North Maharashtra University, Jalgaon

M. E. (Electrical Power System)

Examination Scheme & Structure with Effect from Year 2012-13

FIRST YEAR TERM – I

Sr. No.	Subject	Teaching Scheme per week		Examination Scheme				
		L	P	Paper Hrs.	Paper	TW	PR	OR
1	Power System Optimization Techniques	3	--	3	100	--	--	--
2	Microprocessor and Microcontroller	3	--	3	100	--	--	--
3	Power System Planning & Reliability	3	--	3	100	--	--	--
4	Power System Dynamics	3	--	3	100	--	--	--
5	Elective – I	3	--	3	100	--	--	--
6	Laboratory Practice – I	--	6	--	--	100	--	50
7	Seminar – I	--	4	--	--	100	--	--
Total		**15**	**10**	**--**	**500**	**200**	**--**	**50**
Grand Total		**25**		**750**				

Elective – I

1. FACTs & Power Quality
2. Artificial Intelligence and its Applications in Power Systems
3. Renewable Energy Sources
4. Power Sector Economics, Management and Restructuring

FIRST YEAR TERM – II

Sr. No.	Subject	Teaching Scheme per week		Examination Scheme				
		L	P	Paper Hrs.	Paper	TW	PR	OR
1	Computer Methods Power System Analysis	3	--	3	100	--	--	--
2	Digital Signal Processing	3	--	3	100	--	--	--
3	Power System Modeling & Control	3	--	3	100	--	--	--
4	High Voltage Power Transmission	3	--	3	100	--	--	--
5	Elective – II	3	--	3	100	--	--	--
6	Laboratory Practice – II	--	6	--	--	100	--	50
7	Seminar – II	--	4	--	--	100	--	--
Total		**15**	**10**	**--**	**500**	**200**	**--**	**50**
Grand Total		**25**		**750**				

Elective – II

1. Advanced Power System Protection
2. Power Electronics Applications in Power Systems
3. EHV Transmission Systems
4. Power System Design

North Maharashtra University, Jalgaon

M. E. (Electrical Power System)

Examination Scheme & Structure with Effect from Year 2012-13

SECOND YEAR TERM – I

Sr. No.	Subject	Teaching Scheme per week		Examination Scheme				
		L	P	Paper Hrs.	Paper	TW	PR	OR
1	Seminar –III	--	4	--	--	50	--	50
2	Project Stage – I	--	18	--	--	100	--	--
Total		**--**	**22**	**--**	**--**	**150**	**--**	**50**
Grand Total		**22**		**200**				

SECOND YEAR TERM – II

Sr. No.	Subject	Teaching Scheme per week		Examination Scheme				
		L	P	Paper Hrs.	Paper	TW	PR	OR
1	Progress Seminar	--	--	--	--	50	--	--
2	Project Stage – II	--	18	--	--	150	--	100
Total		**--**	**18**	**--**	**--**	**200**	**--**	**100**
Grand Total		**18**		**300**				

SEMESTER-I

1. Power System Optimization Techniques

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) Introduction to optimization and classical optimization techniques, Linear Programming: Standard form, geometry of LPP, Simplex Method P.F. solving LPP, revised simplex method, duality, decomposition principle, and transportation problem.

2) Non-Linear Programming (NLP): One dimensional methods, Elimination methods, Interpolation methods Unconstrained optimization techniques-Direct search and Descent methods, constrained optimization techniques, direct and indirect methods.

3) Dynamic Programming: Multistage decision processes, concept of sub-optimization and principle of optimality, conversion of final value problem into an initial value problem. CPM and PERT

4) Genetic Algorithm: Introduction to genetic Algorithm, working principle, coding of variables, fitness function. GA operators; Similarities and differences between GAs and traditional methods; Unconstrained and constrained optimization.

5) Applications to Power system: Economic Load Dispatch in thermal and Hudro-thermal system using GA and classical optimization techniques, Unit commitment problem, reactive power optimization. Optimal power flow, LPP and NLP techniques to optimal flow problems.

Reference books:

a. "Optimization - Theory and Applications", By S.S.Rao, Wiley-Eastern Limited
b. "Introduction of Linear and Non-Linear Programming", By David G. Luenberger, Wesley Publishing Company
c. "Computational methods in Optimization ",By Polak, Academic Press
d. "Optimization Theory with Applications" By Pierre D.A., Wiley Publications
e. "Operations Research" By D. S. Hira & P. K. Gupta , S Chand Publications

2. Microprocessor and Microcontroller

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) Overview of 8086 : Architecture, instruction including I/O instructions, Addressing modes, interrupt structure, ISR minimum and maximum mode, Assembly Language Programmes on 16-bit multiplication, 16-bit by 8-bit division, bubble sort, palindrome. **Hardware and Software debugging aids**: 1 Pass and 2 Pass assemblers, cross assemblers, circuit emulators, simulators, linkers, loaders, compiler, cross compiler, Types of interfacing devices-→Latches(74373), Buffers(74244/245).

2) **8051 Architecture**: 8051 Microcontroller Hardware, Input/output. Pins, ports, and circuits, External Memory, Counter and Timers, Serial Data input/ output, Interrupts **Assembly language programming concepts :** The mechanics of programming, The assembly language programming process, PAL instructions, Programming tools and techniques, Programming the 8051 **Moving Data :** Addressing modes, external data moves, code memory read only data moves, push and pop -op codes, data exchanges

3) **Logical Operations :** Byte level logical operations, bit level logical operations, rotate and swap operations **Arithmetic Operations :** Flags, incrementing and decrementing, addition, subtraction, multiplication and division, decimal arithmetic **Jumps and Call Instructions :** The jump and call program range, jumps, calls and subroutines, interrupts and returns

4) **8051 Microcontroller Design :** Microcontroller specification, microcontroller design, testing the design, timing subroutines, look up tables for the 8051, serial data transmission

5) **Applications:** Keyboard, displays→LED & LCD, pulse measurement, D/A and A/D conversion, multiple interrupts **Serial Data Communication:** Network Configuration, 8051 Data Communication.

Reference books:

a. "The 8051 Micro Controller : Architecture, Programming," By Kenneth J.Ayala, Penram International, Mumbai.
b. Intel Embeded Micro Controller Data Book, Intel Corporation.
c. "Microprocessor and Digital Systems" By D.V.Hall, ELBS Publication, London.
d. "Advance Microprocessors and Micro Controllers" By B.P.Singh,, New Age International, New Delhi.
e. "Microprocessors and Interfacing" By D.V.Hall, Tata McGraw Hill Publication, New Delhi.
f. "Microcomputer Systems: the 8086/8088 Family, Architecture, Programming and Design" By Y.C.Liu, Gibson, Prentice Hall of India Publications, New Delhi.
g. "Introduction to Microprocessor, Software, Hardware and Programming" By Lance A. Leventhal,
h. "Microprocessor Architecture, Programming and Applications with the 8085" By Ramesh S.Gaonkar, Penram International, Mumbai.
i. "8051 microcontroller and embedded system" By Muhammad Ali Mazidi, Janice Mazidi, Rollin McKinlay, Pearson Second Edition

3. Power System Planning & Reliability

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) **Load Forecasting :** Introduction, Factors affecting Load Forecasting, Load Research, Load Growth Characteristics, Classification of Load and Its Characteristics, Load Forecasting Methods - (i) Extrapolation (ii) Co-Relation Techniques, Energy Forecasting, Peak Load Forecasting, Reactive Load Forecasting, Non-Weather sensitive load Forecasting, Weather sensitive load Forecasting, Annual Forecasting, Monthly Forecasting, Total Forecasting.

2) **System Planning :** Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.
Reliability : Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost.

3) **Generation Planning and Reliability :** Objectives & Factors affecting Generation Planning, Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods. Interconnected System, Factors Affecting Interconnection under Emergency Assistance.

4) **Transmission Planning and Reliability:** Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.

5) **Distribution Planning and Reliability:** Radial Networks – Introduction, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices. Parallel & Meshed Networks - Introduction, Basic Evaluation Techniques, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Weather Effects, Breaker Failure

Reference Books :

a. “Modern Power System Planning” By X. Wang & J.R. McDonald, McGraw Hill
b. “Electrical Power Distribution Engineering” By T. Gönen, McGraw Hill Book Company
c. “Generation of Electrical Energy” By B.R. Gupta, S. Chand Publications
d. “Electrical Power Distribution” By A.S. Pabla, Tata McGraw Hill Publishing Company Ltd.
e. “Electricity Economics & Planning” By T.W.Berrie, Peter Peregrinus Ltd., London.
f. “Power System Planning” By R.N. Sulivan , McGraw Hill

4. Power System Dynamics

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) Requirement of reliable power system, Basic concepts of stability, Reliable electrical power service, Stability of Synchronous machines, Tie line oscillations, Method of simulation.

2) Synchronous Machines: Review of synchronous machine equations, parameters, Equations in a-b-c phase co-ordinates and Park's co-ordinates, Representation of external system, Low and High order state models, Choice of state variables. Initial state equivalent circuit, Phasor diagram p.u. reactance. System Response to Large Disturbances: System of one machine against infinite bus, Classical Model, Mechanical and electrical torques, Critical clearing angle and time, Automatic reclosing, Pre calculated Swing curves and their use.

3) System Response to Small Disturbances: Two machine system with negligible losses, Clarke diagram for two machine series reactance system, Extension of Clarke diagram to cover any reactance network, Equation for steady State Stability limit, Two-Machine system with losses, Effect of inertia. Effect of governor, action, Conservative criterion for stability, Effect of saliency, saturation and short circuit ratio on steady state power limits.

4) Regulated Synchronous Machines: Demagnetizing effect of armature reaction and effect of small speed changes, Modes of oscillations of unregulated multimachine system. Voltage regulator and governor with delay Distribution of power impacts.

5) Effect of Excitation on Stability: Effect of excitation on generator power limits, transients and dynamic stability, Examination of dynamic stability by Routh's criterion, Root locus analysis of a regulated machine connected to an infinite bus. Approximate System representation, Supplementary Stabilizing Signals, Linear analysis of stabilized generator.

Reference Books :

a. "Synchronous Machines" By C.Concordia, John Wiley & Sons.
b. "Power System Stability" By E.W.Kimbark, Dover Publication, Vol.-3
c. "Power System Control & Stability" By Anderson, Galgotia Publ.
d. "Power System Stability" By S.B. Crary, John Wiley & Sons.
e. "Modern Power System Analysis" By Nagrath I. J. & Kothari D. P.,Tata McGraw Hill Publication New Delhi

ELECTIVE-I

i. FACTs & Power Quality

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) Steady state and dynamic problems in AC systems, Flexible AC transmission systems (FACTS), principles of series shunt compensation.

2) Description of static var compensation (SVC), thyristor controlled series compensation (TCSC) static phase shitters (SPS), static condenser (STATCON), static synchronous series compensator (SSSC) and unified power flow controller (UPFC), modeling and analysis of FACTS controllers, control strategies to improve system stability.

3) Power quality problems in distribution systems, Harmonics, Harmonics creating loads, modeling.

4) Harmonic propagation, series and parallel resonance, harmonic power flow, mitigation of harmonics, filters, passive filters, active filters, shunt and series hybrid filters, voltage sag and swells.

5) Voltage flicker, mitigation of power quality problems using power electronics conditioners, IEEE standards.

Reference Books :

a. "Understanding FACTS" By Hingorani & Gyugui, IEEE press.
b. "FACTS Controllers in Transmission & Distribution" By K. R. Padiyar. New Age Publication.
c. "Power Quality" By G.T.Heydt , Stars in a Circle Publication, Indiana, 1991.
d. "Static Reactive Power Compensation" By E.J.E.Miller John Wiley & Sons, New York, 1982.
e. Recent Publications on Power Systems and Power Delivery.

ii. ***ArtificiaI Intelligence and its Applications in Power Systems***

Teaching Scheme:	***Examination Scheme:***
Lectures: 3 Hrs. /Week	*Theory Paper: 100 Marks*
	Duration: 3 hours

1) **Introduction to Artificial Intelligence:** Introduction, Fuzzy systems, Artificial Neural Network (ANN), Expert Systems, Genetic Algorithm, Evolutionary Programming. Biological neurons: Function of single biological neuron, function of artificial neuron, Basic terminology related to artificial neuron. Characteristics of ANN, Typical applications of ANN such as classification, pattern recognition, forecasting Properties, strength of NN.

2) **Different Architectures of ANN and Learning Processes :** Different architectures of Neural Network, types of activation function, concept of Learning with a Teacher, Learning without a Teacher, Learning Tasks (Any two learning methods and applications)

3) **Single Layer Network and Multi-layer Network :** Single Layer Perception: architecture – training algorithm, Least – Mean square algorithm, learning curves, Learning Rate, Annealing techniques. Feed forward Neural Network(MLP) , Back propagation algorithm. Limitation of Back propagation algorithm. Concept of learning rate, momentum coefficient, Generalization capacity

4) **Fuzzy Mathematics :** Basic concept of Fuzzy Logic, Fuzzy set – Basic definition – Mambership function, Operations of fuzzy sets.

5) **Fuzzy Theory :** Fuzzy relations - Fuzzy graphs - Fuzzy analysis – Propositional logic, predictive logic, Fuzzy set theory.
AI Applications in Power Systems : Application of ANN and Fuzzy logic in Power System Planning, Operation and control – load forecasting, Unit Commitment, Load Dispatch and Protection.

Reference Books:

a. "Neural Networks, Fuzzy Logic & Genetic Algorithms Synthesis & Applications" By S. Rajsekaram, G. A. Vijayalaxmi Pai, Practice Hall India
b. "Introduction to Neural Network Using MATLAB 6.0" By S. N. Sivanandam, S. Sumathi, S. N. Deepa, , Tata McGraw Hill
c. "'Fuzzy Sets, Uncertainty and Information" By George Klir & Tina. A. Folger, Prentice Hall of India Pvt. Ltd
d. "Artificial Intelligence" By G. F. Luger and W. A. Stubblefield, Redwood City, CA: Benjamin Cummings, 1993.
e. "Fundamentals of Artificial Neural Network" By Mohamed H. Hassoun, Practice Hall India.
f. "Introduction to Artificial Intelligence" By Eugene Charniat, Drew McDermott, Pearson Education.
g. "An Introduction to Neural Networks" By James A. Anderson, Practice Hall India Publication.

iii. Renewable Energy Sources

Teaching Scheme:	***Examination Scheme:***
Lectures: 3 Hrs. /Week	*Theory Paper: 100 Marks*
	Duration: 3 hours

1) **Energy Scenario:** Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts. Global environmental concern, Kyoto Protocol, Concept of Clean Development Mechanism (CDM) and Prototype Carbon Funds (PCF). Factors favoring and against renewable energy sources.

2) **Solar Energy:** Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, - solar cells , cell technologies, characteristics of PV systems, equivalent circuit, array design , building integrated PV system, its components , sizing and economics. Peak power operation. Standalone and grid interactive systems.

3) **Wind Energy:** Wind Energy : wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Turbine rating Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.

4) **Other energy sources:** Biomass – various resources, energy contents, technological advancements, conversion of biomass in other form of energy – solid, liquid and gases. Gasifires Biomass fired boilers, Co firing, Generation from municipal solid waste, Issues in harnessing these sources. Hydro energy – feasibility of small, mini and micro hydel plants scheme layout economics. Tidal and wave energy, Geothermal and Ocean-thermal energy conversion (OTEC) systems – schemes, feasibility and viability.

5) **Energy storage and hybrid system configurations:** Energy storage: Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Fly wheel energy relations, components, benefits over battery. Fuel Cell energy storage systems. Ultra Capacitors.
   Grid Integration : Stand alone systems, Hybrid systems – hybrid with diesel, with fuel cell, solar wind, wind –hydro systems, mode controller, load sharing, system sizing. Hybrid system economics. Grid integration with the system: Interface requirements, Stable operation, Transient-safety, Operating limits of voltage, frequency, stability margin, energy storage, and load scheduling. Effect on power quality - harmonic distortion, voltage transients and sags.

Reference Books :

a. "Wind and solar systems" By Mukund Patel, CRC Press.
b. "Solar Photovoltaics for terrestrials" By Tapan Bhattacharya.
c. "Wind Energy Technology" By Njenkins, John Wiley & Sons,
d. "Non Conventional Energy Resources" by D.S. Chauhan and S.K.Srivastava,.
e. "Solar Energy" By S.P. Sukhatme, Tata McGraw Hill.
f. "Solar Energy" By S. Bandopadhay, Universal Publishing.

iv. Power Sector Economics, Management and Restructuring

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) **Power Sector in India**
   Introduction to various institutions in Indian Power sector such as CEA, Planning Commissions, PFC, Ministry of Power, state and central governments, REC, utilities and their roles. Critical issues / challenges before the Indian power sector, Salient features of Electricity act 2003, Various national policies and guidelines under this act.
2) **Power sector economics and regulation**
   Typical cost components and cost structure of the power sector, Different methods of comparing investment options, Concept of life cycle cost , annual rate of return , methods of calculations of Internal Rate of Return(IRR) and Net Present Value(NPV) of project, Short term and long term marginal costs, Different financing options for the power sector. Different stakeholders in the power sector, Role of regulation and evolution of regulatory commission in India, types and methods of economic regulation, regulatory process in India.
3) **Power Tariff**
   Different tariff principles (marginal cost, cost to serve, average cost), Consumer tariff structures and considerations, different consumer categories, telescopic tariff, fixed and variable charges, time of day, interruptible tariff, different tariff based penalties and incentives etc., Subsidy and cross subsidy, life line tariff, Comparison of different tariff structures for different load patterns. Government policies in force from time to time. Effect of renewable energy and captive power generation on tariff. Determination of tariff for renewable energy.
4) **Power sector restructuring and market reform**
   Different industry structures and ownership and management models for generation, transmission and distribution. Competition in the electricity sector- conditions, barriers, different types, benefits and challenges Latest reforms and amendments. Different market and trading models / arrangements, open access, key market entities- ISO, Genco, Transco, Disco, Retailco, Power market types, Energy market, Ancillary service market, transmission market, Forward and real time markets, market power.
5) **Electricity Markets Pricing and Non-price issues**
   Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs. Dynamic, spot pricing and real time pricing, Dispatch based pricing, Power flows and prices. Optimal power flow Spot prices for real and reactive power. Unconstrained real spot prices, constrains and real spot prices. Non price issues in electricity restructuring (quality of supply and service, standards of performance by utility, environmental and social considerations) Global experience with electricity reforms in different countries.

Reference Books :

a. "Know Your Power", A citizens Primer On the Electricity Sector, Prayas Energy Group, Pune
b. Sally Hunt, "Making Competition Work in Electricity", 2002, John Wiley Inc
c. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy

LABORATORY PRACTICE-I

Teaching Scheme:
Practical: 6 Hrs. /Week

Examination Scheme:
Term Work: 100 Marks
Oral: 50 Marks

Term work shall consist of record of minimum eight experiments using Engineering Computation Software such as MATLAB, SCILAB, PSCAD, ETAP, with moderate to high complexity /assignments based on syllabus of subjects from Semester-I

SEMINAR-I

Teaching Scheme: *Practical: 4 Hrs. /Week*

Examination Scheme: *Term Work: 100 Marks*

Each student is required to deliver a seminar in first semester on the topic of his/her own choice. The topic of the seminar should be out of the syllabus and relevant to the latest trends in Electrical Power Systems.

The topic will be decided by the student, Guide and Head of department. Each student will make seminar presentation with audio/video aids, for the duration of 45 minutes and seminar work shall be in format of report to be submitted by the student at the end of semester.

The report copies must be duly signed by Guide and Head of department. (One copy for institute, one copy for guide and one copy for candidates for certification). The student is expected to submit the seminar report in standard format. Attendance of all students for all seminars is compulsory.

SEMESTER-II

1. COMPUTER METHODS IN POWER SYSTEM ANALYSIS

Teaching Scheme: *Lectures: 3 Hrs. /Week*

Examination Scheme: *Theory Paper: 100 Marks* *Duration: 3 hours*

1) Representation of power systems for computerized analysis: Mathematical models of synchronous generator for steady state and transient analysis, Transformer with tap changer, transmission line, phase shifter and loads.

2) Topology of Electric Power System-Network Graphs, Incidence matrices, fundamental loop and cutset matrices, primitive impedance and admittance matrices, equilibrium equations of networks. Singular and nonsingular transformation of network matrices.

3) Formation of bus impedance and admittance matrices by algorithm - Modification of bus impedance and admittance matrix to account for change in networks. Derivation of loop impedance matrix. Three phase network elements-transformation matrix - incidence and network matrices for three phase network. Algorithm for formulation of three - phase bus impedance matrix.

4) Short Circuit Studies: Three phase network, Symmetrical components. Thevenin's theorem and short circuit analysis of multi node power systems using bus impedance matrix. Short circuit calculations for balanced and unbalanced short circuits bus impedance and loop impedance matrices, Stability studies- Solution of state equation by modified Eular method and solution of network equations by Gauss-Seidal interactive method

5) Load flow studies : Slack bus, load buses, voltage control buses, Load flow equations, Power flow model using bus admittance matrix, Power flow solution through Gauss-Seidal and N-R methods - sensitivity analysis, Second order N-R method, fast decoupled load flow method - Sparsity of matrix. Multi area power flow analysis with the line control.

Reference Books :

a. "Computer Methods in Power System Analysis" By G.W. Stagg, A.H.Elabiad, McGraw Hill Book Co.
b. "Computer Techniques in Power System Analysis" By M.A. Pai, Tata McGraw Hill Publication.
c. "Electric Energy System Theory" By O.I.Elgard, Tata McGraw Hill Publication.
d. "Computer Aided Power System Operation and Analysis" By R.N.Dhar, Tata McGraw Hill Publication.
e. "Modern Power System Analysis" By I.J.Nagrath, D.E.Kothar, Tata McGraw Hill, New Delhi.

2. Digital Signal Processing

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) Characterization & Classification of Digital Signals. Digital Signal Processing of continuous signals. Discrete time signals - sequences, representation of signals on orthogonal basis, sampling, aliasing, quantization & reconstruction of signals.

2) Discrete systems-attributes, z-transform, analysis of LTI system. Frequency analysis, inverse systems, Discrete Fourier transforms, Fast Fourier implementation of discrete time system.

3) Digital filters - structures, sampling, recursive, non-recursive A to D & D to A conversion. FIR, IIR & lattice filter structures, Design of FIR digital filters. Window method, Park-McCellan's method. Design of IIR digital filters. Butterworth, Chebyshev.

4) Elliptic approximations, low-pass, band-pass, band-stop & high-pass filters. Effect of finite register length in FIR filter design. Multirate signal processing-motivation-application, decimation & interpolation, sample rate conversion, polyphase implementation of sampling rate conversion, Filter bank theory-DFT filter banks, Adaptive filtering theory.

5) DSP Processors and Applications - DSP Microprocessor architectures, fixed point, floating point precision, algorithm design, mathematical, structural and numerical constraints, DSP programming, filtering, data conversion; communication applications. Real time processing considerations including interrupts.

Reference Books :

a. "Digital Signal Processing Principles, Algorithm and Applications" By J.G.Proakis and D.G.Manolakis '' Prentice Hall 1997
b. "Discrete Time Signal Processing" By A.V.Oppenheim, R.W.Schafer, John Wiley.
c. "Introduction to Digital Signal Processing" By J.R. Johnson,Prentice Hall 1992
d. "Digital Signal Processing" By D.J.Defatta, J.G.Dulas. Hodgekiss, J. Wiley and Sons Singapore, 1988
e. "Theory & Applications of Digital Signal Processing" By L.R.Rabiner & B. Gold , Prentice Hall, 1992
f. "Digital Signal Processing:A Practical Approch" By Emmanuel Ifeachor, Prof. Barrie Jervis, Prentice Hall

3. Power System Modeling & Control

Teaching Scheme: *Lectures: 3 Hrs. /Week*

Examination Scheme: *Theory Paper: 100 Marks* *Duration: 3 hours*

1**)** Transient response and concept of stability in Electrical Power System. Modelling of Power System. Control of voltage, frequency and tie-line power flows, Q-V and P-f control loops, mechanism of real and reactive power control.

2) Mathematical model of speed governing system. Turbine governor as affecting the power system dynamics. Transient and steady state response in the interconnected power systems. Excitation systems. Transformation model of exciter system. Analysis using block diagrams.

3) Power systems stabilizers. Dynamic stability (small disturbances), effect of excitation control and turbine dynamics, characteristic equation, method of analysis of the stability of power system. Multi machine systems, Flux decay effects. Multi machine systems with constant impedance loads, matrix representation of a passive network in the transient state, converting to a common reference frame. Converting machine co-ordinates to system reference, relation between machine current and voltages, system order, machine represented by classical methods.

4) Net interchange tie-line bias control. Optimal, sub-optimal and decentralized controllers. Discrete mode AGC. Time - error and inadvertent interchange correction techniques. On-line computer control. Distributed digital control.

5) Data acquisition systems. Emergency control, preventive control, system, System wide optimization, SCADA. Self excited electro-mechanical oscillations in power system and the means for control.

Reference Books :

a. “Transient Processes in Electrical Power System” By V.Venlkov ,Mir Publication, Moscow.
b. “Electric Energy Systems Theory” By Olle I.Elgard , Tata McGraw Hill Pub. Co., New Delhi.
c. “Power System Control and Stability” By Anderson P.M. & Foaud A.A., Galgotia Pub.
d. “Modern Power System Analysis” By Nagrath I.J., Kothari D.P. , Tata McGraw Hill Pub. Co., New Delhi.

4. High Voltage Power Transmission

Teaching Scheme: *Lectures: 3 Hrs. /Week*

Examination Scheme: *Theory Paper: 100 Marks*
Duration: 3 hours

HIGH VOLTAGE AC TRANSMISSION

1) **Engineering Aspects of EHV AC Transmission System:** Principles, configuration, special features of high voltage AC lines, power transfer ability, reactive power compensation, audible noise, corona bundle conductors, electric field, right of way, clearances in a tower, phase to phase, phase to ground, phase to tower, factors to be considered, location of ground wire, angle of protection, tower configuration. Principles of radio interference, origin of radio interference, method of propagation, factors to be considered in line design.

2) **Power System Transients:** Introduction, circuit closing transients, sudden symmetrical short circuit of alternator, recovery transients due to removal of short circuit, traveling waves on transmission lines, wave equation, surge impedance and wave velocity, specifications of traveling waves, reflection and refraction of waves, typical cases of line terminations , equivalent circuit for traveling wave studies, forked lines, reactive termination, successive reflections, Bewley lattice diagram, attenuation and distortion, arcing grounds, capacitance switching, current chopping, lightning phenomenon, over voltages due to lightning, line design based on direct strokes, protection of systems against surges, statistical aspects of insulation co-ordination.

HIGH VOLTAGE DC TRANSMISSION

3) **General Background :** EHV AC versus HVDC Transmission, power flow through HVDC link, equation for HVDC power flow, effect of delay angle and angle of advance, bridge connections, waveform of six pulse and twelve pulse bridge converter, commutation, phase control, angle of extinction, control of DC voltage, connections of three phase six pulse and twelve pulse converter bridges, voltage and current waveforms.

4) Bipolar HVDC terminal, converter transformer connections, switching arrangements in DC yard for earth return to metallic return, HVDC switching system, switching arrangements in a bipolar HVDC terminal, sequence of switching operations, HVDC circuit breakers, DC current interruption, commutation principle, probable types and applications of HVDC circuit breakers, multi-terminal HVDC systems, parallel tapping, reversal of power, configurations and types of multi-terminal HVDC systems, commercial multi terminal systems.

5) Faults and abnormal condition in bipolar, two terminal HVDC system, pole-wise segregation, protective zones, clearing of DC line faults and reenergizing, protection .of converters, transformer, converter valves, DC yards, integration of protection and controls, hierarchical levels of control, block diagram, schematic diagram, current control, power control, DC voltage control, commutation channel, master control, station control, lead station, trail station, pole control, equidistant firing control, synchronous HVDC link, asynchronous HVDC Link.

Reference Books:

a. "An Introduction to High Voltage Engineering" By Subir Ray, Prentice Hall of India Private Limited, New Delhi – 110 001.
b. "HVDC Transmission" By Adamson C., Hingorani N.G., IEEE Press
c. "Power Transmission" By DC Uhimann E.
d. "HVAC and HVDC Transmission, Engineering and practice" By S. Rao, Khanna Publisher, Delhi.
e. "Electric Power Systems" By B.M. Weddy and B.J.Cory, John Wiely and Sons, Fourth edition (2002)
f. "Power System Analysis and Design" By J.Duncan Glover, Mulukutla S.Sarma, Thomson Brooks/cole /Third Edition (2003)
g. "Power System Analysis and Design" By B.R. Gupta, S.Chand and Company (2004)

ELECTIVE-II

i. Advanced Power System Protection

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) Review of principles of power system equipments protection, configuration of various solid state protection scheme, evolution of digital relays from electromechanical relays,

2) performance & operational characteristics of digital protection, Basic elements of digital filtering, analog multiplexers, conversions of system: the sampling theorem, signal aliasing error, sample & hold circuit, multiplexers, analog to digital conversion, digital filtering concepts, A digital relay. Hardware & Software.

3) Mathematical background to protectional algorithm, first derivative (Mann & Morrison) algorithm, Fourier algorithm- full cycle window algorithm, fractional cycle window algorithm,

4) Walsh function based algorithm, least square based algorithm, differential equation based algorithm, travelling wave based technique.

5) Digital differential protection of transformer, digital line differential protection, recent advances in digital protection of power system.

Reference Books:

a. "Digital Protection for Power System" By A.T.Johns and S.K.Salman, Peter, Published by Peter Peregrinus Ltd. on behalf of the IEE, London, U.K.
b. "Power System Protection and Switchgear" By Badri Ram and D.N.Vishvakarma, Tata McGraw Hill, New Delhi.
c. "Transmission Network Protection" By Theory and Practice, Y.G.Paithankar, Marcel Dekker, New York, U.S.A.
d. "Fundamentals of Power System Protection" By Y.G.Paithankar and S.R. Bhide, Prentice Hall of India, New Delhi.

ii. Power Electronics Applications in Power Systems

Teaching Scheme:	***Examination Scheme:***
Lectures: 3 Hrs. /Week	*Theory Paper: 100 Marks*
	Duration: 3 hours

1) **Power Electronic Controllers**: Basics, challenges and needs, static power converter structures, AC controller based structures, D.C. link converter topologies, converter output and harmonic control, power converter control issues.

2) **Shunt Compensation**: SVC and STATCOM: Operation and control of SVC, STATCOM configuration, control & applications.
Series Compensation: Principle of operation, application of TCSC for damping of electromechanical oscillations, application of TCSC for mitigation of sub-synchronous resonance, TCSC layout and protection, static synchronous series compensator (SSSC).

3) **Unified Power Flow Controller:** Steady state operation, control and characteristics, introduction to transient performance, power flow studies in UPFC embedded systems, Operational constraints on UPFC.

4) **Other FACTS Controllers:** Circuit, model and operating features of Dynamic Voltage Regulator(DVR), Thyristor Controlled Braking Resistors (TCBR), Thyristor Controlled Phase Angle Regulator(TCPAR), comparison of all FACTS controllers.

5) **Control Strategies and co-ordination :** Conventional control, Hysterisis control, Artificial Neural Network, fuzzy logic controls, comparison between different control schemes, co-ordination between different FACTS controllers.

Reference Books:

a. "Flexible A.C. Transmission Systems (FACTS)" By Yong Hua Song and Johns (IEE Power and Energy Series 30)
b. "Thyristor based FACTS controllers" By Mathur & Verma (IEEE Press, New York)
c. "Sub-synchronous Resonance" By K.R. Padiyar, B.S. Publications, Hyderabad.
d. "FACT's Controllers in Transmission & Distribution" by K.R. Padiyar New Age Publishers ,Delhi, May 2007

iii. EHV Transmission Systems

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) Basic Aspects of A.C. Power Transmission, Power-Handling Capacity and Line Loss, Surface Voltage Gradient on Conductors, Electrostatic Field of EHV Lines. Measurement of Electrostatic Fields. Electromagnetic Interference. Traveling Waves and Standing Waves, Line Energization with Trapped - Charge Voltage. Reflection and Refraction of Traveling Waves. Transient Response of Systems with Series and Shunt Lumped Parameters. Principles of Traveling-Wave Protection

2) Lightning & Lightning Protection, Insulation Coordination Based on Lightning

3) Over Voltages in EHV Systems Caused by Switching Operations, Origin of Over Voltages and their Types, Over Voltages Caused by Interruption of Inductive and Capacitive Currents, Ferro-Resonance Over Voltages, Calculation of Switching Surges, Power Frequency Voltage Control and Over Voltages, Power Circle Diagram.

4) Reactive Power Flow and Voltage Stability in Power Systems. Steady - State Static Real Power and Reactive Power Stability, Transient Stability, Dynamic Stability. Basic Principles of System Voltage Control. Effect of Transformer Tap Changing in the Post- Disturbance Period, Effect of Generator Excitation Adjustment, Voltage Collapse in EHV Lines, Reactive Power Requirement for Control of Voltage in Long Lines. Voltage Stability.

5) Power Transfer at Voltage Stability Limit of EHV Lines, Magnitude of Receiving End Voltage at Voltage Stability Limit. Magnitude of Receiving End Voltage During Maximum Power Transfer. Magnitude of Maximum Power Angle at Voltage Stability Limit. Optimal Reactive Power at Voltage Stability Limit.

Reference Books:

a. "Performance, operation & control of EHV power transmission system" A. Chakrabarti, D.P. Kothari, A.K. Mukhopadhyay, wheeler publications
b. "Extra high-voltage A.C. transmission Engineering" By Rakash Das Begamudre, New Age International Pvt. Ltd.
c. "EHVAC & HVDC Transmission Engineering & Practice" By S. Rao, Khanna Publications

iv. Power System Design

Teaching Scheme:
Lectures: 3 Hrs. /Week

Examination Scheme:
Theory Paper: 100 Marks
Duration: 3 hours

1) Power System Components, Location of Main Generating Stations and Substations, Interconnections, Load Dispatch Centers

2) Design of Transmission Lines, Selection of Voltage, Conductor Size, Span, Number of Circuits, Conductor Configurations, Insulation Design, Mechanical Design of Transmission Line, Towers, Sag- Tension Calculations

3) Design of EHV Transmission Line Based Upon Steady State Limits and Transient Over Voltage, Design Factors Under Steady States, Design of 400kV, 1000MW Medium and Long Transmission Line Without and with Series Capacitance Compensation and Shunt Reactors at Both Ends, 750KVLong Transmission Line with Only Shunt Reactors. Extra High Voltage Cable Transmission, Design Basis of Cable Insulation, Search Performance of Cable Systems, Laying of Power Cables

4) Vigorous Solution of Long Transmission Line, Interpretation of Long Line Equations, Ferranti Effect, Tuned Power Lines, Equivalent Circuit of Long Line, Power Flow Thorough Transmission Line and Methods of Voltage Control

5) Power System Earthing, Earth Resistance, Tolerable and Actual Step and Touch Voltages, Design of Earthing Grid, Concrete Encased Electrodes, Tower Footing Resistance, Impulse Behavior of Earthing System

Reference Books:

a. "Electrical Power System Design" By M.V. Deshpande, Tata McGraw Hill
b. "Power System Analysis and Design" By B.R.Gupta, Wheeler Publishing co.
c. "Power System Engineering" By I.J.Nagrath & D. P. Kothari, Tata Mc Graw Hill
d. "Extra high-voltage A.C. transmission Engineering" By Rakosh Das Begamudre, New Age International Pvt. Ltd.
e. "EHV AC & HVDC Transmission Engineering & Protection" By S.S.Rao, Khanna Publishers

LABORATORY PRACTICE-II

Teaching Scheme:
Practical: 6 Hrs. /Week

Examination Scheme:
Term Work: 100 Marks
Oral: 50 Marks

Term work shall consist of record of minimum eight experiments using Engineering Computation Software such as MATLAB, SCILAB, PSCAD, ETAP, with moderate to high complexity /assignments based on syllabus of subjects from Semester-II

SEMINAR-II

Teaching Scheme: *Practical: 4 Hrs. /Week*

Examination Scheme: *Term Work: 100 Marks*

Each student is required to deliver a seminar in second semester on the topic of his/her own choice. The topic of the seminar should be out of the syllabus and relevant to the latest trends in Electrical Power Systems.

The topic will be decided by the student, Guide and Head of department. Each student will make seminar presentation with audio/video aids, for the duration of 45 minutes and seminar work shall be in format of report to be submitted by the student at the end of semester.

The report copies must be duly signed by Guide and Head of department. (One copy for institute, one copy for guide and one copy for candidates for certification). The student is expected to submit the seminar report in standard format. Attendance of all students for all seminars is compulsory.

SEMESTER-III

SEMINAR-III

Teaching Scheme:	***Examination Scheme:***
Practical: 4 Hrs. /Week	*Term Work: 50 Marks*
	Oral: 50 Marks

Each student will select a topic in the area of electrical engineering, related to M. E. Project Stage-I.

The topic will be decided by the student, guide and Head of department. Each student will make seminar presentation with audio/video aids, for the duration of 45 minutes and seminar work shall be in format of report to be submitted by the students at the end of semester.

The report copies must be duly signed by guide and Head of department. (One copy for institute, one copy for guide and one copy for candidates for certification). The student is expected to submit the seminar report in standard format. Attendance of all students for all seminars is compulsory.

PROJECT STAGE-I

Teaching Scheme: *Practical: 18 Hrs. /Week*

Examination Scheme: *Term Work: 100 Marks*

Project Stage – I is the integral part of the dissertation project. The project should be based on the knowledge acquired by the student during the coursework and should contribute to the needs of the society.

The project aims to provide an opportunity of designing and preparing complete system or subsystems in an area where the student like to acquire specialized skills. The student should present the progress of the project. It will consist of problem statement, literature survey; project overview and scheme of implementation (block diagram, algorithm, program, PERT chart, etc.)

The term work should be continuously evaluated as per the norms/guidelines.

SEMESTER-IV

PROGRESS SEMINAR

Examination Scheme:
Term Work: 50 Marks

Each student will select a topic in the area of electrical engineering, related to M. E. Project Stage-II.

The topic will be decided by the student, guide and Head of department. Each student will make seminar presentation with audio/video aids, for the duration of 45 minutes and seminar work shall be in format of report to be submitted by the students at the end of semester.

The report copies must be duly signed by guide and Head of department. (One copy for institute, one copy for guide and one copy for candidates for certification). The student is expected to submit the seminar report in standard format. Attendance of all students for all seminars is compulsory.

PROJECT STAGE-II

Teaching Scheme:
Practical: 18 Hrs. /Week

Examination Scheme:
Term Work: 150 Marks
Oral: 100 Marks

The project work will start in second year (Continue to project stage-I).

The term work should be continuously evaluated as per the norms/guidelines.

The project work (dissertation) should be presented in a standard format.
The oral examination shall be conducted with the help of approved external examiner, appointed by university.