M.TECH. POWER SYSTEM ENGINEERING (EPS)

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. POWER SYSTEM ENGINEERING (EPS)

(2014-16)

I Semester | **Credit Based**

Subject Code	Name of the Subject	Teaching Hours/week		Duration of Exam in Hours	Marks for		Total Marks	Credits
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14MAT11	Applied Mathematics	4	2	3	50	100	150	4
14 EPS 12	Modeling and Analysis of Electrical Machines	4	2	3	50	100	150	4
14 EPS 13	Power system Dynamics and Control	4	2	3	50	100	150	4
14 EPS 14	Digital Protection of Power Systems	4	2	3	50	100	150	4
14 EPS 15X	Elective-I	4	2	3	50	100	150	4
14 EPS 16	Power System Laboratory - I	--	3	3	25	50	75	2
14 EPS 17	Seminar	--	3	--	25	--	25	1
	Total	**20**	**16**	**18**	**300**	**550**	**850**	**23**

Elective – I

Subject Code	Name of the Subject
14EPS151	Linear and Nonlinear Optimization
14EPS152	EHV AC Transmission
14EPS153	High Voltage Power Apparatus

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. POWER SYSTEM ENGINEERING (EPS)

(2014-16)

II Semester **Credit Based**

Subject Code	Name of the Subject	Teaching Hours/week		Duration of Exam in Hours	Marks for		Total Marks	Credits
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14EPS21	Economic Operation & Control of Power Systems	4	2	3	50	100	150	4
14 EPS 22	Distribution System Design & Control	4	2	3	50	100	150	4
14 EPS 23	Reactive Power Management in Power System	4	2	3	50	100	150	4
14 EPS 24	HVDC Power Transmission	4	2	3	50	100	150	4
14 EPS 25X	Elective-II	4	2	3	50	100	150	4
14 EPS 26	Power System Laboratory - II		3	3	25	50	75	2
14 EPS 27	Seminar	--	3	--	25	--	25	1
	**Project Phase-I (6 week Duration)	--	--	--	--	--	--	--
	Total	**20**	**16**	**18**	**300**	**550**	**850**	**23**

**** Between the II Semester and III Semester, after availing a vacation of 2 weeks.**

Elective – II

Subject Code	Name of the Subject
14EPS251	Power System SCADA
14EPS252	Intelligent System Applications to Power System
14EPS253	Power Quality Enhancement using Custom Power Devices

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. POWER SYSTEM ENGINEERING (EPS)

(2014-16)

III Semester: INTERNSHIP								**Credit Based**
Course Code	**Subject**	**No. of Hrs./Week**		**Duration of Exam in Hours**	**Marks for**		**Total Marks**	**Credits**
		Lecture	**Practical/ Field Work**		**I.A.**	**Exam**		
14EPS31	Seminar/Presentation on Internship (After 8 weeks from the date of commencement)	--	--	--	25	--	25	1
14EPS32	Report on Internship	--	--	--	--	75	75	15
14EPS33	Evaluation and Viva-Voce	--	--	--	--	50	50	4
Total		**--**	**--**	**--**	**25**	**125**	**150**	**20**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. POWER SYSTEM ENGINEERING (EPS)

(2014-16)

IV Semester **Credit Based**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	Credits
		Lecture	Field Work / Assignment / Tutorials		I.A.	Exam		
14EPS41	FACTS Controllers	4	--	3	50	100	150	4
14EPS 42X	Elective-III	4	--	3	50	100	150	4
14EPS43	Evaluation of Project Phase – II	--	--	--	25	--	25	1
14EPS44	Evaluation of Project work – III	--	--	--	25	--	25	1
14EPS45	Evaluation of Project Work and Viva-voce	--	--	3	–	100+100	200	18
	Total	**8**	**--**	**09**	**50**	**400**	**550**	**28**

Grand Total (I to IV Sem.) : 2400 Marks

: 94 Credits

Elective – III

Subject code	**Name of the Subject**
14EPS421	Power System Reliability Engineering
14EPS422	Smart Gird
14EPS423	Planning & Management of Deregulated Power Systems

Note:

1) Project Phase – I:6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carryout literature survey / visit to Industries to finalize the topic of dissertation.

2) Project Phase – II**:**16 weeks duration. 3 days for project work in a week during III Semester. Evaluation shall be taken during the first two weeks of the IV Semester. Total Marks shall be 25.

3) Project Phase – III:24 weeks duration in IV Semester. Evaluation shall be taken up during the middle of IV Semester. At the end of the semester Project Work evaluation and Viva-Voce Examinations shall be conducted.

   Total Marks shall be 250 (Phase - II Evaluation: 25 Marks, Phase – III Evaluation:25 Marks, Project Evaluation marks by Internal Examiner (Guide):50, Project Evaluation marks by External Examiner: 50, Viva-Voce Examination: 100 Marks).

   Marks of Evaluation of Project:

   - The I.A. Marks of Project Phase – II & III shall be sent to the University along with Project Workreport at the end of the Semester.

4) During the final viva, students have to submit all the reports.

5) The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following:

   a) Head of the Department (Chairman)
   b) Guide
   c) Two Examiners appointed by the university (Out of two external examiners at least one should be present).

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
APPLIED MATHEMATICS			
Subject Code	14MAT11	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Methods: Solution of algebraic and transcendental equations- iterative methods based on second degree equation – Muller method,(no derivation) Chebyshev method, general iteration method (first order),acceleration of convergence, system of non-linear equations, and complex roots – Newton-Raphson method, polynomial equations – Birge –Vieta method and Bairstow's method.

Numerical Solution of Partial Differential Equations: Classification of second order equations, parabolic equations- solution of one dimensional heat equation, explicit method, Crank-Nicolson method and Du Fort-Frankel method, hyperbolic equations- solution of one dimensional wave equation.

System of Linear Algebraic Equations and Eigen Value Problems: Iterative methods - Gauss-Seidal method, SOR method, Eigen value problems – Gerschgorian circle, Eigen values and Eigen vectors of real symmetric matrices -Jacobi method, Givens method.

Interpolation: Hermite interpolation, spline interpolation, numerical solution of differential equations – Numerov method.

Optimization: Linear programming- formulation of the problem, graphical method, general linear programming problem, simplex method, artificial variable technique -M-method.

Graph Theory: Basic terminologies, types of graphs, sub graphs, graphs isomorphism, connected graphs-walks, paths, circuits, connected and disconnected graphs, operations on graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, applications of graphs.

Linear Algebra: Vector spaces, linear dependent, independence, basis and dimension, elementary properties, examples.

Linear Transformations: Definition, properties, range and null space, rank and nullity, algebra of linear transformations- invertible, singular and non-singular transformations, representation of transformations by matrices.

REFERENCE BOOKS

1. M K Jain, S R K Iyengar and R K Jain, "Numerical Methods for Scientific and Engineering Computations", New Age International, 2004.
2. M K Jain, "Numerical Solution of Differential Equations", 2nd Edition, New Age International, 2008.
3. Dr. B.S. Grewal, "Numerical Methods in Engineering and Science", Khanna Publishers, 1999.
4. Dr. B.S. Grewal, "Higher Engineering Mathematics", 41stEdition, Khanna Publishers, 2011.
5. NarsinghDeo, "Graph Theory with Applications to Engineering and Computer Science", PHI, 2012.
6. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2ndEdition, PHI, 2011.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
MODELING AND ANALYSIS OFELECTRICAL MACHINES			
Subject Code	14EPS12	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of PracticalHours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Basic Concepts of Modeling: Basic two pole machine representation of commutator machines, 3-phase synchronous machine with and without damper bar and 3-phase induction machine, Kron's primitive machine-voltage, current and torque equations.

DC Machine Modeling: Mathematical model of separately excited DC motor-steady state and transient state analysis, sudden application of inertia load, transfer function of separately excited DC motor, mathematical model of dc series motor, shunt motor, linearization techniques for small perturbations.

Reference Frame Theory: Real time model of a two phase induction machine, transformation to obtain constant matrices, three phase to two phase transformation, power equivalence.

Dynamic Modeling of Three Phase Induction Machine: Generalized model in arbitrary frame, electromagnetic torque, deviation of commonly used induction motor models-stator reference frames model, rotor reference frames model, synchronously rotating reference frames model, equations in flux linkages, per unit model, dynamic simulation.

Small Signal Equations of the Induction Machine: Derivation of small signal equations of induction machine, space phasor model, DQ flux linkages model derivation, control principle of the induction motor.

Transformer Modeling: Introduction, single phase transformer model, three phase transformer connections, per phase analysis, normal systems, per unit normalization, per unit three phase quantities, change of base, per unit analysis of normal system, regulating transformers for voltage and phase angle control, auto transformers, transmission line and transformers.

Modeling of Synchronous Machines: Introduction, voltage equations and torque equation in machine variables, stator voltage equations in arbitrary and rotor reference frame variables, Park's equations, torque equations in substitute variables, rotor angle and angle between rotors, per unit system, analysis of steady state operation.

Dynamic Analysis of Synchronous Machines: Dynamic performance during sudden change in input torque and during a 3-phase fault at the machine terminals, approximate transient torque versus rotor angle characteristics, comparison of actual and approximate transient torque-angle characteristics during a sudden change in input torque; first swing transient stability limit, comparison of actual and approximate transient torque-angle characteristics during a 3-phase fault at the machine terminals, critical clearing time, equal area criterion, computer simulation.

REFERENCE BOOKS

1. P.S.Bimbra, “Generalized Theory of Electrical Machines”, 5thEdition, Khanna Publications, 1995.
2. R. Krishnan, “Electric Motor Drives - Modeling, Analysis & Control”, PHI Learning Private Ltd, 2009.
3. P.C.Krause, Oleg Wasynczuk, Scott D.Sudhoff, “Analysis of Electrical Machinery and Drive Systems”, 2ndEdition, Wiley(India),2010.
4. Arthur R Bergen and Vijay Vittal, “Power System Analysis”, 2nd Edition, Pearson, 2009.
5. PrabhaKundur, “Power System Stability and Control”, TMH, 2010.
6. Chee-MunOng, “Dynamic Simulation of Electric Machinery using Matlab / Simulink”,Prentice Hall, 1998.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
POWER SYSTEM DYNAMICS AND STABILITY CONTROL			
Subject Code	14EPS13	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Basic concepts: Power system stability states of operation and system security system dynamics problems system model analysis of steady State stability and transient stability, simplified representation of Excitation control.

Modeling of synchronous machine: synchronous machine, Park's Transformation, Transformation of flux linkages, Transformation of stator voltage equations and rotor equations,
Analysis of steady state performance, per unit quantities, Equivalent circuits of synchronous machine - determination of parameters of equivalent circuits.

Excitation system: Excitation system modeling, excitation systems block Diagram systemrepresentation by state equations. Prime mover control system, Modeling of Transmission lines and loads,

Dynamics of a synchronous generator connected to infinite bus: system model, Synchronous machine model, stator equations, rotor equations, Synchronous machine model with field circuit and one equivalent damper winding on q axis (model 1.1), calculation of Initial conditions.

Analysis of single machine system: small signal analysis with block diagram, Representation characteristic equation and application of Routh Hurwitz criterion, Synchronizing and damping torque analysis, small signal model State equations.

Application of power system stabilizers: basic concepts in applying PSS, Control signals,
structure and tuning of PSS, washout circuit, dynamic compensator analysis of single machine infinite bus system with and without PSS.

REFERENCE BOOKS

1. K.R. Padiyar, "Power system dynamics", B.S. Publications, Hyderabad
2.P.M. Anderson and A.A. Fouad "Power system control and stability", 2nd edition. B.S. Publications Hyderabad.
3.Peter W. Sauer &M. A. PaiPower System Dynamics and Stability Prentice Hall

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
DIGITAL PROTECTION OF POWER SYSTEMS			
Subject Code	14EPS14	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Introduction to Digital Relay: Introduction, advantages of microprocessor technology, microprocessor application to protection, measures of noise and surge immunity, desirable features in a protection scheme, integrated hierarchical computer control and protection, subsystems of a digital relay, operating algorithms, substation digital protection system, adaptive relaying, simulators for testing.

Transient Analysis of Power Systems: Introduction, derivation of linear equivalents, G-matrix building and nodal solutions, modeling of 3-phase networks, frequency dependence of distributed parameters of lines, switches and non-linear elements, modeling of induction motors, synchronous machines, transformers and control devices, analysis of simulation result.

Current Voltage Transformers: Introduction, current transformers, equivalent circuits, transient performance, modeling for transient simulation, use of mimic impedance, voltage transformers, VT model, modeling for transient simulation, wound voltage transformers, relay performance, dynamic compensation for CTs and PTs, compensating algorithms for CTs and dynamic compensation of CTs, analysis of simulation results.

Hardware Considerations: Continuous versus discrete time signals: introduction, computer architectures, analog signal conditioning, anti-aliasing filter, amplitude and phase response of low pass filters, Butterworth low pass filter, sample and hold circuit, multiplexer, A/D relay, microcomputers for digital relay: introduction, data acquisition interface card for personal computer, DSP processor based hardware schemes,TMS32050 DSP based general purpose hardware, Dual DSP based SBC hardware, microcontroller(Intet-80196)based SBC card, digital relay implementation procedure using microcontroller(Intel-80196) SBC card.

Relaying Algorithms: Introduction, classification of relaying algorithms, algorithms for numerical relaying, sample and derivative technique, Proder 70 Algorithm, full cycle Fourier algorithm, cosine filters, Fourier half cycle algorithm modified half cycle Fourier algorithm, Walsh algorithm, Harr algorithm, least squares fitting algorithm, differential equation algorithm, improved digital harmonic filtering algorithm, mean square error minimization technique.

Protection of Power System Components: Introduction, bus bar protection, digital protection schemes for bus bars.

Transformer Protection: Introduction, digital techniques for protection of transformers, harmonic restraint percentage differential protection, voltage restraint technique, flux restraint approach.

Digital Relays for Synchronous Generators Protection: Introduction, multifunction protection scheme, differential protection of stator windings, 100% stator ground fault protection, negative sequence protection, under impedance protection, out of set generator protection, over-fluxing detection algorithm.
Protection Features in Numerical Distance Relays: Relaying algorithms, distance relay characteristics, multiprocessor based poly-phase numerical distance relay, feeder protection, introduction, special over current relay characteristics, typical numerical over-current relay, motor protection.

REFERENCE BOOKS

1. K. Parthasarathy, “Digital Protection of Power Systems”, ISTE WPLP Learning Material Series, Indian Society for Technical Education, Bangalore, 2006.

2. T.S.Madhava Rao, “Power System Protection – Static Relays”, 2nd Edition, TMH Publication, 2009.
3. Arun G. Phadke, James S.Thorp, “Computer Relaying for Power Systems”, John Wiley and Sons Inc, 2nd Edition, 2009.
4. A.T.Johns and S.K.Salman, “Digital Protection for Power Systems” Peter Peregrinus Ltd, Institution of Electrical Engineers, 1997.
5. T.S.M. Rao, Digital/Numerical Relays, TMH,2005.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
LINEAR AND NONLINEAR OPTIMIZATION (ELECTIVE-I)			
Subject Code	14EPS151	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Optimization: Introduction, historical development, engineering applications of optimization, statement of an optimization problem, design vector, design constraints, constraint surface, objective function, objective function surfaces, classification of optimization problems based on existence of constraints, nature of the design variables, physical structure of the problem, nature of the equations involved, nonlinear and linear programming problem(NLP and LPP), permissible values of the design variables, deterministic nature of the functions, number of objective functions, optimization techniques.

Classification of Optimization Problems: Introduction, single variable optimization, multivariable optimization with no constraints, semi-definite case, saddle point, multivariable optimization with equality constraints, solution by direct substitution, by the method of constrained variation and by the method of Lagrange multipliers, multivariable optimization with inequality constraints, Kuhn-Tucker conditions, constraint qualification, formation of LLP, graphical method.

Linear Programming-I: Introduction, applications of linear programming, standard form of a LPP, geometry of LPP, definitions and theorems, solution of a system of linear simultaneous equations, pivotal reduction of a general system of equations, motivation of the simplex method, simplex algorithm, identifying an optimal point, improving a non-optimal basic feasible solution, two phases of the simplex method.

Linear Programming-II: Revised simplex method, duality in linear programming; symmetric and primal-dual relations, primal-dual relations when the primal is in standard form, duality theorems, dual simplex method, decomposition principle, sensitivity or post- optimality analysis, changes in right-hand-side constants b_i, changes in the cost coefficients C_j, addition of new variables, changes in the constraint coefficients a_{ij}, addition of constraints. Transportation problem, Karmarkar's method, statement of the problem, conversion of an LPP into required form, algorithm, quadratic programming.

Non-Linear Programming - One Dimensional Minimization Methods: Introduction, Unimodal function, Unrestricted search with fixed step size and accelerated step size, exhaustive search, dichotomous search, interval halving method, Fibonacci method, golden section method, comparison of elimination methods, interpolation methods, quadratic and cubic, direct root methods, Newton, Quasi-Newton and Secant methods, practical considerations.

Non-Linear Programming - Unconstrained Minimization Methods: Introduction, direct search methods: random search methods, grid search, univariate, pattern directions, Hook and Jeeve's method, Powel's methods, Rosenbrock's method of rotating coordinates, simplex methods, reflection, expansion, contraction, indirect search methods, gradient of a function, Cauchy method, conjugate gradient methods, Newton's method, Marquadrant method, quasi- Newton methods, Davidon-Fletcher-Powel method, Broydon- Fletcher – Goldfarb – Shanno method, test functions , constrained and unconstrained optimization techniques, direct and indirect methods.

REFERENCE BOOKS

1. Singiresu S Rao(S S Rao), "Engineering Optimization", John Wiley and SonsInc,1996.

2. David MautnerHimmelblau, “Applied Nonlinear Programming”, McGraw-Hill, 1972.
3. A P Verma, “Operation Research”, S. K. Kataria& Sons, 2009.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
EHVAC TRANSMISSION (ELECTIVE-I)			
Subject Code	14EPS152	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Transmission Line Trends and Preliminaries: Standard Transmission Voltages, Average Values of Line Parameters, Power-Handling Capacity and Line Loss, Examples of Giant Power Pools and Number of Lines, Costs of Transmission Lines and Equipment, Mechanical Considerations in Line Performance.
Calculation of Line and Ground Parameters: Resistance of Conductors**,** Temperature Rise of Conductors and Current-Carrying Capacity**,** Properties of Bundled Conductors**,** Inductance of EHV Line Configurations**,** Line Capacitance Calculation**,** Sequence Inductances and Capacitances**,** Line Parameters for Modes of Propagation**,** Resistance and Inductance of Ground Return**.**
Voltage Gradients of Conductors: Electrostatics, Field of Sphere Gap, Field of Line Charges and Their Properties, Charge-Potential Relations for Multi-Conductor lines, Surface Voltage Gradient on Conductors, Examples of Conductors and Maximum Gradients on Actual Lines, Gradient Factors and Their Use, Distribution of Voltage Gradient on Sub-conductors of Bundle, Design of Cylindrical Cages for Corona Experiments, Voltage Gradients on Conductors in the Presence of Ground Wires on Towers.
Corona: I^2R Loss and Corona Loss, Corona-Loss formulae, Attenuation of Travelling Waves due to Corona Loss, Audible Noise, Radio Interference
Theory of Travelling Waves and Standing Waves: Travelling Waves and Standing Waves at Power Frequency, Differential Equations and Solutions for General Case, Standing Waves and Natural Frequencies, Open-Ended Line: Double-Exponential Response, Open-Ended Line: Response to Sinusoidal Excitation, Line Energization with Trapped-Charge Voltage, Corona Loss and Effective Shunt Conductance, The Method of Fourier Transforms, Reflection and Refraction of Travelling Waves, Transient Response of Systems with Series and Shunt Lumped Parameters and Distributed Lines, Principles of Travelling-Wave Protection of E.H.V. Lines.
Over voltages in EHV Systems Caused by Switching Operations: Origin of Overvoltages and Their Types**,** Short-Circuit Current and the Circuit Breaker**,** Recovery Voltage and the Circuit Breaker**,** Overvoltages Caused by Interruption of Low Inductive Current**,** Interruption of Capacitive Currents**,** Ferro-Resonance Overvoltages**,** Calculation of Switching Surges—Single Phase Equivalents**,** Distributed-Parameter Line Energized by Source**,** Generalized Equations for Single-Phase Representation**,** Generalized Equations for Three-Phase Systems**,** Inverse Fourier Transform for the General Case**,** Reduction of Switching Surges on EHV Systems**,** Experimental and Calculated Results of Switching-Surge Studies**.**
Power-Frequency Voltage Control and Over voltages: Problems at Power Frequency**,** Generalized Constants**,** No-Load Voltage Conditions and Charging Current**,** The Power Circle Diagram and Its Use**,** Voltage Control Using Synchronous Condensers**,** Cascade Connection of Components**—**Shunt and Series Compensation**,** Sub-Synchronous Resonance in Series-Capacitor Compensated Lines**,** Static Reactive Compensating Systems (Static VAR)**,** High Phase Order Transmission**.**

Design of EHV Lines Based upon Steady-State Limits and Transient Overvoltages: Introduction, Design Factors Under Steady State, Design Examples: Steady-State Limits, Design Examples I to IV, Line Insulation Design Based Upon Transient Overvoltages.

REFERENCE BOOKS

1.Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering,4th Edition”, New Age International Publishers.
2. EHV Transmission line reference book – Edision Electric Institute (GEC) 1986.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
HIGH VOLTAGE POWER APPARATUS(ELECTIVE-I)			
Subject Code	14EPS153	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

HV Power Transformer: Equivalent circuits-limitations and validity- seperation of leakage reactance.

Magnetic Leakage Reactance Calculations: Inductance evaluation in single phase winding and three phase winding transormers, interleaved coils, arbitrary MMF distribution, Scott connection, zig zag and coils of unequal height cases.

Electro Magnetic Forces on Short Circuit: Philosophy, evaluation of radial and tensile forces, Hoop tension and copper loss, axial force calculation, volts per turn and concept of AT thinning, magnetisng current and inrush phenomenon, estimation of magnitude of in rush current and its maximum value, inrush current in three phase transformer, eddy current loss in conductors placed in alternating magnetic field, its evaluation and minimization in transformer.

Surge Phenomenon in Transformer: Equivalent circuit initial voltage distribution with grounded and insulated neutral, voltage gradient line and sress, effective capacitance, role of inductance, travelling wave theory frequency behaviour of velocity of propogaton equivalent circuit fourier spectrum of unit stop wave, standing wave theory for earthed neutral andinsulated neutral cases, insulation requirement of transformer against surges – principle of fully shielded transformers and interleaved disc coils.

High Voltage Switch Gears: Introduction to switch gears- coordinaton between inner and external insulation, insulaion clearences in air, oil, SF6 and vacuum, bushing insulation, Solid insulating materials- dielectric materials- dielectric and mechanical strength consideration, Types of circuit breakers- design, construction and operating principles of bulk oil, minimum oil, air blast, SF6 and Vacuum circuit breakers- comparision of different types of breakers.

Circuit Interruption : Arc characteristics directand alternating current interruptions-arc quenching phenomenon-transient re-striking voltage-RRRV-recovery voltage- current chopping-capacitive current breaking-auto reclosing,Short circuit calculations and rating of breaker:

Types of Faults in Power Systems: Short circuit current and short circuit MVA calculations for different types of faults- rating of circuit breakers- symmetrical and assymetrical ratings.

REFERENCE BOOKS

1. S S Vasutinsky, “Principle, Operation And Design Of Power Transformers” PSG College of Technology, Coimbatore-1962
2. Flursscheim C H, “Power Circuit Breaker Theory and Design”, IEE monograph series 17, Peter Peregrinus Ltd, South Gate House, Stevenago, Herts, SC1 1HQ, England, 1977.
3. Funio Nakanishi, “Switching Phenomena in High Voltage Circuit Breakers”, Marcel Dekker Inc., New York, 1991.
4. M.Heathcote, “Jand P Transformer Book,” 13thEdition,Newness,2007.

5. BHEL, “Transformers”,2^{nd}Edition,TMH,2003.
6. BHEL, “Hand Book of Switch Gear”,TMH,2008.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
POWER SYSTEMS LABORATORY-I			
Subject Code	14EPS16	IA Marks	25
No. of Lecture Hours/Week	--	Exam Hours	03
Number of Practical Hours/week	03	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	--	Exam Marks	50

1. Operator request load flow using voltage and frequency dependent load modelling and generator droop characteristic.
2. Contingency analysis and Ranking for a given inter connected power system having minimum ten buses and ten series elements.
3. Obtaining of PV & PQ curve for a given power system with load buses and Voltage instability analysis
4. ATC computation and open access feasibility studies for the given power system network.
5. Reactive power optimization and loss minimization studies for a given power system.
6. Economic dispatch problem taking into account the network loading constraints and computation of bus incremental cost.
7. Observability analysis, state estimation and bad data detection for a given power system using measurement data.
8. Sequence impedance diagram development and distribution of earth fault current computation in a practical power system having auto transformers with tertiary delta winding, star-delta and delta-star configurations.
9. Over current relay co-ordination with and without instantaneous setting for a given network with NI relay characteristic curves.
10. Harmonic analysis and voltage and current harmonic distortion computation for a given power system. Tuned filter design to eliminate the harmonic currents.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - I			
SEMINAR			
Subject Code	14EPS17	IA Marks	25
No. of Lecture Hours/Week	--	Exam Hours	--
Number of contactHours/week	03	Number of Tutorial Hours/week	--
Total No. of contactHours	--	Exam Marks	--

The aim of the seminar is to inculcate self-learning, face audience, enhance communication skill, involve in group discussion and present his ideas.
Each student, under the guidance of a Faculty, is required to

i) Choose a topic of his/her interest relevant to the Course of Specialization
ii) Carryout literature survey, organize the subject topics in a systematic order
iii) Prepare the report with own sentences
iv) Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities
v) Present the seminar topic at least for 20 minutes orally and/or through power point slides
vi) Answer the queries and involve in debate/discussion lasting for about 10 minutes
vii) Submit two copies of the typed report with a list of references

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.
The internal assessment marks shall be awarded by a committee consisting of at least two staff members based on the relevance of the topic, presentation skill, participation in the question and answer session and quality of report.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
ECONOMIC OPERATION & CONTROL OF POWER SYSTEMS			
Subject Code	14EPS21	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Introduction: Different states of power systems, energy control centers, power systems control problems, steady state & transient security of power systems, security monitoring, SCADA systems, Automatic generation and voltage control.

Power System Security: Introduction, factors affecting system security, power system contingency analysis, and detection of network problems. Network sensitivity methods, calculation of network sensitivity factor, connecting generator dispatch by sensitivity methods, contingency ranking.

Control of Voltage and Reactive Power: Introduction, generation and absorption of reactive power, relation between voltage, power and reactive power at a node-single machine infinity bus system, methods of voltage control-voltage stability, voltage collapse.

Power System Optimization: Optimal system operation with thermal plants, incremental production costs for steam power plants, analytical form of generation costs of thermal power plants, constraints in economic operation flowchart. Transmission loss equation for B co-efficient, unit commitment: statement of the problem, constraints, spinning reserve.

Loss Co-efficient: Definitions and Computation of loss co-efficient, incremental transmission of transmission loss, loss co-efficient using Y Bus, sparse matrix techniques, use of load flow Jacobian for economic dispatch- flow chart -AGC -AGL - use of AGE for economic dispatch, block diagram, block- merit order scheduling.

Hydrothermal Coordination: Introduction, Hydroelectric Plant Models, Scheduling Problems, the Short-Term Hydrothermal Scheduling Problem, Short-Term Hydro-Scheduling: A Gradient Approach, Hydro-Units in Series (Hydraulically Coupled), Pumped-Storage Hydro plants, Dynamic-Programming Solution to the Hydrothermal Scheduling Problem, Hydro-Scheduling Using Linear Programming, Hydro-Scheduling with Storage Limitations

Introduction to State Estimation in Power Systems: Introduction, Power System State Estimation, Maximum Likelihood Weighted Least-Squares Estimation, State Estimation of an AC Network, State Estimation by Orthogonal Decomposition, Introduction to Advanced Topics in State Estimation, Application of Power Systems State Estimation.

REFERENCE BOOKS

1. C.L, Wadhwa,“Electrical Power System”, New Age International,2010.
2. Allen Wood and Woolenberg, “Power Generation Operation and Control”, Wiley India 2nd Edition,2009.
3. Olle.I.Elgerd, “Electrical Energy Systems”, TMH,2001.

4. C.L.Kusic "Computer Aided Power System Analysis", PHI,2010.
5. Nagrath& Kothari, "Modern Power System Analysis",4th Edition,TMH, 2011.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
DISTRIBUTION SYSTEM DESIGN & CONTROL			
Subject Code	14EPS22	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Field work/ Assignment Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Distribution System Planning & Automation: Introduction, distribution system planning; factors affecting system planning, present technique, role of computers in distribution planning, distribution automation, local energy control center, typical control applications.

Distribution Substation: Introduction, load characteristics, substation location, rating a distribution substation, substation services area with 'n' primary feeders, comparison of four and six feeder patterns, derivation of K constant, substation application curves, present voltage drop formula.

Primary and Secondary Distribution Systems: Introduction, feeder types and voltage levels, feeder loading rectangular type development, radial type development application of the A, B, C, D general circuit constants to radial feeders, secondary banking.

Application of Capacitors in Distribution Systems: Introduction, Power capacitors series and shuntpower factor correction, economic power factor, applications of capacitors and installation,types of control, economic justification, practical procedure to determine the best location, mathematical procedure for optimum- allocation, dynamic behavior of distribution system.

Artificial Intelligence Methodologies in Distribution System Operation&Control: Introduction, Expert system, knowledge based system, simulated annealing technique for loss minimization and voltage control, knowledge based methodologies for system reconfiguration and service restoration.

REFERENCE BOOKS

1. Turan Gonen, "Electric Power Distribution System Engineering",2nd Edition, BSP Books Pvt Ltd, 2010.
2. A.S, Pabla, "Electric Power Distribution System", 6th Edition, TMH,2011.
3. Gorti Ramamurthy, "Hand Book of Electrical Power Distribution", University Press, 2nd Edition,2009.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
REACTIVE POWER MANAGEMENT IN POWER SYSTEM			
Subject Code	14EPS23	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Theory of Load Compensation : Introduction- Requirement for compensation, objectives in load compensation, the ideal compensator specifications of a load compensator, power factor correction and voltage regulations in single phase system, phase balancing and power factor correction of unsymmetrical loads, compensation in terms of symmetrical components expression for the compensating susceptance in terms of phase line currents.

Reactive Power Control: Fundamental requirement in AC power transmission, fundamental transmission line equation, surge impedance and natural loading, voltage and current profiles of uncompensated radial and symmetrical line on open circuit, uncompensated line under load, effect of line length, load power and p. f on voltage and reactive power, passive and active compensators, uniformly distributed fixed compensation, passive shunt compensation, control of open circuit voltage by shunt reactance, required reactance of shunt reactors, multiple shunt reactors along the line, voltage control by means of switch shunt compensation, midpoint shunt reactor or capacitor, expression for mid-point voltage, series compensation , objectives and practical limitation , symmetrical line with midpoint series capacitor and shunt reactor, power transfer characteristics and maximum transmissible power for a general case, fundamental concepts of compensation by sectioning.

Dynamic Performance of Transmission Systems with Reactive Power Compensation: The dynamics of electrical power systems, need for adjustable reactive compensation, four characteristics time period.

Principles of Static Compensation: Principle of operation of thyristor controlled reactor, thyristors switch capacitor, saturated reactor compensator.

Series Capacitors: Introduction, protective gear, reinsertion schemes, varistor protective gear.

Synchronous Condenser: Introduction, power system voltage control, emergency reactive power supply, starting methods for motor, reduced voltage starting, static starting.

Harmonics: Sources, effects of harmonics on electrical equipment.

Reactive Power Co-Ordination: Reactive power management, utility objectives and utility practices, transmission benefits.

REFERENCE BOOKS

1. T.J.E Miller, “Reactive Power Control in Electrical Systems”, BSP books PVT Ltd, 2010.
2. D.Tagare, “Reactive Power Management”, TMH, 2011.
3. A.Chakrabarti, D.P Kothari, A.K Mukhopadhyay and D.E Abinandan, “An Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems”,PHI,2010.
4. George J. Wakileh, “Power Systems Harmonics; Fundamentals, Analysis and Filter Design”, Spinger,2014.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
HVDC POWER TRANSMISSION			
Subject Code	14EPS24	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	02	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

DC Power Transmission Technology: Introduction, comparison with AC transmission, application of DC transmission, description of DC transmission system, Planning of HVDC transmission, modern trends in DC transmission, operating problems.

HVDC Converters: Introduction to Line commutated converter, choice of converter configuration for any pulse number, analysis of 6 and 12 pulse Graetz bridge converter without overlap, effect of smoothing reactor. Two and Three level voltage source converters, Pulse Width Modulation. Analysis of converter in two and three, and three and four valve conduction modes, LCC bridge characteristics, Twelve pulse converter, detailed analysis of converters. Analysis of Capacitor Commutated and voltage source converters.

Control of Converters and HVDC link: DC link control principles, converter control characteristics, firing angle control, current and extinction angle control, Starting and stopping of Dc link, Power control, Frequency control, Reactive power control, Tap changer control, Emergency control and Telecommunication requirements. Control of voltage source converter.

Converter Faults and Protection: Converter faults, protection against over currents, over voltages in converter station, surge arrestor, protection against over voltages. Protection against faults in voltage source converter.

Smoothing Reactor and DC line: Smoothing reactors, Effects of corona loss, DC line insulators, Transient over voltages in DC line, Protection in dc line, Detection and protection of faults, DC breaker

Reactive Power Control: Reactive power control in steady state and transient state, sources of reactive power, SVC and STATCOM.

Harmonics and Filters: Introduction, Generation of harmonics, design of AC and DC filters.

Power Flow Analysis in AC/DC Systems: Introduction, dc system model, solution procedure, inclusion of constraints, case study, on line power flow analysis for security control, power flow analysis under dynamic conditions, power flow with VSC based HVDC system.

Stability Analysis and Power Modulation: Introduction to stability concepts, power modulation, practical considerations in the application of modulation controllers, voltage stability, analysis of voltage stability in asynchronous AC/DC system.

Multi Terminal DC Systems: Introduction, applications, types, control and protection.

REFERENCE BOOKS

1. K. R. Padiyar, “HVDC Power Transmission Systems”, New Age International, 2012.
2. E.W.Kimbark “Direct Current Transmission”, Vol.1, Wiley Inter-Science, London, 2006.
3. Arrilaga, “High Voltage Direct Current Transmission”, The Institute of Engineering and Technology, 2ndEdition, 2007.
4. S Kamakshaiah and V Kamaraju, “HVDC Transmission”, TMH, 2011.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
POWER SYSTEM SCADA(ELECTIVE-II)			
Subject Code	14EPS251	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

State Estimation in Energy Control Centers (ECC): Introduction, power system measurements,states of power systems, components of modern ECC, overview of different state estimator techniques, bad data handling, observability analysis.

SCADA System: History of Critical Infrastructure Directives, SCADA system evolution, definitions, SCADA system architecture, SCADA applications, SCADA system security issues, overview, SCADA system desirable properties, SCADA systems in the critical infrastructure, employment of SCADA systems.

Evolution of SCADA Protocols: Background technologies of the SCADA protocols, SCADA protocols(the MODBUS model, the DNP3 protocols, UCA 2.0 and IE61850 standards, control area network, control and information protocol, device Net, control Net, EtherNet/IP, FFB, profibus, the security implications of the SCADA protocols, demilitarized zone.

SCADA Vulnerabilities and Attacks: The myth of SCADA invulnerability, SCADA risk components, risk management components, assessing the risk, mitigating the risk, SCADA threats and attack routes, SCADA Honeynet project.

SCADA Security Methods and Techniques: SCADA security mechanisms, SCADA intrusion detection systems, SCADA security standards and reference documents.

Power System Automation: Introduction, overview of power system instrumentation, power system metering, power plant automation, substation automation, transmission management, distribution management, SCADA distribution management, distribution automation – feeder automation, demand side management, load management.

Substation Automation and Protocol Standards for Power Systems: Need for a automation, definition of integration and automation, substation control panels – with electromechanical devices, with Intelligent Electronic Devices (IED), automatic load restoration – intelligent bus fail over, supply line sectionalizing, monitoring of equipment condition, alarm processing, power quality, switched feeder capacitor banks, equipment rating. Integrated protection functions – adaptive relaying.

REFERENCE BOOKS

1**.** Krutz,Ronald. L, “Securing SCADA Systems”, 2nd Edition, Wiley, 2005.
2. Michael Wiebe, “A Guide to Utility Automation: AMR, Scada, and It Systems for Electric Power”, PennWell Books, 1999

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
INTELLIGENT SYSTEM APPLICATIONS TO POWER SYSTEM(ELECTIVE-II)			
Subject Code	14EPS252	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Fuzzy Logic Systems: Introduction, proven advantages of various industrial fuzzy logic applications, fuzzy logic basics, classical set, and characteristic, classical set operations, characteristic functions, classical set operations, fuzzy set, membership function, fuzzy set operations, various membership functions, parameters sets, conventional fuzzy set operations, functions of fuzzy sets, fuzzy rules, fuzzy reasoning , fuzzy inference system(fuzzy logic controllers), extension principle , various fuzzy inference systems-Mamdani fuzzy logic inference system, Sugeno fuzzy logic inference system, Tsukamoto fuzzy logic inference system, fuzzy system design- automatic generation of fuzzy rules from data, design steps, adaptive fuzzy logic systems.

Artificial Neural Networks: ANN fundamentals, artificial neuron model, ANN networks, static and dynamic artificial neuron models, adaptive function estimators, general, weights , input, bias, activation functions, ANN networks- single-layer and multilayer feed forward ANNs, radial basis function neural network, various ANNs and training strategic for different applications, application of the error back propagation algorithm, unsupervised(self-organized) learning , competitive learning, neuro- control systems.

Study of related papers and implementation for small power system network **Applications of fuzzy logic control**:

1. Overview And Literature Survey Of Fuzzy Set Theory In Power System[IEEE Transactions On Power Systems, Vol. 10 ,No. 3, August 1995]
2. Dynamic Reactive Power Compensation Based On Fuzzy Logic In Power Transmission Grids, [IEEE Xplore, 2008]
3. Fuzzy Based Reactive Power And Voltage Control In A Distribution Systems [IEEE Transactions On Power Delivery, Vol. 18, No. 2, April 2003]
4. A Fuzzy Control For Network Overloads Alleviation [Electrical Power And Energy Systems 23 (2003)]
5. A New Fuzzy Control Approach To Voltage Profile Enhancement For Power Systems [IEEE Transactions On Power Systems, Vol. 11, No. 3, August 1996]
6. Fuzzy- Based Voltage / Reactive Power Scheduling For Voltage Security Improvement And Loss Reduction [IEEE Transactions Power Delivery, Vol. 16, No. 2, April 2001]
7. A Fuzzy Based Optimal Reactive Power Control [IEEE Transactions On Power Systems, Vol. 8, No. 2, May 1993]
8. Fuzzy-Neuro Approach To Fault Classification For Transmission Line Protection. [IEEE Transactions On Power Delivery, Vol. 13, No. 4, Oct 1998]

Applications of ANN:

9. Improving Voltage Stability Margin Using Voltage Profile and Sensitivity Analysis by Neural Network. [Iranian Journal of Electrical & Electronic Engineering, 2011]
10. Matlab Based Artificial Neural Network Algorithm for Voltage Stability Assessment. [D.Thukaram, Sukumar, Kamalasadan, Adel A. Ghandakly]
11. Forecasting Electricity Demand on Short, Medium and Long Time Scales Using Neural Networks. [Journal of Intelligent and Robotic Systems 31: 129–147, 2001.© 2001 Kluwer Academic Publishers. Printed in the Netherlands.]
12. Artificial Neural Network Approach for Short Term Load Forecasting for Illam Region. [World Academy of Science, Engineering and Technology 28 2007]
13. Short-Term Load Forecasting Using an Artificial Neural Network. [Transactions on Power Systems, Vol. 7. No. 1, February 1992]
14. Global model for short-term load forecasting using artificial neural networks [IEE Proc-Gener.Truiisni.Distrib, Vol. 149, No. 2, March 2002]
15. Mid-Term Load Forecasting Based on Neural Network Algorithm: a Comparison of Models. [International Journal of Computer and Electrical Engineering, Vol. 3, No. 4, August 2011]
16. Application of Neural Networks in Power Systems; A Review. [World Academy of Science, Engineering and Technology 6, 2005]

REFERENCE BOOK

K Warwick, Arthur Ekwue, Raj Aggarwal, "Artificial Intelligence Techniques in Power Systems", IEE, UK, 1997.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
POWER QUALITY ENHANCEMENT USING CUSTOM POWER DEVICES (ELECTIVE-II)			
Subject Code	14EPS253	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	02
Total No. of Lecture Hours	52	Exam Marks	100

Introduction and Characterization of Electric Power Quality: Electric Power Quality, Power Electronic applications in Power Transmission Systems, Power Electronic applications in Power Distribution Systems. Power Quality terms and Definitions, Power Quality Problems.
Analysis and Conventional Mitigation Methods: Analysis of Power Outages, Analysis of Unbalance , Analysis of Distortion, Analysis of Voltage Sag, Analysis of Voltage Flicker, Reduced Duration and Customer impact of Outages, Classical Load Balancing Problem, Harmonic Reduction, Voltage Sag or Dip Reduction.
Custom Power Devices: Introduction, Utility-Customer Interface, Custom Power Devices, Custom Power Park, Status of Application of CP Devices, Closed-Loop Switching Control, Second and higher order Systems.
Solid State Limiting, Breaking and Transferring Devices: Solid State Current Limiter, Solid State Breaker, Issues in Limiting and Switching operations, Solid State Transfer Switch, Sag/Swell Detection Algorithms.
Load Compensation using DSTATCOM: Compensating Single-Phase Loads, Ideal Three-Phase Shunt Compensator Structure, Generating Reference Currents Using Instantaneous PQ Theory, Generating reference currents using instantaneous Symmetrical Components, General Algorithm for generating reference currents, Generating Reference currents when the Source is Unbalanced.
Realization and Control of DSTATCOM: DSTATCOM Structure, Control of
DSTATCOM Connected to a Stiff Source, DSTATCOM Connected to weak Supply Point, DSTATCOM Current Control through Phasors, DSTATCOM in Voltage Control Mode.
Series Compensation of Power Distribution System: Rectifier Supported DVR, DC Capacitor Supported DVR, DVR Structure, Voltage Restoration, Series Active Filter.
Unified Power Quality Conditioner: UPQC Configurations, Right-Shunt UPQC Characteristics, Left-Shunt UPQC Characteristics, Structure and Control of Right-Shunt UPQC, Structure and Control of Left-Shunt UPQC.

REFERRENCE BOOKS

1. Arindam Ghosh et.al, Power Quality Enhancement Using Custom Power Devices,Kluwer Academic Publishers,2002.
2. Math H J Bollen, "Understanding Power Quality Problems; Voltage Sags and Interruptions", Wiley India, 2011.
3. Roger C Dugan, et.al, "Electrical Power Systems Quality", 3rd Edition, TMH, 2012.
4. Ewald F Fuchs, et.el, "Power Quality in Power System and Electrical Machines", Academic Press, Elsevier, 2009.
5. C. Shankaran "Power Quality", CRC Press, 2013.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
POWER SYSTEM LABORATORY - II			
Subject Code	14EPS26	IA Marks	25
No. of Lecture Hours/Week	--	Exam Hours	03
Number of Practical Hours/week	03	Number of Tutorial Hours/week	--
Total No. of Practical Hours	--	Exam Marks	50

1. Transient stability studies for a given system having minimum 10 buses, machines and an infinite grid to determine (i) Critical clearing time (ii) Natural frequency of oscillations of electro-mechanical system considering classical representation of the machine and detailed modelling (sub-transient model) of the machine.
2. The AVR and Governor modelling and their effect on system stability.
3. Eigen value computation and small signal stability studies for a given power system with at least 3 machines and 10 buses using IEEE-Type 1 AVR and turbine-governor models.
4. Dynamic VAR compensation and voltage control using shunt SVC.
5. Frequency and voltage dependency model of the load and under frequency load shedding.
6. Capacitor bank switching studies and control of over voltage and inrush current.
7. Electromagnetic transient analysis during charging of a 400 kV, 300 km long line (i) without pre-insertion resistance (ii) With pre-insertion resistance (iii) With shunt reactor at the receiving end of the line.
8. Vacuum circuit breaker current chopping phenomenon and suppression of over voltage using (i) Surge arrestor (ii) R-C network.
9. Lightning impulse model and surge arrestor modeling studies using electromagnetic transient analysis for a given transmission line.
10. CT and CVT transients modelling using electromagnetic transient analysis.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - II			
SEMINAR			
Subject Code	14EPS27	IA Marks	25
No. of Lecture Hours/Week	--	Exam Hours	--
Number of contactHours/week	03	Number of Tutorial Hours/week	--
Total No. of Hours	--	Exam Marks	--

<table>
<tr><th colspan="6">M.TECH. POWER SYSTEMENGINEERING (EPS)
SEMESTER - III</th></tr>
<tr><th colspan="6">INTERNSHIP</th></tr>
<tr><td>Subject Code</td><td>14EPS31</td><td colspan="3">IA Marks Seminar/Presentation</td><td>25</td></tr>
<tr><td rowspan="2">Duration</td><td rowspan="2">16 weeks</td><td rowspan="2">Exam Marks</td><td>14EPS32</td><td>Report on Internship</td><td>75</td></tr>
<tr><td>14EPS33</td><td>Internship Evaluation and Viva-voce</td><td>50</td></tr>
</table>

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - IV			
FACTS CONTROLLERS			
Subject Code	14EPS41	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Introduction: Basics of power transmission networks - control of power flow in AC - transmission line- flexible AC transmission system controllers – application of FACTS controllers in distribution systems.

AC Transmission Line and Reactive Power Compensation: Analysis of uncompensated AC Line - passive reactive power compensation - compensation by a series capacitor connected at the midpoint of the line - shunt compensation connected at the midpoint of the line - comparison between series and shunt capacitor - compensation by STATCOM and SSSC - some representative examples.

Static Var Compensator: Analysis of SVC - Configuration of SVC- SVC Controller – voltage regulator design - some issues - harmonics and filtering - protection aspects – modeling of SVC – applications of SVC.

Thyristor and GTO Controlled Series Capacitor: Introduction - basic concepts of controlled series compensation -operation of TCSC - analysis of TCSC- control of TCSC - modeling of TCSC for stability studies - GTO thyristor controlled series capacitor (GCSC) - mitigation of sub synchronous resonance with TCSC and GCSC - applications of TCSC.

Static Phase Shifting Transformer: General - basic principle of a PST - configurations of SPST improvement of transient stability using SPST - damping of low frequency power oscillations - applications of SPST.

Static Synchronous Compensator (STATCOM): Introduction - principle of operation of STATCOM - a simplified analysis of a three phase six pulse STATCOM - analysis of a six pulse VSC using switching functions - multi-pulse converters control of type 2 converters - control of type I Converters - multilevel voltage source converters - harmonic transfer and resonance in VSC, applications of STATCOM.

SSSC and UPFC:
SSSC-operation of SSSC and the control of power flow –modelling of SSSC in load flow and transient stability. Unified Power Flow Controller (UPFC) – Principle of operation – modes of operation – applications – modeling of UPFC for power flow studies.
Special Purpose FACTS Controllers: Interline Power Flow Controller - operation and control.

REFERENCE BOOKS

1. K.R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International, 2007.
2. Narain G Hingorani and L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, Wiley India, 2011.

3. Y. H. Song and A. T. Johns, “Flexible AC Transmission System”, Institution of Engineering and Technology, 2009.
4.Mohan Mathur, R., Rajiv. K. Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - IV			
POWER SYSTEM RELIABILITY ENGINEERING(ELECTIVE- III)			
Subject Code	14EPS421	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Basic Concepts: Adequacy, security, reliability, cost/worth/data, reliability test system (RTS).

System Adequacy Evaluation: RTS, Monte Carlo simulation, contingency enumeration approach, basic distribution systems and reliability assessment.

Assessment of Reliability Worth: Interruption costs for commercial, industrial and residential users, interruption energy assessment rate; dependency effects in power system reliability and evaluation of statistical distributions.

REFERENCE BOOKS

1. Roy Billington, “Reliability Assessment of Large Electric Power Systems”, Kluwer Academic Press/Springer India,2008.
2. R. Billington and A.N. Allen, “Reliability Evaluation of Engineering Systems; Concepts and Techniques”, Springer,1992.
3. Hammersley J.M., Handscomb D.C,“Monte Carlo Methods”, John Wiley and Sons Inc.NY, 1964.
4. IEEE committee report, IEEE Reliability Test System, IEEE PAS, Vol. PAS98, 1979, pp 2047-54.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - IV			
SMART GIRD(ELECTIVE- III)			
Subject Code	14EPS422	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Introduction: Introduction to smart grid, electricity network, local energy networks, electric transportation, low carbon central generation, attributes of the smart grid, alternate views of a smart grid.

Smart Grid to Evolve a Perfect Power System: Introduction, overview of the perfect power system configurations, device level power system, building integrated power systems, distributed power systems, fully integrated power system, nodes of innovation.

DC Distribution and Smart Grid: AC Vs. DC sources, benefits of and drives of dc power delivery systems, powering equipment and appliances with DC, data centers and information technology loads, future neighborhood, potential future work and research.

Intelligrid Architecture for the Smart Grid: Introduction, launching intelligrid, intelligrid today, smart grid vision based on the intelligrid architecture, barriers and enabling technologies.

Dynamic Energy Systems Concept: Smart energy efficient end use devices, smart distributed energy resources, advanced whole building control systems, integrated communications architecture, energy management, role of technology in demand response, current limitations to dynamic energy management, distributed energy resources, overview of a dynamic energy management, key characteristics of smart devices, key characteristics of advanced whole building control systems, key characteristics of dynamic energy management system.

Energy Port as Part of the Smart Grid: Concept of energy -port, generic features of the energy port.

Policies and Programs to Encourage End – Use Energy Efficiency: Polices and programs in action; multinational, national, state, city and corporate levels.
Market Implementation: Framework, factors influencing customer acceptance and response, program planning, monitoring and evaluation.

Efficient Electric End – Use Technology Alternatives: Existing technologies ,lighting, space conditioning, indoor air quality, domestic water heating, hyper efficient appliances, ductless residential heat pumps and air conditioners, variable refrigerant flow air conditioning, heat pump water heating, hyper efficient residential appliances, data center energy efficiency, LED street and area lighting, industrial motors and drives, equipment retrofit and replacement, process heating, cogeneration, thermal energy storage, industrial energy management programs, manufacturing process, electro -technologies, residential, commercial and industrial sectors.

REFERENCE BOOKS

1. Clark W Gellings, “The Smart Grid, Enabling Energy Efficiency and Demand Side Response”, CRC Press, 2009.
2. Janaka Ekanayake, Kithsiri Liyanage,Jianzhong.Wu, Akihiko Yokoyama, Nick Jenkins, “Smart Grid :Technology and Applications”, Wiley,2012.

3. James Momoh, “Smart Grid :Fundamentals of Design and Analysis”, Wiley, IEEE Press,2012.

M.TECH. POWER SYSTEMENGINEERING (EPS) SEMESTER - IV			
PLANNING & MANAGEMENT OF DEREGULATED POWER SYSTEMS (ELECTIVE- III)			
Subject Code	14EPS423	IA Marks	50
No. of Lecture Hours/Week	04	Exam Hours	03
Number of Practical Hours/week	--	Number of Tutorial Hours/week	--
Total No. of Lecture Hours	52	Exam Marks	100

Deregulation of the Electricity Supply Industry: Introduction, meaning of deregulation, background to deregulation and the current situation around the world, benefits from a competitive electricity market, after effects of deregulation.

Power System Economic Operation Overview: Introduction, economical load dispatch, optimal power flow as a basic tool, unit commitment, formation of power pools.

Power System Operation in Competitive Environment: Introduction, role of independent system operator (ISO), operational planning activities of ISO,Operational planning activities of a Genco.

Transmission Open Access and Pricing Issues: Introduction, power wheeling, transmission open access, cost components in transmission, pricing of power transactions, transmission open access and pricing mechanisms in various countries, developments in international transmission pricing in Europe, security management in deregulated environment, congestion management in deregulation.

Ancillary Services Management: Ancillary services and management in various countries, reactive power as an ancillary service.

Reliability and Deregulation: Terminology, reliability analysis, network model, reliability costs, hierarchical levels, reliability and deregulation, performance indicators.

REFERENCE BOOKS

1. Kankar Bhattacharya, Math H J Bollan, Jaap E Daalder, “Operation of Restructured Power Systems”, Kluwer Academic Publishers, 2001.
2. Loi Lei Lai, “Power System Restructuring and Deregulation; Trading, Performance and Information Technology”, John Wiley and Sons, Ltd, 2002.