M.TECH –ELECTRICAL POWER SYSTEMS
(Applicable for the Batch admitted from the Academic Year 2023-24 onwards)
(R23) COURSE STRUCTURE AND SYLLABUS

I YEAR I SEMESTER

Sr.No	Core/Elective	Course Name	L	T	P	Credits
1.	Program Core-I	Advanced Power System Analysis	3	0	0	3
2.	Program Core-II	Economic Operation of Power Systems	3	0	0	3
3.	Program Elective-I	Advanced Power Electronic Converters Renewable Energy Technologies Smart Grid Technologies Modern Control Theory	3	0	0	3
4.	Program Elective-II	HVDC Transmission Electrical Power Distribution System Reactive Power Compensation and Management Electric Vehicles and Design	3	0	0	3
5.	MC	Research Methodology & IPR	2	0	0	2
6.	Lab-I	Power Systems Computation Lab-I	0	0	4	2
7.	Lab-II	Advanced Power Systems Lab	0	0	4	2
8.	Audit-I	Audit Course-I	2	0	0	0
		Total Credits	**16**	**0**	**8**	**18**

I YEAR II SEMESTER

Sr.No	Core/Elective	Course Name	L	T	P	Credits
1.	Program Core-III	Digital Protection of Power System	3	0	0	3
2.	Program Core-IV	Power System Dynamics	3	0	0	3
3.	Program Elective-III	Restructured Power Systems Power Quality Improvement Techniques EHV AC Transmission Swarm Intelligence Techniques in Power Systems	3	0	0	3
4.	Program Elective-IV	AI Techniques in Power Systems Electric Vehicle Charging Techniques Power System Reliability and Planning Industrial Load Modelling and Control	3	0	0	3
5.	MPWS	Mini Project with Seminar	0	0	4	2
6.	Lab-III	Power Systems Computation Lab-II	0	0	4	2
7.	Lab-IV	Power System Protection Lab	0	0	4	2
8.	Audit-II	Audit Course-II	2	0	0	0
		Total Credits	**14**	**0**	**12**	**18**

II YEAR I SEMESTER

			L	T	P	Credits
Sr.No	**Core/Elective**	**Course Name**				
1.	Program Elective-V	Power System Transients FACTS and custom Power Devices Gas Insulated Systems SCADA System and Applications	3	0	0	3
2.	Open Elective	Photovoltaic Systems	3	0	0	3
3.	Dissertation	Dissertation Stage-I	0	0	12	6
		Total Credits	**6**	**0**	**12**	**12**

II YEAR II SEMESTER

IV Semester			L	T	P	Credits
Sr.No	**Core/Elective**	**Course Name**				
1.	Dissertation	Dissertation Stage-II	0	0	12	6
2.	Dissertation	Dissertation Viva-Voce	0	0	28	14
		Total Credits	**0**	**0**	**40**	**20**

Open Elective

1. Photovoltaic Systems (Offered by **EEE** Department)

Audit Course I & II

1. English for Research Paper Writing.
2. Disaster Management.
3. Value Education.
4. Pedagogy Studies.

M. Tech – I Semester

L	T	P	C
3	0	0	3

ADVANCED POWER SYSTEM ANALYSIS

(Program Core-I)

Prerequisite: Computer Methods in Power Systems

Course Objectives:

- To build the Nodal admittance and Nodal impedance matrices of a practical network.
- To study various methods of load flow and their advantages and disadvantages.
- To understand how to analyze various types of faults in power system.
- To understand power system security concepts and study the methods to rank the contingencies.
- To understand need of state estimation and study simple algorithms for state estimation.

Course Outcomes: After completion of the course, students will be able to:

CO1. Build/construct YBUS and ZBUS of any practical network.

CO2. Calculate voltage phasors at all buses, given the data using various methods of load flow.

CO3. Calculate fault currents in each phase.

CO4. Rank various contingencies according to their severity.

CO5. Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps, CB status etc.

UNIT-I:

NETWORK MATRICES

Introduction, 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-Seidel, Newton-Raphson, Fast decoupled load flow methods, 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, Equivalent circuits, Selection of circuit breakers, 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.

TEXTBOOKS:

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.

M. Tech – I Semester

L	T	P	C
3	0	0	3

ECONOMIC OPERATION OF POWER SYSTEMS

(Program Core-II)

Prerequisite: Electrical Power Systems

Course Objectives:

- To formulate and derive the necessary conditions for economical load scheduling problem.
- To understand various constraints, problem formulation and methods to solve the unit commitment problem.
- To understand the constraints related to hydel power plants, problem formulation and solutiontechniques for hydro-thermal scheduling problem.
- To understand the necessity, factors governing the frequency control and analyze the uncontrolledand controlled LFC system.
- To understand the basic difference between ELS and OPF problem, formulation of the OPFproblem and solution techniques.

Course Outcomes: After completion of the course, students will be able to:

CO1. Solve the economic load scheduling with and without network losses both in classical method anditerative methods.
CO2. Solve the unit commitment problem using priority-list method and forward-dynamic method.
CO3. Solve hydro-thermal scheduling problem for short-term and long-term range.
CO4. Analyze the single area and two area systems for frequency deviation under sudden change inload.
CO5. 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 considered.

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) and its 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.

TEXTBOOKS:

1. J.J. Grainger & W.D.Stevenson, "Power system analysis", McGraw Hill, 2003.
2. Allen J. Wood,Bruce F.Wollenberg, Gerald B. Sheblé, "Power Generation Operation and Control"Wiley-Interscience, 2013.

REFERENCES:

1. Olle l. Elgerd, "Electric Energy Systems Theory an Introduction", TMH, 2nd Edition, 1983.

M. Tech – I Semester

L	T	P	C
3	0	0	3

ADVANCED POWER ELECTRONIC CONVERTERS
(Program Elective-I.1)

Prerequisite: Power Electronics, Power Electronic Converters

Course Objectives:
- To understand various advanced power electronics devices.
- To describe the operation of multi-level inverters with switching strategies for high power applications.
- To comprehend the design of resonant converters and switched mode power supplies.

Course Outcomes: After completion of the course, students will be able to:
CO1. Develop and analyze various converter topologies.
CO2. Design AC or DC switched mode power supplies.

UNIT-I:
MODERN POWER SEMICONDUCTOR DEVICES
Modern power semiconductor devices – Insulated Gate Bipolar Transistor (IGBT) –MOSFET- MOS Turn off Thyristor (MTO) – Emitter Turn Off Thyristor (ETO) – Integrated Gate-Commutated Thyristor (IGCTs) – MOS- controlled thyristors (MCTs)– Power integrated circuits (PICs) – symbol, structure and equivalent circuit – comparison of their features.
.
UNIT-II:
RESONANT PULSE INVERTERS
Resonant pulse inverters – series resonant inverters – series resonant inverters with unidirectional switches – series resonant inverters with bidirectional switches – analysis of half bridge resonant inverter – evaluation of currents and voltages of a simple resonant inverter – analysis of half bridge and full bridge resonant inverter with bidirectional switches – Frequency response of series resonant inverters – for series loaded inverter – for parallel loaded inverter – For series and parallel loaded inverters – parallel resonant inverters – Voltage control of resonant inverters – class E resonant inverter – class E resonant rectifier – evaluation of values of *C*'s and *L's* for class E inverter and Class E rectifier – numerical problems.

UNIT-III:
RESONANT CONVERTERS
Resonant converters – zero current switching resonant converters – L type ZCS resonant converter – M type ZCS resonant converter – zero voltage switching resonant converters – comparison between ZCS and ZVS resonant converters – Two quadrant ZVS resonant converters – resonant dc-link inverters – evaluation of L and C for a zero current switching inverter – Numerical problems.

UNIT-IV:
MULTILEVEL INVERTERS

Multilevel concept – Classification of multilevel inverters – Diode clamped Multilevel inverter – principle of operation – main features – improved diode Clamped inverter – principle of operation – Flying capacitors multilevel inverter-principle of operation – main features – cascaded multilevel inverter – principle of operation – main features
– Multilevel inverter applications – reactive power compensation – back to back intertie system – adjustable drives -Switching device currents – dc link capacitor voltage balancing – features of Multilevel inverters – comparisons of multilevel converters.

UNIT-V:
D.C & A.C POWER SUPPLIES

DC power supplies – classification - switched mode dc power supplies – fly back Converter – forward converter – push-pull converter – half bridge converter – Full bridge converter – Resonant d c power supplies – bidirectional power supplies – Applications.
AC power supplies – classification – switched mode ac power supplies – Resonant AC power supplies – bidirectional ac power supplies – multistage conversions – control circuits – applications. Introduction – power line disturbances – power conditioners – Uninterruptible Power supplies – applications.

TEXTBOOKS:

1. Mohammed H. Rashid – "Power Electronics"– Pearson Education-Third Edition – first Indian reprint -2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins- "Power Electronics"– John Wiley & Sons –Second Edition.

REFERENCES:

1. Milliman Shepherd and Lizang – "Power converters circuits" – Chapter 14 (Matrix converter) PP- 415-444,
2. M.H.Rashid - Power electronics hand book –
3. Marian P. Kaźmierkowski, Ramu Krishnan, Frede Blabjerg Edition:" Control in power electronics"
4. illustrated Published by Academic Press, 2002.
5. NPTEL online course, "Pulse width Modulation for Power Electronic Converters" Dr.G.Narayanan, https://www.youtube.com/playlist?list=PLbMVogVj5nJQoZqyLxx-cg_dYE-Dt2UMH

M. Tech – I Semester

L	T	P	C
3	0	0	3

RENEWABLE ENERGY TECHNOLOGIES
(Program Elective-I.2)

Prerequisite: Power Systems and Electrical Machines

Course Objectives:
- To learn various renewable energy sources
- To gain understanding of integrated operation of renewable energy sources
- To understand Power Electronics Interface with the Grid.

Course Outcomes: After completion of the course, students will be able to:

CO1. Gain knowledge about renewable energy

CO2. Understand the working of distributed generation system in autonomous/grid connected modes

UNIT- I:
SOLAR ENERGY SYSTEMS:
Introduction to 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.

TEXTBOOKS:

1. D.P.Kothari, K.C.Singal, R.Ranjan, "Renewable Energy Resources and emerging technologies",PHI 2nd Edition, 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, NewDelhi, 2000.
4. Rakosh das Begamudre, "Energy conversion systems", New Age International publishers, NewDelhi, 2000.
5. John Twidell and Tony Weir, "Renewable Energy Resources", 2nd Edition, Fspon & Co.

REFERENCES:

1. Volker Quaschning, "Understanding Renewable Energy Systems", 2005, UK.
2. Faner Lin Luo Honer Ye, "Renewable Energy Systems Advanced Conversion Technologies & Applications", CRC press, Taylor & Francis group.

M. Tech – I Semester

L	T	P	C
3	0	0	3

SMART GRID TECHNOLOGIES
(Program Elective-I.3**)**

Prerequisite: Power Systems

Course Objectives:
- To understand concept of smart grid and its advantages over conventional grid
- To know smart metering techniques
- To learn wide area measurement techniques
- To understand the problems associated with integration of distributed generation & its solution through smart grid.

Course Outcomes: After completion of the course, students will be able to:

CO1. Appreciate the difference between smart grid & conventional grid
CO2. Apply smart metering concepts to industrial and commercial installations
CO3. Formulate solutions in the areas of smart substations, distributed generation and wide area measurements
CO4. Come up with 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:
Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation.

UNIT-III:
Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).

UNIT-IV:
Concept of micro-grid, Need& applications of micro-grid, Formation of micro-grid, Issues of interconnection, Protection & control of micro-grid, Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, Fuel-cells, micro-turbines, Captive power plants, Integration of renewable energy sources.

UNIT-V:
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. Advanced Metering Infrastructure (AMI) and Various Communication means and IP based Protocols.

TEXTBOOKS:

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", CRCPress, 2009.

REFERENCES:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, "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.

M. Tech – I Semester

L	T	P	C
3	0	0	3

MODERN CONTROL THEORY
(Program Elective-I.4**)**

Prerequisite: 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.

Course Outcomes: After completion of the course, students will be able to:

CO1. Know various terms of basic and modern control system for the real time analysis and design of control systems.
CO2. Perform state variables analysis for any real time system.
CO3. Examine a system for its stability, controllability and observability.
CO4. Implement basic principles and techniques in designing linear control systems.
CO5. 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.

UNIT III:
STATE FEEDBACK CONTROLLERS AND OBSERVERS

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

UNIT IV:
NON-LINEAR SYSTEMS

Introduction to 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 V:
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.

TEXTBOOKS:

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, 3rd Edition.
2. Donald E.Kirk, "Optimal Control Theory an Introduction", Prentice Hall Network series, 1st Edition.

M. Tech – I Semester

L	T	P	C
3	0	0	3

HVDC TRANSMISSION
(Program Elective-II.1**)**

Prerequisite: Power Systems and Power Electronics

Course Objectives:
- To understand the state-of-the-art HVDC technology.
- To learn the methods to carry out modeling and analysis of HVDC system frontier-area powerflow regulation.

Course Outcomes: After completion of the course, students will be able to:

CO1. Expose to the basics of HVDC technology.
CO2. Gain Knowledge of modelling and analysis of HVDC system for inter-area power flow regulation.
CO3. Analyze the converter and dc grid faults and methods to mitigate them.
CO4. Understand the HVDC converter reactive power requirements and identifying the necessary meansto address those 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 & AC-DC POWER FLOW ANALYSIS

Smoothing reactor and DC Lines, Reactive power requirements, Harmonic analysis, Filter design. Power flow Analysis in AC/DC systems, Modelling of DC links, Solutions of AC-DC Power flow.

TEXTBOOKS:

1. J. Arrillaga, "High Voltage Direct Transmission", Peter Peregrinus Ltd. London, 1983.
2. K. R. Padiyar, "HVDC Power Transmission Systems", Wiley Eastern Ltd., 1990.

REFERENCES:

1. E. W. Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, 1971.
2. Erich Uhlmann, "Power Transmission by Direct Current", B.S. Publications, 2004.
3. SN.Singh, "Electric Power Generation, Transmission and Distribution, PHI, New Delhi, 2nd Edition, 2008.
4. V. Kamaraju, "HVDC Transmission", Tata McGraw-Hill Education Pvt Ltd, New Delhi, 2011.

M. Tech – I Semester

L	T	P	C
3	0	0	3

ELECTRICAL POWER DISTRIBUTION SYSTEM
(Program Elective-II.2**)**

Prerequisite: Power Systems

Course Objectives:
- To learn about power distribution system
- To learn of SCADA system
- To understand distribution automation

Course Outcomes: After completion of the course, students will be able to:
CO1. Gain knowledge of power distribution system
CO2. Study the distribution automation and its application in practice
CO3. Learn SCADA system

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

UNIT-II:
Advantages of Distribution Management System (D.M.S.), Distribution Automation: Definition, Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints, Power Factor Correction.

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

TEXTBOOKS:
1. A.S. Pabla, "Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., 4th Edition.
2. M.K. Khedkar, G.M. Dhole, "A Text Book of Electrical Power Distribution Automation", University Science Press, New Delhi.

REFERENCES:
1. Anthony J Panseni, "Electrical Distribution Engineering", CRC Press.
2. James Momoh, "Electric Power Distribution automation protection & control", CRC Press.

M. Tech – I Semester

L	T	P	C
3	0	0	3

REACTIVE POWER COMPENSATION AND MANAGEMENT
(Program Elective-II.3**)**

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: After completion of the course, students will be able to:
CO1. Distinguish the importance of load compensation in symmetrical as well as unsymmetrical loads
CO2. Work out on various compensation methods in transmission lines
CO3. Construct models for reactive power coordination
CO4. 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 REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS
Uncompensated line, Types of compensation, Passive shunt and series and dynamic shunt compensation, Examples.

TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS
Characteristic time periods, Passive shunt compensation, Static compensation, Series capacitor compensation, Compensation using synchronous condenser, Examples.

UNIT-III:
REACTIVE POWER COORDINATION
Objective, Mathematical modeling, Operation planning, Transmission benefits, Basic concepts of quality of power supply, Disturbances, Steady–state variations, Effect of under-voltages, Frequency, Harmonics, Radio frequency and electromagnetic interference.

UNIT-IV:

DEMAND SIDE MANAGEMENT

Load patterns, Basic methods load shaping, Power tariffs, KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels.

DISTRIBUTION SIDE REACTIVE POWER MANAGEMENT

System losses, Loss reduction methods, Examples, Reactive power planning, Objectives, 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 ARCFURNACES

Typical layout of traction systems, Reactive power control requirements, Distribution transformers, Electric arc furnaces, Basic operation, Furnaces transformer, Filter requirements, Remedial measures, Power factor of an arc furnace.

TEXTBOOKS:

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

REFERENCES:

1. Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just, “Reactive Power Compensation: APractical Guide”, Wiley Publication, April2012.

.

M. Tech – I Semester

L	T	P	C
3	0	0	3

ELECTRIC VEHICLES AND DESIGN
(Program Elective-II.4)

Prerequisite: Power Semiconductor Drives, Electrical Drives and Control, Utilization of Electric Energy

Course Objectives:

- To understand the fundamental concepts, principles, analysis and design of hybrid and electricvehicles.
- To know the various aspects of hybrid and electric drive train such as their configuration, types ofelectric machines that can be used energy storage devices, etc.

Course Outcomes: After completion of the course, students will be able to:

CO1. Understand the models to describe hybrid vehicles and their performance.
CO2. Understand the different possible ways of energy storage.
CO3. Understand the different strategies related to energy storage systems.

UNIT-I:
INTRODUCTION
Conventional Vehicles: Basics of vehicle performance, Vehicle power source characterization, Transmission characteristics, Mathematical models to describe vehicle performance.

UNIT-II:
INTRODUCTION TO HYBRID ELECTRIC VEHICLES
History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies.
Hybrid Electric Drive-Trains: 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:
ELECTRIC TRAINS
Electric Drive-Trains: Basic concept of electric traction, introduction to various electric drive train topologies, Power flow control in electric drive-train topologies, Fuel efficiency analysis.
Electric Propulsion Unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, Drive system efficiency.

UNIT-IV:
ENERGY STORAGE

Energy Storage: Introduction to Energy Storage, Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.

Sizing the drive system: 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 STRATEGIES

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, Classification of different energy management strategies, Comparison of different energy management strategies, Implementation issues of energy management strategies.

Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).

TEXTBOOKS:

1. C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications withPractical Perspectives", John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies",Springer, 2015.

REFERENCES:

1. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel CellVehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
2. T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016.

M. Tech – I Semester

L	T	P	C
3	0	0	3

RESEARCH METHODOLOGY & IPR

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 about the patent rights

Course Outcomes: After completion of the course, students will be able to:
CO1. Understand research problem formulation.
CO2. Analyze research related information
CO3. Follow research ethics
77Understand that today's world is controlled by Computer, Information Technology, buttomorrow world will be ruled by ideas, concept and creativity.
CO4. 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.
CO5. 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 a report, paper in 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 grant 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.

TEXTBOOKS:

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 TechnologicalAge”, 2016.
7. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008.

M. Tech – I Semester

L	T	P	C
0	0	4	2

POWER SYSTEMS COMPUTATION LAB-I

(Lab-I)

Prerequisite: Power systems

Course Objectives:

- To construct Y-bus, Z-bus for a n-bus system.
- To analyze various Load flow studies.
- To know steady state, transient stability analysis.
- To understand economic load dispatch problem.
- To understand unit commitment problem.
- To understand state estimation of power system.

Course Outcomes: After completion of the course, students will be able to:

CO1. Construct Y-bus and Z-bus

CO2. Compare the different load flow methods

CO3. Analyze the different stability analysis of variety of power systems

CO4. Understand Economic load dispatch and Unit commitment problems.

CO5. Understand 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 Program for Short Circuit Analysis using ZBUS Algorithm.
9. Develop Program for Transient Stability Analysis for Single Machine connected to Infinite Bus
10. Develop Program for Economic Load Dispatch Problem using Lambda Iterative Method.
11. Develop Program for Unit Commitment Problem using Forward Dynamic Programming Method.
12. Develop Program for State Estimation of Power System.

Note: From the above list, minimum of 10 experiments are to be conducted using suitable software

M. Tech – I Semester

L	T	P	C
0	0	4	2

ADVANCED POWER SYSTEMS LAB

(Lab-II)

Prerequisite: Power systems and FACTS

Course Objectives:

- To determine transmission line parameters
- To determine transmission line regulation and efficiency
- To determine various fault calculations
- To perform load and line compensation

Course Outcomes: After completion of the course, students will be able to:

CO1. Calculate transmission line parameters
CO2. Calculate transmission line regulation and efficiency
CO3. Calculate various fault parameters
CO4. Compare system parameters with and without compensation

List of Experiments:

1. Determination of Line Parameters R, L and C.
2. Fault Analysis of Single Line to Ground fault (L-G).
3. Performance and Testing of Transformer
4. Determination of sequence impedances of three phase transformers
5. Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine.
6. Determination of Sub-transient reactance’s of a Salient Pole Synchronous Machine.
7. Determination of negative sequence currents
8. Determination of maximum operating voltage
9. Determination of maximum current rating
10. Determination of minimum operating voltage of the feeder

M. Tech – I Semester

L	T	P	C
3	0	0	3

DIGITAL PROTECTION OF POWER SYSTEM
(Program Core-III**)**

Prerequisite: Power System Protection

Course Objectives:
- To study numerical relays.
- To develop mathematical approach towards protection.
- To study algorithms for numerical protection.

Course Outcomes: After completion of the course, students will be able to:
CO1. Learn the importance of Digital Relays.
CO2. Apply Mathematical approach towards protection.
CO3. 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, and 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- b a s e d 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.

TEXTBOOKS:

1. A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studiesPress, 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.

M. Tech – I Semester

L	T	P	C
3	0	0	3

POWER SYSTEM DYNAMICS
(Program Core-IV)

Prerequisite: Power Systems and Electrical Machines

Course Objectives:
- To develop mathematical models for synchronous machine, Exciter, Governor and Prime mover.
- To study power system dynamic phenomena and the effects of exciter and governor control.
- To improve dynamic stability of a system.

Course Outcomes: After completion of the course, students will be able to:
CO1. Understand the modeling of synchronous machine in details
CO2. Understand the modeling of Exciter and Governor control
CO3. Carry out simulation studies of power system dynamics using MATLAB-SIMULINK, MIPOWER
CO4. Carry out stability analysis with and without power system stabilizer

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.
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.

TEXTBOOKS:

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.

M. Tech – II Semester

L	T	P	C
3	0	0	3

RESTRUCTURED POWER SYSTEMS
(Program Elective-III.1)

Prerequisite: Power Systems and Electrical Machines

Course Objectives:
- To understand what is meant by restructuring of the electricity market
- To understand the need behind requirement for deregulation of the electricity market
- To understand the money, power & information flow in a deregulated power system

Course Outcomes: After completion of the cours0e, students will be able to:
CO1. Describe various types of regulations in power systems.
CO2. Identify the need of regulation and deregulation.
CO3. Define and describe the Technical and Non-technical issues in Deregulated Power Industry.
CO4. Identify and give examples of existing electricity markets.
CO5. 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:
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.

UNIT-V:
Developments in India, IT applications in restructured markets, working of restructured power systems, PJM, Recent trends in Restructuring.

TEXTBOOKS:
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 powersystems", Kluwer Academic Pub., 2001.
2. Mohammad Shahidehpour, Muwaffaq Alomoush, "Restructuredelectrical power systems: operation, trading and volatility", Marcel Dekker.

M. Tech – II Semester

L	T	P	C
3	0	0	3

POWER QUALITY IMPROVEMENT TECHNIQUES
(Program Elective-III.2)

Prerequisite: Power Systems and Power Electronics

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

Course Outcomes: After completion of the course, students will be able to:

CO1. Know the severity of power quality problems in distribution system

CO2. Understand the concept of voltage sag transformation from up-stream (higher voltages) to down-stream (lower voltage)

CO3. Compute the power quality improvement by using various mitigating custom power devices.

UNIT-I:
INTRODUCTION AND POWER QUALITY STANDARDS
Introduction, Classification of Power Quality Problems, Causes, Effects and Mitigation Techniques of Power Quality Problems, Power Quality Terminology, Standards, Definitions, Monitoring and Numerical Problems.

UNIT-II:
CAUSES OF POWER QUALITY PROBLEMS
Introduction to Non-Linear Loads, Power Quality Problems caused by Non-Linear Loads, Analysis of Non- Linear Loads, Numerical Problems.

UNIT-III:
PASSIVE SHUNT AND SERIES COMPENSATION
Introduction, Classification and Principle of operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators for Single-Phase System, Three-Phase Three Wire System and Three-Phase Four Wire System.

UNIT-IV:
ACTIVE SHUNT AND SERIES COMPENSATION
Introduction to Shunt compensators: Classification of DSTATCOM’s, Principle of Operation of DSTATCOM.

Different Control Algorithms of DSTATCOM: PI Controller, I-Cosφ Control Algorithm, Synchronous Reference Frame Theory, Single-Phase PQ theory and DQ Theory Based Control Algorithms, Analysis and Design of Shunt Compensators, Numerical Problems.

Introduction to Series Compensators: Classification of Series Compensators, Principle of Operation of DVR.
Different Control Algorithms of DVR: Synchronous Reference Frame Theory-Based Control of DVR, Analysis and Design of Active Series Compensators, Numerical Problems.

UNIT-V:
UNIFIED POWER QUALITY COMPENSATORS
Introduction to Unified Power Quality Compensators (UPQC), Classification of UPQCs, Principle of Operation of UPQC.
Control of UPQCs: Synchronous Reference Frame Theory-Based UPQC, Analysis and Design of UPQCs, Numerical Problems.

TEXTBOOKS:

1. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality Problems and Mitigation Techniques", Wiley Publications, 2015.
2. Math H J Bollen, "Understanding Power Quality Problems", IEEE Press, 2000.

REFERENCES:

1. R.C. Dugan, M.F. McGranaghan and H.W. Beaty, "Electric Power Systems Quality", New York, McGraw-Hill, 1996.
2. G.T. Heydt, "Electric power quality", McGraw-Hill Professional, 2007.
3. J. Arrillaga, "Power System Quality Assessment", John wiley, 2000.
4. G.T. Heydt," Electric Power Quality", 2ndEdition, West Lafayette, IN, Stars in Circle Publications,1994.
5. R. SastryVedamMulukutlaS.Sarma, "Power Quality VAR Compensation in Power Systems",CRC Press.
6. A Ghosh, G. Ledwich," Power Quality Enhancement Using Custom Power Devices", KluwerAcademic, 2002.

M. Tech – II Semester

L	T	P	C
3	0	0	3

EHV AC TRANSMISSION

(Program Elective-III.3**)**

Prerequisite: Power Systems

Course objectives:

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

Course Outcomes: After completion of the course, students will be able to:

CO1. Understand the importance of EHV AC transmission

CO2. Estimate choice of voltage for transmission, line losses and power handling capability of EHV Transmission.

CO3. Analyze by applying the statistical procedures for line designs, scientific and engineering principles in power systems.

UNIT-I:

E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages, Estimation at line and ground parameters, Bundled conductor systems, Inductance and Capacitance of E.H.V. lines, Positive, negative and zero sequence impedance, Line Parameters for Modes of Propagation.

UNIT-II:

Electrostatic field and voltage gradients, Calculation 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 E.H.V. lines, Corona loss formulae, Attention of traveling waves due to Corona, Audio noise due to Corona and its generation, Characteristic and limits.

Measurement of audio noise radio interference due to Corona, Properties of radio noise, Frequency spectrum of RI fields, Measurement of RI and RIV.

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

TEXTBOOKS:

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 Edition, 2012.

REFERENCES:

1. S. Rao, "EHVAC and HVDC Transmission Engineering Practice", Khanna Publishers.
2. Arrillaga. J, "High Voltage Direct Current Transmission", 2nd edition (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.

M. Tech – II Semester

L	T	P	C
3	0	0	3

SWARM INTELLIGENCE TECHNIQUES IN POWER SYSTEMS
(Program Elective-III.4**)**

Prerequisite: Artificial Intelligence Techniques in Electrical Engineering
Course Objectives:
- To understand Evolutionary algorithms like GA, PSO, ANT COLONY and BEE COLONY etc.
- To apply these Evolutionary algorithms to solve power systems problems
- To also able to understand solution of multi-Objective optimization using these algorithms

Course Outcomes: After completion of the course, students will be able to:
CO1. Discriminate the capabilities of bio-inspired system and conventional methods in solving optimization problems.
CO2. Examine the importance of exploration and exploitation of swarm intelligent system to attain near global optimal solution.
CO3. Distinguish the functioning of various swarm intelligent systems.
CO4. 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 condition, 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 & 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 & 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 & BAT OPTIMIZATION ALGORITHM

Bat algorithm, Echolocation of bats, Behavior 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.

TEXTBOOKS:

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.

L	T	P	C
3	0	0	3

M. Tech – II Semester

AI TECHNIQUES IN POWER SYSTEMS
(Program Elective-IV.1**)**

Prerequisite: Artificial Intelligence Techniques in Electrical Engineering

Course Objectives:
- To understand fuzzy logic, Artificial Neural Networks
- To understanding Genetic Algorithms & Evolutionary Programming

Course Outcomes: After completion of the course, students will be able to:

CO1. Learn the concepts of biological foundations of artificial neural networks
CO2. Learn Feedback networks and radial basis function networks and fuzzy logics
CO3. Identify fuzzy and neural network
CO4. Acquire the knowledge of Genetic Algorithms

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.

TEXTBOOKS:

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 Com.

M. Tech – II Semester

L	T	P	C
3	0	0	3

ELECTRIC VEHICLE CHARGING TECHNIQUES

(Program Elective-IV.2**)**

Prerequisite: Electric and Hybrid Vehicles, Power Electronics, Smart Grid Technologies

Course Objectives:

- To understand the charging infrastructure for EV's
- To explore the working of grid connected with EV's.

Course Outcomes: After completion of the course, students will be able to:

CO1. Understand the planning and operational issues related to EV's charging.

CO2. Acquire knowledge about EV's charging implementation models.

UNIT-I:
AN OVERVIEW OF EV CHARGING INFRASTRUCTURE:
Orients the reader to EV charging infrastructure, providing a brief introduction to technical concepts of electric vehicle supply equipment, AC and DC charging, power ratings, and charging standards.

UNIT-II:
LOCATION PLANNING AND LAND ALLOCATION:
Covers the location and site planning aspects for EV charging, by framing the principles of location planning and demonstrating a methodology for spatial allocation of charging demand, and identifies enabling processes and policies to integrate public charging in urban planning.

UNIT-III:
CONNECTING EVs TO THE ELECTRICITY GRID:
Focuses on supply of electricity for charging infrastructure, familiarizing readers with the regulations that govern electricity supply for EV charging, the role of DISCOMs in provision of EV charging connections, and the three methods of arranging for power supply for charging infrastructure.

UNIT-IV:
ACHIEVING EFFECTIVE EV-GRID INTEGRATION:
Zooms out from site-level considerations for supply of electricity to assess grid-level impacts, and then highlights the need for smart charging to minimize adverse impacts of EV charging loads on the grid.

UNIT-V:
MODELS OF EV CHARGING IMPLEMENTATION
Defines the typical roles within an implementation model for EV charging infrastructure and identifies three models in India – the government-driven model, the consumer-driven model and the charge point operator-driven model – for charging infrastructure implementation.

TEXTBOOKS:

1. Sulabh Sachan, P. Sanjeevikumar, Sanchari Deb, "Smart Charging Solutions for Hybrid and ElectricVehicles",Wiley Publications, March 2022.
2. Handbook of Electric Vehicle Charging Infrastructure Implementation Version-1

REFERENCES:

1. Vahid Vahidinasab, Behnam Mohammadi-Ivatloo, "Electric Vehicle Integration via Smart Charging,Springer, 2022.
2. Alam, Mohammad Saad, Pillai, Reji Kumar, Murugesan, N, "Developing Charging Infrastructure andTechnologies for Electric Vehicles", IGI Global

M. Tech – II Semester

L	T	P	C
3	0	0	3

POWER SYSTEM RELIABILITY AND PLANNING

(Program Elective-IV.3**)**

Prerequisite: Reliability Engineering

Course Objectives:

- To describe the generation system model and recursive relation for capacitive model building
- To explain the equivalent transitional rates, cumulative probability and cumulative frequency
- To develop the understanding of risk, system and load point reliability indices
- To explain the basic and performance reliability indices

Course Outcomes: After completion of the course, students will be able to:

CO1. Understand the importance of maintaining reliability of power system components.

CO2. Apply the probabilistic methods for evaluating the reliability of generation and transmission systems.

CO3. Assess the different models of system components in reliability studies.

CO4. Assess the reliability of single area and multi area systems.

UNIT-I:

BASIC RELIABILITY CONCEPTS:

The general reliability function, the 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.

TEXTBOOKS:

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.

M. Tech – II Semester

L	T	P	C
3	0	0	3

INDUSTRIAL LOAD MODELLING AND CONTROL

(Program Elective-IV.4**)**

Prerequisite: Power Systems

Course Objectives:

- To understand the energy demand scenario
- To understand the modeling of load and its ease to study load demand industrially
- To know electricity pricing models
- To study reactive power management in Industries

Course Outcomes: After completion of the course, students will be able to:

CO1. Acquire knowledge about load control techniques in industries and its application.

CO2. Understand different types of industrial processes and optimize the process using tools like LINDO and LINGO.

CO3. Apply load management to reduce demand of electricity during peak time.

CO4. Apply different energy saving opportunities in industries.

UNIT-I:

Electric Energy Scenario, Demand Side Management, Industrial Load Management. Load Curve, Load Shaping Objective, Methodologies.
Barriers: Classification of Industrial Loads, Continuous and Batch processes, Load Modeling.

UNIT-II:

Direct load control, Interruptible load control. Bottom- u p approach, Scheduling, Formulation of load models, Optimization and control algorithms, Case studies. Reactive power management in industry, Controls, Power quality impacts, Application of filters, Energy saving in industries.

UNIT-III:

Cooling and heating loads, Load profiling, Modeling. Cool storage, Types, Control strategies. Optimal operation, Problem formulation, Case studies.

UNIT-IV:

Captive power units, Operating and control strategies, Power Pooling, Operation models. Energy banking, Industrial Cogeneration.

UNIT-V:

Selection of Schemes, Optimal Operating Strategies. Peak load saving, Constraints, Problem formulation Case study. Integrated Load management for Industries.

TEXTBOOKS:

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,April1981.
2. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Inter science 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 inIndustrial facilities", IEEE Inc, USA.

M. Tech – II Semester

L	T	P	C
0	0	4	2

POWER SYSTEMS COMPUTATION LAB-II
(Lab-III)

Prerequisite: Power Systems and Artificial Neural Networks

Course Objectives:

- To know Neural network tool box
- To know the various Evolutionary Algorithms
- To apply various Evolutionary Algorithms to power system problems

Course Outcomes: After completion of the course, students will be able to:

CO1. Understood Neural network and fuzzy logic tool box
CO2. Understood various Evolutionary Algorithms
CO3. Solve power system problems by applying various Evolutionary Algorithms

List of Experiments:

1. Load Flow analysis using Neural Network
2. State Estimation using Neural Network
3. Contingency Analysis using Neural Network
4. Power system Security using Neural Network
5. Fuzzy Logic based AGC – Single area system – Two area system
6. Fuzzy Logic based small signal stability analysis
7. Economic Dispatch of Thermal Units using ANN
8. Economic Dispatch of Thermal Units using GA
9. Unit commitment problem by using GA
10. Unit commitment problem by using PSO
11. Optimal location and sizing of capacitor in distribution system using PSO
12. Security constrained optimal power dispatch using GA
13. Optimal Reactive power dispatch using PSO.

Note: From the above list, minimum of 10 experiments are to be conducted using suitable software

M. Tech – II Semester

L	T	P	C
0	0	4	2

POWER SYSTEM PROTECTION LAB
(Lab-IV)

Prerequisite: Power System Protection

Course Objectives:
- To understand practically different types of Faults occurring in power systems
- To study the characteristics of different types of relays
- To apply different protection schemes and understand the principle of operation

Course Outcomes: After completion of the course, students will be able to:

CO1. Calculate various faults
CO2. Analyze the various time-current characteristics of protective relays
CO3. Know the Performance and Testing of various electrical models and systems

List of Experiments:

1. Characteristics of Over Current Relays
2. Characteristics of Percentage biased Differential Relay.
3. Characteristics of Over Voltage Relay.
4. Characteristics of Under Voltage (UV) and Negative sequence Relays
5. Performance and Testing of Generator Protection System.
6. Performance and Testing of Transformer Protection System.
7. Performance and Testing of Feeder Protection System.
8. Performance and Testing of Transmission Line Model.
9. Differential protection on Single Phase Transformer.
10. Design of protection scheme for Cylindrical Rotor Synchronous Machine.

M. Tech – III Semester

L	T	P	C
3	0	0	3

POWER SYSTEM TRANSIENTS
(Program Elective-V.1**)**

Prerequisite: Power Systems

Course Objectives:

- To learn the reasons for occurrence of transients in a power system.
- To understand the change in parameters like voltage & frequency during transients.
- To know about the lightning phenomenon and its effect on power system.

Course Outcomes: After completion of the course, students will be able to:

CO1. Get knowledge of various transients that could occur in power system and their mathematical formulation.

CO2. Design various protective devices in power system for protecting equipment and Personnel.

CO3. Coordinate the insulation of various equipment in power system.

CO4. Model the power system for transient analysis.

UNIT-I:

Fundamental circuit analysis of electrical transients, Laplace Transform method of solving simple Switching transients, damping circuits, abnormal switching transients, Three-phase circuits and transients, Computation of power system transients.

UNIT-II:

Principle of digital computation, Matrix method of solution, Modal analysis, Z-transform, Computation using EMTP, Lightning, Switching and temporary over voltages, Lightning, Physical phenomena of lightning.

UNIT-III:

Interaction between lightning and power system, Influence of tower footing resistance and Earth Resistance, Switching, Short line or kilometric fault, energizing transients, Closing and re-closing of lines, Line dropping, Load rejection, over voltages induced by faults.

UNIT-IV:

Switching HVDC line, travelling waves on transmission line, Circuits with distributed Parameters, Wave Equation, Reflection, Refraction, Behavior of Travelling waves at the line Terminations, Lattice Diagrams, Attenuation and Distortion factors, multi-conductor system and Velocity wave.

UNIT-V:

Insulation co-ordination: Principle of insulation co-ordination in Air Insulated Substation (AIS) and Gas Insulated Substation (GIS), Coordination between insulation and protection level, Statistical approach. Protective devices**,** Protection of system against over voltages**,** Lightning arresters, Substation earthling.

TEXTBOOKS:

1. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc., New York, 1991.
2. Harold A Peterson, “Transient in Power Systems”, McGraw Hill, 1966.

REFERENCES:

1. Kuffel and Abdullah, “High Voltage Engineering”, PHI, 2000.
2. Rakesh D. Begamudre, “EHV AC Transmission Engineering”, PHI, 2006.

M. Tech – III Semester

L	T	P	C
3	0	0	3

FACTS AND CUSTOM POWER DEVICES
(Program Elective-V.2)

Prerequisite: Power Electronics and Power Systems

Course Objectives:

- To understand uncompensated lines and their behavior under heavy loading conditions.
- To understand the concept and importance of controllable parameters of FACTS controllers.
- To emphasize the objectives of Shunt compensation and basic operation of SVC and STATCOM.
- To analyze the functioning of series controllers like GCSC, TSSC and TCSC

Course Outcomes: After completion of the course, students will be able to:

CO1. Choose proper controller for the specific application based on system requirements

CO2. Understand various systems thoroughly and their requirements

CO3. Interpret the control circuits of Shunt Controllers SVC & STATCOM for various functions viz.Transient stability Enhancement, voltage instability prevention and power oscillation damping

CO4. Detect the Power and control circuits of Series Controllers GCSC, TSSC and TCSC

UNIT-I:

FACTS CONCEPTS

Transmission interconnections power flow in an AC system, Loading capability limits, Dynamic stability considerations, Importance of controllable parameters basic types of FACTS controllers, Benefits from FACTS controllers.

UNIT-II:

VOLTAGE SOURCE CONVERTERS

Single phase & three phase full wave bridge converters, Transformer connections for 12 pulse, 24 and 48 pulse operation. Three level voltage source converter, Pulse width modulation converter, Basic concept of current source Converters, Comparison of current source converters with voltage source converters.

UNIT-III:

STATIC SHUNT COMPENSATION

Objectives of shunt compensation, Mid-point voltage regulation, Voltage instability prevention, Improvement of transient stability, Power oscillation damping, Methods of controllable VAR generation, Variable impedance type static VAR generators switching converter type VAR generators, Hybrid VAR generators.

UNIT-IV:

SVC AND STATCOM

The regulation and slope transfer function and dynamic performance, Transient stability enhancement and power oscillation damping operating point control and summary of compensator control.

UNIT-V:
STATIC SERIES COMPENSATORS

Concept of series capacitive compensation, Improvement of transient stability, Power oscillation damping and functional requirements of GTO thyristor-controlled series capacitor (GSC), Thyristor switched series capacitor (TSSC) and thyristor-controlled series capacitor (TCSC). Control schemes for GSC, TSSC and TCSC.

TEXTBOOKS:

1. Hingorani H G and Gyugyi. L, "Understanding FACTS-Concepts and Technology of FlexibleAC Transmission Systems", New York, IEEE Press, 2000.
2. Padiyar.K.R, "FACTS Controllers in Power Transmission and Distribution", New Age Int. Publishers, 2007.

REFERENCES:

1. Zhang, Xiao-Ping, Rehtanz, Christian, Pal, Bikash, "Flexible AC Transmission Systems: Modeling and Control", Springer, 2012.
2. Yong-Hua Song, Allan Johns, "Flexible AC Transmission Systems", IET, 1999.

M. Tech – III Semester

L	T	P	C
3	0	0	3

GAS INSULATED SYSTEMS

(Program Elective-V.3**)** **Prerequisite:** Switch Gear and Protection

Course objectives:

- To know the GIS concepts and principles
- To distinguish Air Insulated and Gas insulated Substations
- To demonstrate the design and constructional aspects of GIS
- To analyze transient phenomenon, problems and diagnostic methods in GIS

Course Outcomes: After completion of the course, students will be able to:

CO1. Know the advantages of GIS systems over air insulated systems
CO2. Observe constructional design features of GIS design
CO3. Discriminate the problems and design diagnostic methods of GIS

UNIT–I:
INTRODUCTION TO GIS AND PROPERTIES OF SF6

Characteristics of GIS- Introduction to SF6 , Physical properties, Chemical properties, Electrical properties, Specification of SF6 gas for GIS application, Handling of SF6 gas before use, Safe handling of Sf6 gas in electrical equipment, Equipment for handling the SF6 Gas, SF6 and environment.

UNIT–II:
LAYOUT OF GIS STATIONS

Advancement of GIS station, Comparison with Air Insulated Substation, Economics of GIS, User Requirements for GIS, Main Features for GIS, Planning and Installation components of a GIS station.

UNIT–III:
DESIGN AND CONSTRUCTION OF GIS STATION

Introduction, Rating of GIS components, Design Features, Estimation of different types of Electrical Stresses, Design Aspects of GIS components, Insulation Design for Components, Insulation Design for GIS, Thermal Considerations in the Design of GIS, Effect of Very Fast Transient Over-voltages (VFTO) on the GIS design, Insulation Coordination systems, Gas handling and Monitoring System Design.

UNIT-IV:
FAST TRANSIENT PHENOMENA IN GIS

Introduction, Disconnector Switching in Relation to Very fast Transients-Origin of VFTO, Propagation and Mechanism of VFTO, VFTO Characteristics, Effects of VFTO, Testing of GIS for VFTO.

UNIT–V:
SPECIAL PROBLEMS IN GIS AND GIS DIAGNOSTICS

Introduction, Particles their effects and their control, Insulating Spacers and their Reliability, SF6 Gas Decomposition, Characteristics of imperfections in insulation, Insulation Diagnostic methods, PD Measurement and UHF Method.

TEXTBOOKS:

1. M. S. Naidu," Gas Insulated Substations", IK International Publishing House.
2. Hermann J. Koch, "Gas Insulated Substations", Wiley-IEEE Press, Jun, 2014.

REFERENCES:

1. Olivier Gallot-Lavellee, "Dielectric materials and Electrostatics", Wiley-IEEE Press.
2. Jaun Martinez, "Dielectric Materials for Electrical Engineering", Wiley-IEEE Press.

M. Tech – III Semester

L	T	P	C
3	0	0	3

SCADA SYSTEMS AND APPLICATIONS

(Program Elective-V.4**)**

Prerequisite: None

Course Objectives:

- To understand what is meant by SCADA and its functions.
- To know SCADA communication.
- To get an insight into its application**.**

Course Outcomes: After completion of the course, students will be able to:

CO1. Describe the basic tasks of Supervisory Control Systems (SCADA) as well as their typical Applications.

CO2. Acquire knowledge about SCADA architecture, various advantages and disadvantages of each system.

CO3. Acquire knowledge about single unified standard architecture IEC 61850.

CO4. Learn about SCADA system components: remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server.

CO5. Learn and understand about SCADA applications in transmission and distribution sector, industries etc.

UNIT–I:

Introduction to SCADA, Data acquisition systems, Evolution of SCADA, Communication technologies. Monitoring and supervisory functions, SCADA applications in utility Automation, Industries SCADA.

UNIT–II:

Industries SCADA System Components, Schemes, Remote Terminal Unit (RTU), Intelligent Electronic Devices (IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems.

UNIT–III:

SCADA Architecture**,** Various SCADA architectures, Advantages and disadvantages of each System, Single unified standard architecture -IEC 61850.

UNIT–IV:

SCADA Communication, Various industrial communication technologies, Wired and wireless methods and fiber optics, Open standard communication protocols.

UNIT–V:

SCADA Applications: Utility applications**,** Transmission and Distribution sector operations, Monitoring, analysis and improvement**.** Oil, gas and water industries case studies: Implementation, Simulation exercises.

TEXTBOOKS:

1. Stuart A. Boyer, "SCADA-Supervisory Control and Data Acquisition", Instrument Society

ofAmerica Publications, USA, 2004.
2. Gordon Clarke, Deon Reynders, “Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems”, Newnes Publications, Oxford, UK, 2004.

REFERENCES:

1. William T. Shaw, “Cyber Security for SCADA systems”, PennWell Books, 2006.
2. David Bailey, Edwin Wright, “Practical SCADA for industry”, Newnes, 2003.
3. Michael Wiebe, “A guide to utility automation: AMR, SCADA, and IT

M. Tech – III Semester

L	T	P	C
3	0	0	3

PHOTOVOLTAIC SYSTEMS
(Open Elective)

Prerequisite: None
Course Objectives:

- To introduce photovoltaic systems
- To deal with various technologies of solar PV cells
- To understand details about manufacture, sizing and operating techniques
- To have knowledge of design considerations.

Course Outcomes: After completion of the course, students will be able to:

CO1. Identify photovoltaic system components and system types
CO2. Calculate electrical energy and power
CO3. Correctly size system components, design considerations of solar equipment
CO4. Design a basic grid-tie PV system.

UNIT-I:
SOLAR ENERGY
Sun and Earth, Solar Spectrum, Solar Geometry, Solar radiation on horizontal and inclined planes, Instruments for measurement of solar radiation, Solar cell, Equivalent circuit, V-I characteristics, Performance improvement.

UNIT-II:
SOLAR CELLS
Manufacture of Solar Cells-Technologies, Design of Solar cells, Photovoltaic modules, Design requirements, Encapsulation systems, Manufacture, Power rating, Hotspot effect, Design qualifications.

UNIT-III:
PROTECTION AND MEASUREMENTS
Flat plate arrays, Support structures, Module interconnection and cabling, Lightning protection, Performance measurement using natural sun light and simulator, Determination of temperature coefficients, Internal series resistance, Curve correction factor.

UNIT-IV:
PHOTOVOLTAIC SYSTEMS
Photovoltaic systems, Types, General design considerations, System sizing, Battery sizing, Inverter sizing, Design examples, Balance of PV systems.

UNIT-V:
MAXIMUM POWER POINT TRACKERS
Maximum power point trackers, Perturb and observe, Incremental conductance method, Hill climbing method, Hybrid and complex methods, Data based and other approximate methods, Instrument design, OtherMPP techniques, Grid interactive PV system.

TEXTBOOKS:

1. F.C.Treble, "Generating electricity from Sun", Pergamon Press.
2. A.K.Mukherjee, Nivedita Thakur,"Photovoltaic systems: Analysis and design", PHI, 2011.

REFERENCES:

1. C.S.Solanki," Solar Photovoltaic's: Fundamentals, Technologies and applications", PHI, 2009.

M. Tech – I & II Semester

L	T	P	C
2	0	0	0

ENGLISH FOR RESEARCH PAPER WRITING

(Audit-I &II .1**)**
Prerequisite: None

Course objectives:

- To Understand that how to improve your writing skills and level of readability
- To Learn about what to write in each section
- To Understand the skills needed when writing a Title Ensure the good quality of paper at very first-time submission

UNIT-I:
Planning and Preparation, Word Order, breaking up long sentences, Structuring Paragraphs and Sentences,Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT-II:
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing andPlagiarism, Sections of a Paper, Abstracts. Introduction

UNIT-III:
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT-IV:
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills areneeded when writing an Introduction, skills needed when writing a Review of the Literature,

UNIT-V:
Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed whenwriting the Discussion, and skills are needed when writing the Conclusions

UNIT-VI:
Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

TEXTBOOKS/ REFERENCES:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman’s book
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

M. Tech – I& II Semester

L	T	P	C
2	0	0	0

DISASTER MANAGEMENT

(Audit-I &II .2**)**
Prerequisite: None
Course Objectives:

- To learn to demonstrate a critical understanding of key concepts in disaster risk reduction andhumanitarian response.
- To evaluate disaster risk reduction and humanitarian response policy and practice from multipleperspectives.
- To develop an understanding of standards of humanitarian response and practical relevance inspecific types of disasters and conflict situations.
- To understand the strengths and weaknesses of disaster management approaches,
- To plan and program in different countries, particularly their home country or the countries they work

UNIT-I:
Introduction:
Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural andManmade Disasters: Difference, Nature, Types and Magnitude.

UNIT-II:
Repercussions of Disasters and Hazards:
Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

UNIT-III:
Disaster Prone Areas in India:
Study of Seismic Zones; Areas Prone to Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics

UNIT-IV:
Disaster Preparedness and Management:
Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT-V:
Risk Assessment Disaster Risk:
Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

UNIT-VI:

Disaster Mitigation:
Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigationand Non-Structural Mitigation, Programs of Disaster Mitigation in India.

TEXTBOOKS/ REFERENCES:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall ofIndia, New Delhi.
3. Goel S. L., Disaster Administration and Management Text and Case Studies", Deep &DeepPublication Pvt. Ltd., New Delhi.

M. Tech – I & II Semester

L	T	P	C
2	0	0	0

VALUE EDUCATION
(Audit-I &II .4**)**

Prerequisite: None

Course Objectives:

- To understand value of education and self- development
- To imbibe good values in students
- To know about the importance of character

Course outcomes: After completion of the course, students will be able to:

CO1. Get Knowledge of self-development
CO2. Learn the importance of Human values
CO3. Develop the overall personality

UNIT-I:
Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

UNIT-II:
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

UNIT-III:
Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness -Avoid fault Thinking. Free from anger, Dignity of labor- Universal brotherhood and religious tolerance - True friendship - Happiness Vs suffering, love for truth - Aware of Self-destructive habits - Association and Cooperation - Doing best for saving nature

UNIT-IV:
Character and Competence –Holy books vs. Blind faith - Self-management and good health - Science of reincarnation - Equality, Nonviolence, Humility, Role of Women - All religions and same message - Mind your Mind, Self-control - Honesty, Studying effectively

TEXTBOOKS/ REFERENCES:

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford UniversityPress, New Delhi

M. Tech – I & II Semester

L	T	P	C
2	0	0	0

PEDAGOGY STUDIES
(Audit-I &II.6**)**

Prerequisite: None
Course Objectives:

- To review existing evidence on the review topic to inform programme design and policy makingundertaken by the DfID, other agencies and researchers.
- To identify critical evidence gaps to guide the development.

Course Outcomes: After completion of the course, students will be able to:

CO1. Understand what pedagogical practices are being used by teachers in formal and informal classroomsin developing countries?

CO2. Understand what is the evidence on the effectiveness of these pedagogical practices, in whatconditions, and with what population of learners?

CO3. Understand how can teacher education (curriculum and practicum) and the school curriculum andguidance materials best support effective pedagogy?

UNIT-I:
Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions**.** Overview of methodology and searching.

UNIT-II:
Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

UNIT-III:
Evidence on the effectiveness of pedagogical practices, Methodology for the in-depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT-IV:
Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community. Curriculum and assessment, Barriers to learning: limited resources and large class sizes

UNIT-V:
Research gaps and future directions: Research design**,** Contexts**,** Pedagogy**,** Teacher education**,** Curriculum and assessment**,** Dissemination and research impact.

TEXTBOOKS/ REFERENCES:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245- 261.

2. Agrawal M (2004) curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxfordand Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, ‘learning to read’ campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.