AFFILIATED INSTITUTIONS

ANNA UNIVERSITY, CHENNAI

REGULATIONS - 2009

CURRICULUM & SYLLABUS

M.E. POWER MANAGEMENT

SEMESTER

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA9314	Applied Mathematics for Electrical Engineers	3	1	0	4
2	PS9311	Power System Analysis	3	1	0	4
3	PS9312	Power System Operation and Control	3	1	0	4
4	PS9313	Electrical Transients in Power Systems	3	0	0	3
5	PS9314	System Theory	3	1	0	4
6	E01	Elective I	3	0	0	3
					TOTAL	**22**

ELECTIVES FOR M.E POWER MANAGEMENT

SEMESTER

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
		Elective I (E01)				
1	PS9001	Power System Dynamics	3	0	0	3
2	PS9002	Soft Computing Techniques	3	0	0	3
3	PS9003	Modeling and Analysis of Electrical Machines	3	0	0	3

MA9314 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS **L T P C**
3 1 0 4

UNIT I ADVANCED MATRIX THEORY **9**

Eigen-values using QR transformations – Generalized eigen vectors – Canonical forms – Singular value decomposition and applications – Pseudo inverse – Least square approximations.

UNIT II LINEAR PROGRAMMING **9**

Formulation – Graphical Solution – Simplex Method – Two Phase Method – Transportation and Assignment Problems.

UNIT III ONE DIMENSIONAL RANDOM VARIABLES **9**

Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable.

UNIT IV QUEUEING MODELS **9**

Poisson Process – Markovian queues – Single and Multi Serve r Models – Little's formula – Machine Interference Model – Steady State analysis – Self Service queue.

UNIT V COMPUTATIONAL METHODS IN ENGINEERING **9**

Boundary value problems for ODE – Finite difference methods – Numerical solution of PDE – Solution of Laplace and Poisson equations – Liebmann's iteration process – Solution of heat conduction equation by Schmidt explicit formula and Crank-Nicolson implicit scheme – Solution of wave equation.

L : 45 T :15 TOTAL : 60PERIODS

REFERENCES:

1. Bronson, R., Matrix Operation, Schaum's outline series, McGraw Hill, New York, 1989.
2. Taha, H. A., Operations Research: An Introduction, Seventh Edition, Pearson Education Edition, Asia, New Delhi,2002.
3. Walpole.R.E, Myers.R.H, Myers.S.L, and Ye.K, Probability and Statistics for Engineers & Scientists, Asia, 8th Edition, 2007.
4. Donald Gross and Carl M. Harris, Fundamentals of Queueing theory, 2nd edition, John Wiley and Sons, New York ,1985.
5. Grewal, B.S., Numerical methods in Engineering and Science, 7th edition, Khanna Publishers, 2004

PS9311 POWER SYSTEM ANALYSIS **L T P C**
3 1 0 4

UNIT I SOLUTION TECHNIQUE **9**

Sparse Matrix techniques for large scale power systems: Optimal ordering schemes for preserving sparsity. Flexible packed storage scheme for storing matrix as compact arrays –Factorization by Bifactorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices.

UNIT II POWER FLOW ANALYSIS 9

Power flow equation in real and polar forms; Review of Newton's method for solution; Adjustment of P-V buses; Review of Fast Decoupled Power Flow method; Sensitivity factors for P-V bus adjustment; Net Interchange power control in Multi-area power flow analysis: ATC, Assessment of Available Transfer Capability (ATC) using Repeated Power Flow method; Continuation Power Flow method.

UNIT III OPTIMAL POWER FLOW 9

Problem statement; Solution of Optimal Power Flow (OPF) – The gradient method, Newton's method, Linear Sensitivity Analysis; LP methods – With real power variables only – LP method with AC power flow variables and detailed cost functions; Security constrained Optimal Power Flow; Interior point algorithm; Bus Incremental costs.

UNIT IV SHORT CIRCUIT ANALYSIS 9

Fault calculations using sequence networks for different types of faults. Bus impedance matrix (Z_{BUS}) construction using Building Algorithm for lines with mutual coupling; Simple numerical problems. Computer method for fault analysis using Z_{BUS} and sequence components. Derivation of equations for bus voltages, fault current and line currents, both in sequence and phase domain using Thevenin's equivalent and Z_{BUS} matrix for different faults.

UNIT V STABILITY STUDIES 9

Definitions and Illustration of Terms – A simple two machine stability Problem – Importance of stability to system operation and design – Deleterious effects on instability – Swing equation for a synchronous machine – Step by step procedure for solution of swing equations – Assumption in transient stability studies –Equal Area Criterion – Determination of critical clearing angle – Factors affecting transient stability – Fault analysis for stability studies.

L: 45 T:15 TOTAL : 60 PERIODS

REFERENCES:

1. Stagg.G.W , El. Abiad.A.H "Computer Methods in Power System Analysis", McGraw Hill, 1968.
2. Kundur.P, "Power System Stability and Control", McGraw Hill, 1994.
3. Wood.A.J and Wollenberg.B.F, "Power Generation Operation and Control", John Wiley and sons, New York, 1996.
4. Tinney.W.F and Meyer.W.S, "Solution of Large Sparse System by Ordered Triangular Factorization" IEEE Trans. on Automatic Control, Vol : AC-18, pp:333-346, Aug 1973.
5. Zollenkopf.K, "Bi-Factorization : Basic Computational Algorithm and Programming Techniques ; pp:75-96 ; Book on "Large Sparse Set of Linear Systems" Editor: J.K.Rerd,Academic Press, 1971.

PS9312 POWER SYSTEM OPERATION AND CONTROL L T P C
3 1 0 4

UNIT I REACTIVE POWER AND VOLTAGE CONTROL 9

Production and absorption of reactive power- Methods of Voltage Control – Shunt reactors – Shunt Capacitors – Series Capacitors – Synchronous condensers – Static Var systems – Principles of Transmission system compensation – Modeling of reactive compensating devices – Application of tap changing transformers to transmission systems – Distribution system voltage regulation – Modelling of transformer ULTC control systems.

UNIT II UNIT COMMITMENT 9

Constraints in unit commitment – Spinning reserve **–** Thermal unit constraints **–** Other constraints – Solution using Priority List method, Dynamic programming method - Forward DP approach Lagrangian relaxation method – adjusting □.

UNIT III GENERATION SCHEDULING 9

The Economic dispatch problem – Thermal system dispatching with network losses considered – The Lambda – iteration method – Gradient method of economic dispatch – Economic dispatch with Piecewise Linear cost functions – Transmission system effects **–** A two generator system **–** coordination equations **–** Incremental losses and penalty factors-Hydro Thermal Scheduling using DP.

UNIT IV CONTROL OF POWER SYSTEMS 9

Review of AGC and reactive power control -System operating states by security control functions – Monitoring, evaluation of system state by contingency analysis – Corrective controls (Preventive, emergency and restorative) - Energy control center – SCADA system – Functions – monitoring , Data acquisition and controls – EMS system.

UNIT V STATE ESTIMATION 9

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

L: 45 T:15 TOTAL : 60 PERIODS

REFERENCES:

1. Elgerd.O.I, “Electric Energy System Theory - an Introduction”, - Tata McGraw Hill, New Delhi – 2002.
2. Kundur.P ; “Power System Stability and Control”, EPRI Publications, California , 1994.
3. Allen J.Wood and Bruce.F.Wollenberg, “Power Generation Operation and Control’, John Wiley & Sons , New York, 1996.
4. Mahalanabis.A.K, Kothari.D.P. and Ahson.S.I., “Computer Aided Power System Analysis and Control”, Tata McGraw Hill publishing Ltd , 1984.

PS9313 ELECTRICAL TRANSIENTS IN POWER SYSTEMS **L T P C**
3 0 0 3

UNIT I INTRODUCTION 9
Introduction – Travelling waves on transmission lines – Wave Equation – surge impedance and wave velocity – Specification of Travelling waves - Reflection and Refraction of waves – Typical cases of line terminations – Equivalent circuit for Travelling wave studies – Forked line – Reactive termination – Analysis of trapezoidal wave - Analysis of complicated waves.

UNIT II TRAVELLING WAVES ON TRANSMISSION LINE 9
Successive reflections – Bewley Lattice Diagrams – Attenuation and Distortion – Multi-conductor system – Self and mutual surge impedance – Voltage and currents for two conductor systems.

UNIT III LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES 9
Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Switching: Short line or kilometric fault – Energizing transients - closing and re-closing of lines - line dropping, load rejection - Voltage induced by fault – Very Fast Transient Overvoltage (VFTO)

UNIT IV PROTECTION OF SYSTEMS AGAINST SURGES 9
Transmission line insulation and performance – Ground wires – Protective angle – Tower footing resistance – Driven rods – Counterpoise – Protector tube – Substation protection – surge diverters – Selection of arrester rating – Location of arresters – Influence of additional lines – Effect of short length of cable – Surge capacitor, surge reactor and surge absorber – Shielding substation with ground wires – Protection of rotating machines.

UNIT V INSULATION CO-ORDINATION 9
Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level –overvoltage protective devices – lightning arresters, substation earthing.

TOTAL : 45 PERIODS

REFERENCES
1. Gupta.B.R, "Power System Analysis and Design", S.Chand Publications 2004
2. Thapar.B,.Gupta.B.R and Khera.L.K, "Power System Transients and High Voltage Principles", Mohindra Capital Publishers
3. Allan Greenwood, "Electrical Transients in Power System", Wiley & Sons Inc. New York, 1991.
4. Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980.
5. Rakosh Das Begamudre, "Extra High Voltage AC Transmission Engineering", (Second edition) Newage International (P) Ltd., New Delhi, 1990.
6. Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

PS9314 **SYSTEM THEORY** **L T P C**
3 1 0 4

UNIT I STATE VARIABLE REPRESENTATION 9

Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-No uniqueness of state model-State Diagrams-Physical System and State Assignment - Solution of State Equation - Existence and uniqueness of solutions to Continuous-time state equations- Evaluation of matrix exponential-System modes-Role of Eigen values and Eigenvectors.

UNIT II DISCRETE TIME STATE MODEL 9

Introduction – Discrete Time State Model – Sample and Hold Digital Equivalent – Methods of Discretization – Sampling Effects – Discrete Time State Model – Conversion from Continuous Time State Models – Discrete Time State Transition Matrix – Solution Space of State Equation.

UNIT III CONTROLLABILITY AND OBSERVABILITY 9

Introduction - Controllability and Observability- Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case-Output Controllability-Reducibility-System Realizations.

UNIT IV STABILITY 9

Introduction-Equilibrium Points-Stability in the sense of Lyapunov-BIBO Stability-Stability of LTI Systems-Equilibrium Stability of Nonlinear Continuous Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous Time Autonomous Systems-Krasovskii and Variable-Gradiant Method.

UNIT V MODAL CONTROL 9

Introduction-Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability-Pole Placement by State Feedback for both SISO and MIMO Systems-Full Order and Reduced Order Observers.

L: 45 T:15 TOTAL : 60 PERIODS

REFERENCES:

1. Gopal.M, “Modern Control System Theory”, New Age International, 2005.
2. Ogatta.K, “Modern Control Engineering”, PHI, 2002.
3. John S. Bay, “Fundamentals of Linear State Space Systems”, McGraw-Hill, 1999.
4. Roy Choudhury.D, “Modern Control Systems”, New Age International, 2005.
5. John J. D’Azzo, C. H. Houpis and S. N. Sheldon, “Linear Control System Analysis and Design with MATLAB”, Taylor Francis, 2003.
6. Bubnicki.Z, ”Modern Control Theory”, Springer, 2005.

PS9001 **POWER SYSTEM DYNAMICS** **L T P C**
3 0 0 3

UNIT I SYNCHRONOUS MACHINE MODELLING 9

Schematic Diagram, Physical Description: armature and field structure, machines with multiple pole pairs, mmf waveforms, direct and quadrature axes, Mathematical Description of a Synchronous Machine: Basic equations of a synchronous machine: stator circuit equations, stator self, stator mutual and stator to rotor mutual inductances, dq0 Transformation: flux linkage and voltage equations for stator and rotor in dq0 coordinates, electrical power and torque, physical interpretation of dq0 transformation, Per Unit Representations: Lad-reciprocal per unit system and that from power-invariant form of Park's transformation; Equivalent Circuits for direct and quadrature axes, Steadystate Analysis: Voltage, current and flux-linkage relationships, Phasor representation, Rotor angle, Steady-state equivalent circuit, Computation of steady-state values, Equations of Motion: Swing Equation, calculation of inertia constant, Representation in system studies, Synchronous Machine Representation in Stability Studies: Neglect of stator p terms and speed variations.Simplifications for large-scale studies: variations, Simplified model with amortisseurs neglected: two-axis model with amortisseur windings neglected, classical model.

UNIT II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9

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

UNIT III SMALL SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS 9

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: Statespace representation, stability of dynamic system, Linearisation, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example.

UNIT IV SMALL SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS 9

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System Stabiliser: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical a example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example. Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers.

UNIT V ENHANCEMENT OF SMALL SIGNAL STABILITY 9

Power System Stabilizer – Stabilizer based on shaft speed signal (delta omega) – Delta –P-Omega stabilizer-Frequency-based stabilizers – Digital Stabilizer – Excitation control design – Exciter gain – Phase lead compensation – Stabilizing signal washout stabilizer gain – Stabilizer limits

TOTAL : 45 PERIODS

REFERENCES

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

PS9002 SOFT COMPUTING TECHNIQUES L T P C
3 0 0 3

UNIT I INTRODUCTION 9

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

UNIT IIARTIFICIAL NEURAL NETWORKS 9

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis and wavelet transformations. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and anD-colony search techniques for solving optimization problems.

UNIT V APPLICATIONS 9

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

TOTAL : 45 PERIODS

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

PS9003 MODELLING AND ANALYSIS OF ELECTRICAL MACHINES L T P C
3 0 0 3

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION 9
Introduction to self commutated switches : MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated Thyristor inverters.

UNIT II REFERENCE FRAME THEORY 9
Static and rotating reference frames – transformation of variables – reference frames – transformation between reference frames – transformation of a balanced set –balanced steady state phasor and voltage equations – variables observed from several frames of reference.

UNIT III DC MACHINES 9
Voltage and toque equations – dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.

UNIT IV INDUCTION MACHINES 9
Voltage and toque equations – transformation for rotor circuits – voltage and toque equations in reference frame variables – analysis of steady state operation – free acceleration characteristics – dynamic performance for load and torque variations – dynamic performance for three phase fault – computer simulation in arbitrary reference frame.

UNIT V SYNCHRONOUS MACHINES 9
Voltage and Torque Equation – voltage Equation in arbitrary reference frame and rotor reference frame – Park equations - rotor angle and angle between rotor – steady state analysis – dynamic performances for torque variations- dynamic performance for three phase fault – transient stability limit – critical clearing time – computer simulation.

TOTAL : 45 PERIODS

REFERENCES
1. Paul C.Krause, OlegWasyzczuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, IEEE Press, Second Edition.
2. Krishnan.R, “Electric Motor Drives, Modeling, Analysis and Control” , Prentice Hall of India, 2002
3. Samuel Seely, “ Electromechanical Energy Conversion”, Tata McGraw Hill Publishing Company,
4. Fitzgerald.A.E, Charles Kingsley, Jr, and Stephan D, Umanx, “ Electric Machinery”, Tata McGraw Hill, 5th Edition, 1992