and Design of D.C. Machines”, Sir I. Pitman & sons, Ltd.
2. M.G. Say, “The Performance and Design of A.C. Machines “, Pitman

REFERENCES:

1. Sawhney A.K, “A course in Electrical Machine Design”, Dhanpat Rai & Sons, 5th Edition

POWER SYSTEM RELIABILITY AND PLANNING
(Professional Elective - IV)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Reliability Engineering
Course Objectives: to prepare the students to:
- describe the generation system model and recursive relation for capacitive model building
- explain the equivalent transitional rates, cumulative probability and cumulative frequency
- develop the understanding of risk, system and load point reliability indices
- explain the basic and performance reliability indices

Course Outcomes: the student will be able to:
- Understand the importance of maintaining reliability of power system components.
- Apply the probabilistic methods for evaluating the reliability of generation and transmission systems.
- Assess the different models of system components in reliability studies.
- Assess the reliability of single area and multi area systems.

UNIT-I: Basic Reliability Concepts: The general reliability function, exponential distribution – Mean time to failures – series and parallel systems. Markov process – continuous Markov process – Recursive techniques – Simple series and parallel system models.

UNIT-II: Generating Capacity – Basic Probability Methods: The generation system model – Loss of load indices – Capacity expansion analysis – scheduled outages. Load forecast uncertainty Loss of energy indices. The frequency and duration method.

UNIT-III: Transmission Systems Reliability Evaluation: Radial configuration – Conditional probability approach – Network configurations – State selection.

UNIT-IV: Generation Planning: Comparative economic assessment of individual generation projects – Investigation and simulation models – Heuristic and linear programming models – Probabilistic generator and load models.

UNIT-V: Transmission and Distribution Planning: Deterministic contingency analysis – Probabilistic transmission system – reliability analysis. Reliability calculations for single area and multi–area power systems. Network configuration design–consisting of schemes – security criteria configuration synthesis.

TEXT BOOKS:

1. Roy Billinton and Ronald Allan Pitam: Reliability Evaluation of Power Systems,1996.
2. R.L. Sullivan: Power System Planning, McGraw Hill International, 1977.

REFERENCES:

1. Wheel Wright and Makridakis: Forecasting methods and Applications, John Wiley, 1992.
2. J. Endremyl: Reliability Modelling in Electric Power Systems, John Wiley, 2005.
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POWER SYSTEMS COMPUTATION LAB – II
(Lab - III)

M. TECH. I Year II Sem. (EPE)

Prerequisite: power systems and Artificial Neural Networks

Course Objectives: Students will be able to:
- Known Neural network tool box
- Know the various Evolutionary Algorithms
- Apply various Evolutionary Algorithms to power system problems

Course Outcomes: At the end of the course the student will be able to:
- Understood Neural network and fuzzy logic tool box
- Understood various Evolutionary Algorithms
- Solved power system problems by applying various Evolutionary Algorithms

List of Experiments
1. Develop Program for Generation System Reliability Analysis.
2. Develop Program for Distribution System Reliability Analysis.
3. Develop Program for Economic Load Dispatch Problem using Lambda Iterative Method.
4. Develop Program for Unit Commitment Problem using Forward Dynamic Programming Method.
5. Develop Program for State Estimation of Power System.
6. Load Flow analysis using Neural Network
7. State Estimations using Neural Network
8. Contingency Analysis using Neural Network.
9. Fuzzy Logic based AGC – Single area system – Two area system
10. Fuzzy Logic based small signal stability analysis
11. Economic Dispatch of Thermal Units using ANN
12. Economic Dispatch of Thermal Units using GA
13. Optimal location and sizing of capacitor in distribution system using PSO
14. Optimal Reactive power dispatch using PSO

POWER SYSTEM PROTECTION LAB
(Lab - IV)

M. TECH. I Year II Sem. (EPE)

Prerequisite: Power systems protection

Course Objectives: Upon successful completion of the lab students will be familiar with:
- Different types of Faults occurring in power systems
- Characteristics of different types of relays
- Protection schemes

Course Outcomes: At the end of the course, the student should be able to:
- Calculate various faults
- Analyze the various time-current characteristics of protective relays
- Know the Performance and Testing of various electrical models and systems

List of Experiments
1. Characteristics of IDMT over current relay.
2. Characteristics of IDMT over voltage relay
3. Characteristics of IDMT under voltage relay
4. Characteristics of Microprocessor over voltage relay
5. Characteristics of Microprocessor under voltage relay
6. Characteristics of Microprocessor over current relay
7. Characteristics of percentage biased differential relay
8. Characteristics of negative and zero sequence relay
9. Differential protection on Single Phase Transformer
10. Performance and Testing of Feeder Protection System
11. Performance and Testing of Transmission Line Model.
12. Fault Analysis :
    a) Single-Line to Ground fault(L-G)
    b) Line to Line(L-L)
    c) Double Line to Ground fault (L-L-G)
    d) Triple Line to Ground fault (L-L-L-G)

NOTE: From the above list minimum 10 experiments are to be conducted