GOVERNMENT COLLEGE OF TECHNOLOGY

(An Autonomous Institution Affiliated to Anna University)

Coimbatore - 641 013

Regulations, Curriculum And Syllabi For

M.E. (POWER SYSTEMS ENGINEERING)

(Full Time / Part Time)

2012

Regulations

OFFICE OF THE CONTROLLER OF EXAMINATIONS,
GOVERNMENT COLLEGE OF TECHNOLOGY
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Curriculum

CURRICULUM FOR CANDIDATES ADMITTED
DURING 2012-2013 AND ONWARDS
BRANCH: M.E. (POWER SYSTEMS ENGINEERING) - (FULL TIME)

FIRST SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	L	T	P	C
1	12PS01	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERING	25	75	100	3	0	1	4
2	12PS02	SYSTEMS THEORY	25	75	100	3	0	0	3
3	12PS03	COMPUTER AIDED POWER SYSTEM ANALYSIS	25	75	100	3	0	0	3
4	12PS04	POWER SYSTEM CONTROL AND OPERATION	25	75	100	3	0	1	4
5	12PS05	POWER SYSTEM TRANSIENTS AND SURGE PROTECTION	25	75	100	3	0	0	3
6	E1	ELECTIVE - I	25	75	100	3	0	0	3
		TOTAL							**20**

SECOND SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	L	T	P	C
1	12PS06	DIGITAL POWER SYSTEM PROTECTION	25	75	100	3	0	0	3
2	12PS07	POWER SYSTEM DYNAMICS AND CONTROL	25	75	100	3	0	0	3
3	12PS08	POWER SYSTEM STABILITY	25	75	100	3	0	0	3
4	12PS09	POWER SYSTEM SIMULATION LAB	25	75	100	0	0	3	2
5	E2	ELECTIVE - II	25	75	100	3	0	0	3
6	E3	ELECTIVE - III	25	75	100	3	0	0	3
		TOTAL							**17**

THIRD SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	E4	ELECTIVE - IV	25	75	100	3	0	0	3
2	E5	ELECTIVE - V	25	75	100	3	0	0	3
3	E6	ELECTIVE - VI	25	75	100	3	0	0	3
4	12PS10	PROJECT -I AND VIVA-VOCE	50	150	200	0	0	12	6
		TOTAL							**15**

FOURTH SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PS11	PROJECT -II AND VIVA-VOCE	100	300	400	0	0	24	12

Total Credits : 20+17+15+12=64

L : Credits for Lecture Hours T : Credits for Tutorial Hours

P : Credits for Practical Hours C : Total Number of Credits

CURRICULUM FOR CANDIDATES ADMITTED
DURING 2012-2013 AND ONWARDS
BRANCH: M.E. (POWER SYSTEMS ENGINEERING) - (PART TIME)

FIRST SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PS01	APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERING	25	75	100	3	1	0	4
2	12PS02	SYSTEMS THEORY	25	75	100	3	0	0	3
3	12PS03	COMPUTER AIDED POWER SYSTEM ANALYSIS	25	75	100	3	0	0	3
		TOTAL							**10**

SECOND SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PS06	DIGITAL POWER SYSTEM PROTECTION	25	75	100	3	0	0	3
2	12PS07	POWER SYSTEM DYNAMICS AND CONTROL	25	75	100	3	0	0	3
3	12PS08	POWER SYSTEM STABILITY	25	75	100	3	0	0	3
		TOTAL							**9**

THIRD SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PS04	POWER SYSTEM CONTROL AND OPERATION	25	75	100	3	0	0	3
2	12PS05	POWER SYSTEM TRANSIENTS AND SURGE PROTECTION	25	75	100	3	0	0	3
3	E1	ELECTIVE – I	25	75	100	3	0	0	3
		TOTAL							**9**

FOURTH SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PS09	POWER SYSTEM SIMULATION LAB	25	75	100	0	0	0	2
2	E2	ELECTIVE - II	25	75	100	3	0	0	3
3	E3	ELECTIVE - III	25	75	100	3	0	0	3
		TOTAL							**8**

FIFTH SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	E4	ELECTIVE - IV	25	75	100	3	0	0	3
2	E5	ELECTIVE - V	25	75	100	3	0	0	3
3	E6	ELECTIVE - VI	25	75	100	3	0	0	3
4	12PS10	PROJECT -I AND VIVA-VOCE	50	150	200	0	0	12	6
		TOTAL							**15**

SIXTH SEMESTER

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
1	12PS11	PROJECT -II AND VIVA-VOCE	100	300	400	0	0	24	12

Total Credits : 10+9+10+8+15+12=64

L : Credits for Lecture Hours T : Credits for Tutorial Hours
P : Credits for Practical Hours C : Total Number of Credits

LIST OF ELECTIVE SUBJECTS FOR POWER SYSTEMS ENGINEERING

S. No.	Subject Code	Course title	Sessional Marks	Final Exam marks	Total marks	Credits			
						L	T	P	C
		ELECTIVE I							
1	12PS12	NON LINEAR SYSTEMS	25	75	100	3	0	0	3
2	12PS13	HIGH VOLTAGE DC TRANSMISSION SYSTEMS	25	75	100	3	0	0	3
3	12PS14	MODELLING AND ANALYSIS OF ELECTRICAL MACHINES	25	75	100	3	0	0	3
4	12PS15	ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING	25	75	100	3	0	0	3
5	12PS16	POWER SYSTEM ECONOMICS	25	75	100	3	0	0	3
		ELECTIVE II							
6	12PS17	MICROCONTROLLER BASED SYSTEM DESIGN	25	75	100	3	0	0	3
7	12PS18	MODERN POWER GENERATION SYSTEMS	25	75	100	3	0	0	3
8	12PS19	POWER SYSTEM PLANNING AND RELIABILITY	25	75	100	3	0	0	3
9	12PS20	INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN	25	75	100	3	0	0	3
10	12PS21	POWER QUALITY ASSESSMENT AND MITIGATION	25	75	100	3	0	0	3
		ELECTIVE III							
11	12PS22	CONTROL SYSTEM SOFTWARE	25	75	100	3	0	0	3
12	12PS23	SUPPORT VECTOR MACHINE	25	75	100	3	0	0	3
13	12PS24	AI TECHNIQUES FOR POWER SYSTEMS	25	75	100	3	0	0	3
14	12PS25	POWER SYSTEM OPTIMIZATION	25	75	100	3	0	0	3
15	12PS26	ENERGY AUDITING AND MANAGEMENT	25	75	100	3	0	0	3
		ELECTIVE IV							
16	12PS27	ADVANCED ELECTRIC DRIVES AND CONTROLS	25	75	100	3	0	0	3
17	12PS28	POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS	25	75	100	3	0	0	3
18	12PS29	FLEXIBLE AC TRANSMISSION SYSTEMS	25	75	100	3	0	0	3
19	12PS30	EHV AC TRANSMISSION SYSTEMS	25	75	100	3	0	0	3
20	12PS31	HIGH VOLTAGE AND INSULATION SYSTEMS	25	75	100	3	0	0	3
		ELECTIVE V							
21	12PS32	POWER SYSTEM SECURITY	25	75	100	3	0	0	3
22	12PS33	POWER SYSTEM RESTRUCTURING AND DEREGULATION	25	75	100	3	0	0	3
23	12PS34	WIND ENERGY CONVERSION SYSTEMS	25	75	100	3	0	0	3
24	12PS35	POWER ELECTRONICS FOR RENEWABLE ENERGY	25	75	100	3	0	0	3
25	12PS36	FEM MODELLING OF HIGH VOLTAGE APPARATUS AND SYSTEMS	25	75	100	3	0	0	3
		ELECTIVE VI							
26	12PS37	MODEL PREDICTIVE CONTROL	25	75	100	3	0	0	3
27	12PS38	VIRTUAL INSTRUMENTATION	25	75	100	3	0	0	3
28	12PS39	ADVANCED POWER SYSTEM DYNAMICS	25	75	100	3	0	0	3
29	12PS40	PARTIAL DISCHARGES IN ELECTRICAL APPARATUS	25	75	100	3	0	0	3
30	12PS41	DISTRIBUTED AUTOMATION	25	75	100	3	0	0	3

12PS01 APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERING

(Common to PSE and PED)

L	T	P	C
3	1	0	4

CALCULUS OF VARIATION (09)

Functional - Euler's equation - Variational problems involving one unknown function - Several unknown functions - Functional dependent on higher order derivatives - Several independent variables - Isoperimetric problems.

ADVANCED MATRIX THEORY (09)

Matrix Norms – Jordan Canonical Form – Generalized Eigenvectors – Singular Value Decomposition – Pseudo Inverse – Least Square Approximation – QR Algorithm.

SINGLE VARIABLE OPTIMIZATION (09)

Optimality criteria – Exhaustive search method – Bounding phase method – Interval halving method – Fibonacci search method – Golden section search method – Successive quadratic estimation method – Newton Raphson method – Bisection method – Secant method – Cubic search method – Root finding using optimization techniques.

LINEAR PROGRAMMING (09)

Simplex algorithm - Two phase and Big -M method - Duality theory - Dual simplex method - Transportation and Assignment problems.

NON-LINEAR PROGRAMMING (09)

Formulation of non-linear programming problem – Constrained optimization with Equality constraints – Constrained optimization with inequality constraints – Saddle point problem – Graphical method of non-linear programming problem involving only two variables – Kuhn-Tucker conditions with non-negative constraints.

Lecture : 45 Tutorial : 15 Total : 45 Hrs.

Reference Books

1. *Venkataraman M.K, "**Higher Mathematics for Engineering & Science**", National Publishing Company, 2000.*
2. *Kandasamy. P, "**Engineering Mathematics Volume – II**", S.Chand & Co., Third Edition, 2006.*
3. *Gupta P.K. Hira D.S, **"Operations Research"**, S.Chand & Co., Third Edition, 2008.*
4. *Veerarajan. T, "**Probability, Statistics & Random Processes**", Tata McGraw Hill, Second Edition, 2002.*
5. *Kalyanmoy Deb, "**Optimization for Engineering Design – Algorithms and Examples**", Prentice Hall of India Pvt. Ltd., 2004.*

12PS02 SYSTEMS THEORY

(Common to PSE and PED)

L	T	P	C
3	0	0	3

STATE VARIABLE REPRESENTATION (09)

Concepts of state, state variables and state model- State model for linear time invariant systems – state space representation using physical, phase and canonical variables – transfer function from state model – Direct cascade parallel decomposition – solution of state equation – state transition matrix.

SYSTEM MODELS (09)

Characteristic equation – Eigen values and eigen vectors – Invariance of eigen values – Diagonaliozation – Jordan canonical form – Concept of controllability and observability – Kalman's and Gilbert's tests – Controllable and Observable Phase Variable forms for SISO and MIMO systems – Effect of pole-zero cancellation on controllability and observability – Pole placement by state feedback – Full order and reduced order observers

NON-LINEAR SYSTEMS (09)

Types of non linearity – Phase plane analysis – Singular points – Limit cycles – Construction of phase trajectories – Describing function method – Derivation of describing functions

STABILITY (09)

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-Gradient Method.

ADVANCED CONTROL SYSTEMS (09)

Adaptive Control: Model – Reference Adaptive Control fundamental concepts – Self tuning Control – Robust Control; Parameter perturbations – Design of robust control system – PID controllers – Fuzzy Logic Control – Neutral Network Controller – Genetic Algorithm

Total : 45 Hrs.

Reference Books

1. *Katsuhiko Ogata, "**Modern Control Engineering**", Pearson Hall of India Private Ltd, New Delhi, III Edition, 2002*
2. *Gopal.M, "**Modern Control System Theory**", New Age International, 2005.*
3. *Roy Choudhury.D, "**Modern Control Systems**", New Age International, 2005*
4. *John J. D'Azzo, Houpis.C.H and Sheldon.S.N, "**Linear Control System Analysis and Design with MATLAB**", Taylor Francis, 2003.*
5. *Bubnicki.Z, "**Modern Control Theory**", Springer, 2005.*

12PS03 COMPUTER AIDED POWER SYSTEM ANALYSIS

L	T	P	C
3	0	0	3

AC POWER FLOW ANALYSIS (09)

Introduction, Modeling of Power System Components, Power Flow Equations, Formation of Ybus Matrix, Power Flow Solution Algorithms, Newton Raphson Load Flow Method, Fast Decoupled Load Flow Method And DC Load Flow Method, AC-DC System Power Flow Analysis-Sequential and Simultaneous Solution Algorithms.

SPARSE MATRICES (09)

Sparsity directed Optimal Ordering Schemes, Solution Algorithms - LU Factorization, Bifactorization and Iterative Methods.

ANALYSIS OF FAULTED POWER SYSTEM (09)

Symmetrical and Asymmetrical Faults, Zbus Formulation, Short Circuit Analysis of Large Power Systems using Zbus, Analysis of Open Circuit faults.

SECURITY ANALYSIS (09)

Basic Concepts, Static Security Analysis at Control Centers, Contingency Analysis, Contingency Selection.

STABILITY ANALYSIS (09)

Classification of Power System Stability, Classical Model of Synchronous Machines and Excitation System, Transient Stability Analysis of Multi-Machine Systems, Eigen Analysis of Dynamical Systems, Small Signal Stability Analysis using Classical Model, Basic Concepts of Voltage Stability Analysis.

Total : 45 Hrs.

Reference Books

1. *Elgerd O.I., "**Electric Energy Systems Theory - An Introduction**", Second Edition, Tata McGraw-Hill, 2007.*
2. *Bergen A.R. and Vijay Vittal,"**Power Systems Analysis**", Pearson Education Asia, III edition, 2009.*
3. *Grainger J.J. and Stevenson W.D., "**Power System Analysis**", McGraw-Hill, New York, 1994.*
4. *NagrathI.J. and Kothari D.P., "**Power System Engineering**", Tata McGraw-Hill Publishing Co., Second Edition, 2008.*
5. *Glover J.D., SarmaM. and Overbye T.J., "**Power System Analysis and Design**", Fifth Edition, CL- Engineering Press, 2011.*
6. *Kundur P., "**Power System Stability and Control**", McGraw Hill, 5th reprint, 2008.*

12PS04 POWER SYSTEM CONTROL AND OPERATION

L	T	P	C
3	1	0	4

REACTIVE POWER AND VOLTAGE CONTROL (09)

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 COMMITMENT (09)

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 .

GENERATION SCHEDULING (09)

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.

CONTROL OF POWER SYSTEMS (09)

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.

STATE ESTIMATION (09)

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

Lecture : 45 Tutorial : 15 Total Hrs : 60

Reference Books

1. *Elgerd.O.I, "**Electric Energy System Theory - an Introduction**", - Tata McGraw Hill, New Delhi – 2002.*
2. *Kundur .P ; "**Power System Stability and Control**", Tata McGraw Hill, 5th reprint, 2008.*
3. *Allen J.Wood and Bruce.F.Wollenberg, "**Power Generation Operation and Control** , John Wiley & Sons New York, 2006.*
4. *Mahalanabis.A.K, Kothari.D.P. and Ahson.S.I., "**Computer Aided Power System Analysis and Control**", Tata McGraw Hill publishing Ltd , 1984.*

12PS05 POWER SYSTEM TRANSIENTS AND SURGE PROTECTION

L	T	P	C
3	0	0	3

INTRODUCTION (09)

Review of various types of power system transients-Lightning surges, Switching surges : Inductive energy transient and Capacitive energy transient – effect of transients on power systems- relevance of the study and computation of power system transients – Surge voltage and surge current specifications(As per BIS).

LIGHTNING SURGES (09)

Lightning- overview- Lightning surges- Electrification of thunderclouds – Simpson's theory of thunderclouds – Direct and Indirect strokes –Stroke to conductor, midspan and tower – Conventional lightning protection technique: Collection Volume method (Dynasphere).

TRANSIENT CALCULATION (09)

Travelling wave concepts – Telegraphic Equation, Wave Propagation, Reflections – Bewley's Lattice diagrams for various cases –Analysis in time and frequency domain –Eigen value approach –Z-transform.

SWITCHING SURGES (09)

Closing and reclosing of lines – load rejection –fault initiation –fault clearing –short line faults – Ferro Resonance – isolator switching surges –temporary over voltages – surges on an integrated system – switching – harmonics –Protection scheme.

INSULATION CO ORDINATION (09)

Principles of insulation co-ordination –recent advancements in insulation co ordination -BIL, Design of EHV system – Insulation coordination as applied to transformer, substations –Examples.

Total: 45 Hrs.

Reference Books

1. *Allan Greenwood, "**Electrical Transients in power Systems**", Willey Interscience, Newyork, Second Edition, 1991.*
2. *Klaus Ragaller. "**Surges in High Voltage Networks**", Plenum Press, NewYork, 1980.*
3. *Indulkar C.S., and Kothari D.P., "**Power System Transients**"- A Statistical approach, Prentice Hall 2004.*
4. *Subir Ray,"**Electrical Power Systems – Concepts, Theory and Practice**", Prentice Hall of India, NewDelhi, 2007.*
5. *Rakosh das Begamurde, "**Extra High Voltage AC Transmission Engineering**", Wiley Eastern Ltd, New Delhi, 2009.*
6. *Chakrabarthy.A, Soni.M.L, Gupta.P.V. and Bhatnagar.U.S. "**A Text Book on Power System Engineering**" DhanpatRai& Sons., NewDelhi, 2008.*
7. *Bewely L.V., "**Travelling waves and Transmission Systems**", Dover Publications, New York, 1963.*

12PS06 DIGITAL POWER SYSTEM PROTECTION

L	T	P	C
3	0	0	3

NUMERICAL PROTECTION (08)

Introduction , block diagram of numerical relay, sampling theorem, correlation with a reference wave, Least Error Squared (LES) technique, digital filtering, numerical overcurrent protection.

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DIGITAL PROTECTION OF TRANSMISSION LINE (09)

Introduction, Protection scheme of transmission line, distance relays, traveling wave relays, digital protection scheme based upon fundamental signal, hardware design,software design, digital protection of EHV/UHV transmission line based upon traveling wave phenomenon, new relaying scheme using amplitude comparison.

DIGITAL PROTECTION OF SYNCHRONOUS GENERATOR AND POWER TRANSFORMER (10)

Introduction, faults in synchronous generator, protection schemes for synchronous generator, digital protection of synchronous generator. Faults in a transformer, schemes used for transformer protection, digital protection of transformer.

DISTANCE AND OVERCURRENT RELAY SETTING AND CO-ORDINATION (09)

Directional instantaneous IDMT overcurrent relay, directional multizone distance relay, distance relay setting, co-ordination of distance relays, co-ordination of overcurrent relays, computer graphics display, man-machine interface subsystem, integrated operation of national power system, application of computer graphics.

PC APPLICATIONS IN SHORT CIRCUIT STUDIES FOR DESIGNING RELAYING SCHEME (09)

Types of faults, assumptions, development of algorithm for S.C. studies, PC based integrated software for S.C. studies, transformation to component quantities, S.C.studies of multiphase systems.

Ultra high speed protective relays for high voltage long transmission line.

Total: 45 Hrs.

Reference Books

1. *Singh L.P., "**Digital Protection, 2nd Edition New Age International (P) Limited**, New Delhi, 1997.*
2. *Paithankar , **"Transmission Network Protection"**, Marcel & Dekker, New York, 1998.*
3. *Paithankar and Bhide, **"Fundamentals of Power System Protection",** Prentice Hall of India Pvt. Ltd., New Delhi, second edition, 2010.*
4. *Stanley Horowitz, **"Protective Relaying for Power System II"**, John Wiley & sons, 2008.*
5. *Rao T.S.M., **"Digital Relay / Numerical relays"**, Tata McGraw Hill, New Delhi, 2005.*

12PS07 POWER SYSTEM DYNAMICS AND CONTROL

L	T	P	C
3	0	0	3

ANALYSIS OF DYNAMICAL SYSTEMS (09)

Concept of Equilibria, Small and Large Disturbance Stability, Example: Single Machine Infinite Bus System, Modal Analysis of Linear Systems, Analysis using Numerical Integration Techniques, Issues in Modeling: Slow and Fast Transients, Stiff Systems.

MODELING OF A SYNCHRONOUS MACHINE (09)

Physical Characteristics, Rotor Position Dependent model, D-Q Transformation, Model with Standard Parameters, Steady State Analysis of Synchronous Machine, Short Circuit Transient Analysis of a Synchronous Machine, Synchronous Machine Connected to Infinite Bus.

MODELING OF EXCITATION AND PRIME MOVER SYSTEMS (09)

Physical Characteristics and Models, Control system components, Excitation System Controllers, Prime Mover Control Systems.

MODELING OF TRANSMISSION LINES AND LOADS (09)

Transmission Line Physical Characteristics, Transmission Line Modeling, Load Models - induction machine model, Other Subsystems - HVDC, protection systems.

STABILITY ISSUES IN INTERCONNECTED POWER SYSTEMS (09)

Single Machine Infinite Bus System, Multi-machine Systems, Stability of Relative Motion, Frequency Stability: Centre of Inertia Motion, Concept of Load Sharing: Governors, Single Machine Load Bus System: Voltage Stability, Torsional Oscillations.

Total: 45 Hrs.

Reference Books

1. Padiyar K.R., ***"Power System Dynamics, Stability & Control"****, 2nd Edition,B.S. Publications, Hyderabad, 2002.*

2. Kundur P., ***"Power System Stability and Control"****, McGraw Hill Inc., New York,1995.*

3. Sauer P. and Pai M.A., ***"Power System Dynamics and Stability",*** *Prentice Hall, 1998.*

12PS08 POWER SYSTEM STABILITY

L	T	P	C
3	0	0	3

INTRODUCTION (09)

Power System stability considerations – definitions- classification of stability – rotor angle and voltage stability- synchronous machine representation- classical model – load modeling- concepts- modeling of excitation systems – modeling of prime movers.

TRANSIENT STABILITY ANALYSIS (09)

Transient stability-swing equation-equal area criterion-solution of swing equation-Numerical methods-Euler method-Runge-Kutta method-critical clearing time and angle-effect of excitation system and governors-Multimachine stability –extended equal area criterion- transient energy function approach.

SMALL SIGNAL STABILITY (09)

Small signal stability – state space representation – eigen values- modal matrices-small signal stability of single machine infinite bus system – synchronous machine classical model representation-effect of field circuit dynamics-effect of excitation system-small signal stability of multi machine system.

VOLTAGE STABILITY (09)

Review of transmission aspects – Generation aspects : Review of synchronous machine theory - Voltage and frequency controllers – Limiting devices affecting voltage stability – V- Q characteristics of synchronous generators – Capability curves – Effect of machine limitation on deliverable power – Load aspects – Voltage dependence of loads – Load restoration dynamics – Induction motors – Load tap changers – Thermostatic load recovery – General aggregate load models.

IMPROVING STABILITY (09)

Methods of improving stability – transient stability enhancement – high speed fault clearing – steam turbine fast valving -high speed excitation systems- Fundamentals and performance of Power System Stabilizer – Multi band PSS – Three dimensional PSS – Location & dispatch of reactive power by VAR sources.

Total: 45 Hrs.

Reference Books

1. *Kundur, P.,* ***"Power System Stability and Control",*** *McGraw-Hill International Editions,1994.*
2. *Anderson, P.M. and Fouad, A.A., "****Power System Control and Stability",*** *GalgotiaPublications, New Delhi, Second Edition, 2002.*
3. *Van Cutsem, T. and Vournas, C.,* ***"Voltage Stability of Electric Power Systems",*** *Kluwer Academic Publishers, 2007.*
4. *Taylor.C.W,* ***"Power System Voltage Stability",*** *McGraw-Hill, 1994.*
5. *Kimbark.E.W,* ***"Power System Stability Vol. II",*** *John Wiley &Sons, 1950.*

12PS09 POWER SYSTEM SIMULATION LAB

L	T	P	C
0	0	3	2

ANALYSIS USING MATLAB/SIMULINK, EMTP AND PSCAD

1. Power flow analysis by Newton-Raphson method.
2. Power flow analysis by Fast decoupled method.
3. Transient stability analysis of single machine-infinite bus system using classical machine model.
4. Contingency analysis: Generator shift factors and line outage distribution factors.
5. Economic dispatch using lambda-iteration method.
6. Unit commitment: Priority-list schemes and dynamic programming.
7. Load flow analysis of two-bus system with STATCOM.
8. Transient analysis of two-bus system with STATCOM.
9. Available transfer capability calculation using an existing load flow program.
10. Computation of harmonic indices generated by a rectifier feeding a R-L load.

Total : 45 Hrs.

12PS12 NON LINEAR SYSTEMS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

INTRODUCTION TO NON LINEAR SYSTEMS (09)

Introduction, Characteristics of Non linear systems, Jump resonance, Sub-harmonic oscillations, Limit cycles, Frequency entertainment quenching, Non-linearities - inherent and intentional.

PHASE PLANE ANALYSIS (09)

Phase plane analysis, Singular points, sketching of phase portraits, Limit cycles, nonlinear conservative system with nonlinear damping. Effect of non-linearities on the step response of the position control and relay systems.

DESCRIBING FUNCTION ANALYSIS (09)

Describing function techniques - Describing functions of nonlinear characteristics, Expression for the functions, Accuracy of describing function methods, Describing functions for multiple non linearities, Evaluation of the gain function for analytically and graphically defined characteristics.

CONCEPTS OF STABILITY (09)

Experimental determination of gain functions, Condition for stability, stability of oscillations, Stability of systems with multiple non-linearities, Closed loop frequency response, Transient response, Dual input describing functions.

STABILITY ANALYSIS (09)

Lyapunov's and Popov's stability criteria, Linearisation and stability in the small and large sense, Second method of Lyapunov, Variable gradient methods, Lure's problem, Popov's stability Theorem.

Total : 45Hrs

Reference Books

1. *H.Khalil,* ***"Non linear Systems"****, Macmillan Pub. Company, New york, 1992 .*
2. *I.J.Nagrath and M.Gopal,* ***"Control System Engineering"****, John Wiley Publishing Ltd., 1993.*
3. *Ogata,* ***"Modern Control Engineering"****, Prentice Hall India, 1991.*

12PS13 HIGH VOLTAGE DC TRANSMISSION SYSTEMS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

DC POWER TRANSMISSION TECHNOLOGY (09)

Introduction - Comparison of AC and DC transmission – Application of DC transmission – Description of DC transmission system – Planning for HVDC transmission – Modern trends in DC transmission.

ANALYSIS OF HVDC CONVERTERS (09)

Pulse number – Choice of converter configuration – Simplified analysis of Graetz circuits – Converter bridge characteristics – Characteristics of twelve-pulse converter – Detailed analysis of converters.

CONVERTER AND HVDC SYSTEM CONTROL (09)

General principles of DC Link control – Converter control characteristics – System control hierarchy- Firing angle control – Current and extinction angle control – Starting and stopping of DC link- Power control – Higher level controllers – Telecommunication requirements.

HARMONICS AND FILTERS (09)

Introduction – Generation of harmonics – Design of AC filters – DC filters – Carrier frequency and RI noise.

SIMULATION OF HVDC SYSTEMS (09)

Introduction – System simulation: Philosophy and tools – HVDC system simulation – Modelling of HVDC systems for Digital Dynamics Simulation.

Total : 45 Hrs.

Reference Books

1. *Padiyar .K .R. ,* ***'HVDC Power Transmission Systems '****, New age international(P) Ltd, New Delhi, 2002.*
2. *Edward Wilson Kimbark ,* ***'Direct Current Transmission'****, Vol 1 , Wiley Interscience, Newyork, London, Sydney, 1971.*
3. *Rakosh Das Begamudre ,* ***'Extra High Voltage AC Transmission Engineering'*** *,Wiley Eastern Ltd, New Delhi, 2006.*
4. *Arrillaga .J,* ***'High Voltage Direct Current Transmission'****, Peter Pregrinus London, Second Edition, 1998.*
5. *Adamson .C and Hingorani N.G.,* ***'High Voltage Direct Current Power Transmission",*** *Garraway Ltd., London, 1967.*
6. *Kundur.P,* ***"Power system stability and control"****, McGraw Hill, 1994.*
7. *www.abb.se/pow/hvdc.htm*
8. *www.pwrgen.westinghouse.com/energy/facts.htm*
9. *www.hvdc.ca*

12PS14 MODELING AND ANALYSIS OF ELECTRICAL MACHINES

(Common to PSE and PED)

L	T	P	C
3	0	0	3

PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION (09)

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.

REFERENCE FRAME THEORY (09)

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.

DC MACHINES (09)

Voltage and torque equations – dynamic characteristics of permanent magnet and shunt DC motors – state equations - solution of dynamic characteristic by Laplace transformation.

INDUCTION MACHINES (09)

Voltage and torque equations – transformation for rotor circuits – voltage and torque 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.

SYNCHRONOUS MACHINES (09)

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 : 45Hrs.

Reference Books

1. *Paul C.Krause, Oleg Wasyzczuk, Scott S, Sudhoff,* ***"Analysis of Electric Machinery and Drive Systems",*** *IEEE Press, Second Edition, 2002.*
2. *Krishnan.R,* ***"Electric Motor Drives, Modeling, Analysis and Control"****, Prentice Hall of India, 2002.*
3. *Samuel Seely****, "Eletromechanical Energy Conversion"****, Tata McGraw Hill Publishing Co, 1962.*
4. *Fitzgerald.A.E, Charles Kingsley, Jr, and Stephan D, Umanx,* ***"Electric Machinery",*** *Tata McGraw Hill, 6th Edition, 2002.*

12PS15 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING

L	T	P	C
3	0	0	3

INTRODUCTION (09)

Review of basic field theory – electric and magnetic fields – Maxwell's equations –Laplace, Poisson and Helmoltz equations – principle of energy conversion – force/torque calculation – Electro thermal formulation.

SOLUTION OF FIELD EQUATIONS BY ANALYTICAL METHODS (09)

Limitations of the conventional design procedure, need for the field analysis baseddesign, problem definition , solution by analytical methods-direct integration method –variable separable method – method of images, solution by numerical methods- Finite Difference Method.

SOLUTION OF FIELD EQUATIONS BY NUMERICAL METHODS (09)

Finite element method (FEM) – Differential/ integral functions – Variational method –Energy minimization – Discretisation – Shape functions –Stiffness matrix –1D and 2Dplanar and axial symmetry problem.

FIELD COMPUTATION FOR BASIC CONFIGURATIONS (09)

Computation of electric and magnetic field intensities– Capacitance and Inductance –Force, Torque, Energy for basic configurations.

DESIGN APPLICATIONS (09)

Insulators- Bushings – Cylindrical magnetic actuators – Transformers – Rotating machines.

Total: 45 Hrs.

Reference Books

1. *K.J.Binns, P.J.Lawrenson and C.W Trowbridge,* ***"The Analytical and Numerical Solution of Electric and Magnetic Fields"****, John Wiley & Sons, 1993.*
2. *Nathan Ida and Joao P.A.Bastos ,* ***"Electromagnetics and Calculation of Fields",*** *Springer-Verlag, Second Edition, 1997.*
3. *Nicola Bianchi ,* ***"Electrical Machine Analysis Using Finite Elements",*** *Taylor andFrancis Group, CRC Publishers, 2005.*
4. *Salon S.J.,* ***"Finite Element Analysis of Electrical Machines."*** *Kluwer AcademicPress, London, 1995*
5. *User manuals of* ***MAGNET, MAXWELL & ANSYS*** *software.*
6. *Silvester and Ferrari,* ***"Finite Elements for Electrical Engineers"*** *CambridgeUniversity Press, Third Edition, 1996.*

12PS16 POWER SYSTEM ECONOMICS

L	T	P	C
3	0	0	3

CHARACTERISTICS AND OPERATION OF POWER PLANTS (09)

Characteristic operation of power plants - Choice of power plants - Hydro, Thermal and Nuclear - Size of plant – Input / Output curves.

OPTIMAL SYSTEM OPERATION OF POWER PLANTS (09)

Economic scheduling - Cost and loss calculation for optimum economy - Practical calculation - Evaluation and application of economic scheduling of generation - Simple problems.

CALCULATION OF TRANSMISSION LOSSES (09)

Transmission losses - Concept of transformation - Calculation of losses -Representation of loads - Reactive losses.

GENERATION SYSTEM COST ANALYSIS (09)

Economic Planning - Generation system - Cost analysis - Capacity cost -Production cost - Plant cost - Timing of unit additions - System cost analysis.

GENERATION SYSTEM RELIABILITY ANALYSIS (09)

Load forecasting and system reliability - Load forecasting - Generation system reliability - Co-ordination methods - Economic operation of power systems - Simple problems.

Total: 45 Hrs.

Reference Books

1. *Kirchmayer L.K.,**"Economic Operation of Power System",** JohnWiley, New York,1958.*
2. *Murthy P.S.R. **"Power System Operation and Control",** Tata McGraw Hill, New Delhi, 1984.*
3. *Nagrath I.J. and Kothari D.P., **"Modern Power System Analysis",** Tata McGraw Hill Book Publishing Company Ltd., New Delhi,1990.*
4. *Allen.J.Wood and Wollenberg B.F., **"Power Generation Operation and Control",** John Wiley and Sons, New York,1989.*
5. *Murthy P.S.R. **"Operation and Control in Power Systems",** Tata McGraw Hill, New Delhi, 2011.*

12PS17 MICROCONTROLLER BASED SYSTEM DESIGN

(Common to PSE and PED)

L	T	P	C
3	0	0	3

PIC 16C7X MICRO CONTROLLER –FRAME WORK (09)

Architecture- Program memory considerations-register file structure- CPU registers -Addressing modes-Instruction set -simple programs.

REAL TIME CONTROL (09)

Interrupt structure - Interrupt logic-Interrupt service routine - Interrupt constraints - Critical regions – Shortening an interrupt handler -Timers -0-1-2 and uses – Timer External event counter -PWM outputs.

PERIPHERALS OF PIC MICROCONTROLLER (09)

I^2C bus for peripherals chip access- I^2C Bus operation A/D converters- overview-ADC characteristics ADC use - UART wave forms and baud rate accuracy – UART data handling circuitry - UART uses.

INPUT/OUTPUT PORT EXPANSIONS (09)

Synchronous serial port module - serial peripherals interface- output port expansion-input port expansion-LCD Display-motor control.

FRONT PANEL I/O (09)

Overview - Soft keys-state machines and key switches-Display of variable strings-Display of constant strings-Special features – configuration word- oscillator configuration – low power operation.

Total: 45 Hrs.

Reference Books

1. *John B.Peatman,* ***"Design with PIC Microcontroller",*** *Pearson Education, Asia, 2004.*
2. *MykePredko,* ***"Programming and Customizing the PIC Microcontroller",*** *Tata McGraw Hill, III Edition, 2007.*

12PS18 MODERN POWER GENERATION SYSTEMS

L	T	P	C
3	0	0	3

RENEWABLE ENERGY POLICY AND LEGISLATION (09)

Rural Energy - Biogas plants - Improved biomass cooking stoves - Biomass production and utilization – briquetting and gasifiers - Integrated Rural Energy Programme

SOLAR ENERGY (09)

Solar Photovoltaic systems - Solar thermal systems - Solar Energy Centre.

POWER GENERATION (09)

Biomass Power - Wind Power - Small Hydro Power - Solar photovoltaic Power – Solar Thermal Power - Energy from Urban, Municipal and Industrial Wastes.

NEW TECHNOLOGY (09)

Geothermal energy - ocean energy - alternate fuel for surface transport including electric vehicles - chemical sources of energy including fuel cells and hydrogen energy.

R&D- INDIAN CONTEXT (09)

Indian Renewable Energy Development Agency Ltd - Information and Public Awareness - International Relations - Integrated Finance – Planning - co-ordination and administration.

Total : 45 Hrs.

Text Books

1. *G. D. Rai,**"Non Conventional Energy Sources"**, ISBN: 8174090738, Khanna Publishers.*
2. *Dan Chiras, **"The Homeowner's Guide to Renewable Energy"**, New Society Publishers ,ISBN: 9780865715363.*
3. ***"Renewable energy engineering and technology"**, TERI Press.*
4. ***"TERI Energy Data Directory & Yearbook"** (TEDDY) 2005/06.*
5. ***"National Energy Map for India"**, ISBN: 81-7993-064-5.*

References

1. *www. mnes.nic.in*
2. *www.indiasolar.com*
3. *www.bioenergyindia.kar.nic.in*
4. *www.niot.res.in*
5. *www.geos.iitb.ac.in*
6. *www.alt-e.blogspot.com*

12PS19 POWER SYSTEM PLANNING AND RELIABILITY

L	T	P	C
3	0	0	3

LOAD FORECASTING (09)

Objectives of forecasting - Load growth patterns and their importance in planning – Load forecasting Based on discounted multiple regression technique-Weather sensitive load forecasting-Determination of annual forecasting-Use of AI in load forecasting.

GENERATION SYSTEM RELIABILITY ANALYSIS (09)

Probabilistic generation and load models- Determination of LOLP and expected value of demand not served –Determination of reliability of iso and interconnected generation systems.

TRANSMISSION SYSTEM RELIABILITY ANALYSIS (09)

Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP andexpected value of demand not served.

EXPANSION PLANNING (09)

Basic concepts on expansion planning-procedure followed for integrate transmission system planning, current practice in India-Capacitor placer problem in transmission system and radial distributions system.

DISTRIBUTION SYSTEM PLANNING OVERVIEW (09)

Introduction, sub transmission lines and distribution substations-Design primary and secondary systems-distribution system protection and coordination of protective devices.

Total: 45 Hrs.

Reference Books

1. *Proceeding of work shop on* ***"Energy systems planning & manufacturing CI"****.*
2. *Sullivan R.L.,* ***" Power System Planning"****, MC Grow Hill, Inc., US 1977.*
3. *Roy Billinton and Allan Ronald,* ***"Power System Reliability****." Gardon & Breach, Newyork 1970.*
4. *Turan Gonen,* ***"Electric Power Distribution System Engineering",*** *Second Edition, CRC press, 2007.*

12PS20 INDUSTRIAL POWER SYSTEM ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

MOTOR STARTING STUDIES (09)

Introduction-Evaluation Criteria-Starting Methods-System Data-Voltage Drop Calculations-Calculation of Acceleration time-Motor Starting with Limited-Capacity Generators-Computer-Aided Analysis.

POWER FACTOR CORRECTION STUDIES (09)

Introduction-System Description and Modeling-Acceptance Criteria-Frequency Scan Analysis-Voltage Magnification Analysis-Sustained Overvoltage's-Switching Surge Analysis-Back-to-Back Switching.

HARMONIC ANALYSIS (09)

Harmonic Sources-System Response to Harmonics-System Model for Computer-Aided Analysis-Acceptance Criteria-Harmonic Filters-Harmonic Evaluation-Case Study.

FLICKER ANALYSIS (09)

Sources of Flicker-Flicker Analysis-Flicker Criteria-Data for Flicker analysis- Case Study- Arc Furnace Load-Minimizing the Flicker Effects.

GROUND GRID ANALYSIS (09)

Introduction-Acceptance Criteria-Ground Grid Calculations-Computer-Aided Analysis - Improving the Performance of the Grounding Grids.

Total: 45 Hrs.

Reference Books

1. *Ramasamy Natarajan,* ***"Computer-Aided Power System Analysis",*** *Marcel Dekker Inc, 2002.*

2 *George L.Kusic,* ***"Computer-Aided Power System Analysis",*** *CRC press, 2008.*

12PS21 POWER QUALITY ASSESSMENT AND MITIGATION

L	T	P	C
3	0	0	3

INTRODUCTION (08)

Importance of power quality - terms and definitions of power quality as per IEEE std.1159. for transients, short and long duration voltage variations, interruptions, short and long voltage fluctuations, imbalance, flickers and transients- Symptoms of poor power quality. Definitions and terminology of grounding- Purpose of groundings- Good grounding practices and problems due to poor grounding.

FLICKERS & TRANSIENT VOLTAGES (09)

RMS voltage variations in power system and voltage regulation per unit system- complex power. Principles of voltage regulation- Basic power flow and voltage drop.Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects- Short term and long term flickers. Various means to reduce flickers- Transient over voltages, sources, impulsive transients, switching transients, Effect of surge impedance and line termination, control of transient voltages.

VOLTAGE SAG, SWELLS AND INTERRUPTIONS (09)

Definitions of voltage sag and interruptions- Voltage sags versus interruptions- Economic impact of voltage sag. Major causes and consequences of voltage sags- Voltage sag characteristics- Voltage sag assessment. Influence of fault location and fault level on voltage sag. Areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag limits for computer equipment, CBEMA, ITIC, SEMI F 42curves. Representation of the results of voltage sags analysis. Voltage sag indices. Mitigation measures for voltage sags, such as DSTATCOM, UPQC,UPS, DVR, SMEs, CVT etc., utility solutions and end user solutions.

WAVEFORM DISTORTION (10)

Definition of harmonics, inter-harmonics, sub-harmonics- Causes and effect of harmonics. Voltage versus current distortion. Overview of Fourier analysis. Harmonic indices. A.C. quantities under non-sinusoidal conditions. Triplen harmonics, characteristics and non characteristics harmonics. Harmonics series and parallel resonances- Consequences of harmonic resonance. Principles for controlling harmonics. Reducing harmonic currents in loads. K-rated transformer. Harmonic study procedure. Computer tools for harmonic analysis- Locating sources of harmonics. Harmonic filtering, passive and active filters - Modifying the system frequency response- IEEE Harmonic standard 519-1992.

ANALYSIS AND CONVENTIONAL MITIGATION METHODS (09)

Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

Total: 45 Hrs.

Reference Books

1. *M. H. J. Bollen,* ***"Understanding Power Quality Problems, Voltage Sag and Interruptions",*** *IEEE Press, series on Power Engineering, 2000.*
2. *Roger C. Dugan, Mark F. McGranaghan, Surya Santoso and Wayne Beaty H.,* ***"Electrical Power System Quality"****, Second Edition, McGraw Hill Publication Co., 2008.*
3. *G.T.Heydt,* ***"Electric Power Quality",*** *Stars in a Circle Publications, 1994(2nd edition).*
4. *Enrique Acha, Manuel Madrigal****, "Power System Harmonics: Computer Modeling and Analysis", John Wiley and Sons,*** *2001****.***
5. *ArrillagaJ. and Watson N****."Power System Harmonics",*** *John Wiley & Sons Ltd., England, 2003.*
6. *IEEE Std. 519-1992/ IEEE Std. 1159 IEEE recommended practices andrequirements for harmonics control in electrical power system.*

12PS22 CONTROL SYSTEM SOFTWARE

(Common to PSE and PED)

L	T	P	C
3	0	0	3

MATLAB BASICS (09)

Introduction - Matrices and Vectors - Matrix and Array operations - Build in functions - Saving and loading data - Script files - Function files - Language specific features.

MATLAB APPLICATIONS AND GRAPHICS (09)

Applications in linear algebra, Curve fitting and interpolation, Data analysis and statistics - Ordinary differential equations and nonlinear algebraic equations - Basic 2-D plots-multiple graphs layout - Handle graphics.

SIMULINK MODELS (09)

Starting simulink - Selecting objects - Blocks - Connecting blocks - Working with signals – Annotations - Working with data types - Creating subsystems.

SIMULATION (09)

Running a simulation with menu commands - Simulation parameter - Dialogue box - Viewing output trajectories - Equilibrium point determination - Running a simulation from command line.

MATLAB TOOLBOXES (09)

Control system toolbox: Linear models - MIMO models - Interconnecting linear models - Continuous/Discrete conversions - LTI viewer - Functions for time and frequency response - Simulink LTI viewer - Principles of symbolic math toolbox.

Total : 45 Hrs.

Reference Books

1. *Rudra Pratap,* ***"Getting Started with MATLAB 7",*** *Oxford University Press, 2009.*
2. *Duane C. Hanselman, and Bruce Littlefield ,* ***"Mastering Matlab",*** *Prentice Hall, 2012.*
3. ***Simulink Manual*** *, The Mathworks Inc.,2000, www.mathworks.com.*
4. ***Control System Toolbox Manual*** *, The Mathworks Inc.,2000, www. mathworks.com.*

12PS23 SUPPORT VECTOR MACHINE

(Common to PSE and PED)

L	T	P	C
3	0	0	3

LEARNING AND SOFT COMPUTING (09)

Examples of Applications in Diverse Fields –Basic tools of soft computing: Neural Networks, Fuzzy Logic Systems, and Support vector machines –Basic mathematics of soft computing – Learning and statistical approaches to Regression and classification.

GENERALIZATION AND OPTIMIZATION THEORY (09)

Learning from examples and generalization-Statistical learning theory – Empirical Risk minimization –Key theorem-VC dimension-Structural Risk minimization.

SUPPORT VECTOR MACHINE (09)

Introduction-Optimal hyper plane for linearly separable classes –Optimal hyper plane for non linear separable classes – Kernel trick and mercer condition-Non linear SVM classifier .

KERNEL INDUCED FEATURE SPACE (09)

Learning in Feature space-The implicit mapping in feature space –Making Kernels and Gaussian process –PCA.

APPLICATION OF SPM (09)

Principles of pattern recognition-support vector machine for pattern recognition-Non linear regression-identification of process using SVM-Fault diagnosis using SVM-Fault diagnosis using SVM-Modeling and control using Hybrid Intelligent systems.

Total : 45 Hrs.

Reference Books

1. *Nello Cristianini and John Shave –Taylor,* ***"An introduction to support vector machines and other kernel based learning methods"****, Springer.*
2. *Vladmir N.Vapnik,* ***"The Nature of statistical learning theory"****, 2nd edition,Springer 2000.*
3. *Bernhard Schlkopf, Alexander J .Smola, Learning with Kernels :* ***"Support vector machines , Regularization, Optimization and Beyond"*** *(Adaptive computation and machine learning),Springer.*
4. *Vojislav keeman,* ***"Learning and soft computing: Support Vector machines"****, Neural Networks and Fuzzy Logic models, Springer.*
5. *T.Hastie, R.Tibshirani, Friedman,* ***"The Elements of Statistical Learning"****, Springer.*
6. *Satish Kumar,* ***"Neural Network – A classroom approach"****, Tata MCGraw Hill,2004.*
7. *Simon Haykin,* ***"Neural Networks A Comprehensive Foundation"****, 2nd Edition, Prentice Hall of India.*
8. *Richard O.Duda, Peter E.Hart and David G.Stork,* ***"Pattern classification"****, 2nd Edition ,Wiley Publication.*

12PS24 AI TECHNIQUES FOR POWER SYSTEMS

L	T	P	C
3	0	0	3

INTRODUCTION TO NEURAL NETWORKS (09)

Basics of ANN - perceptron - delta learning rule - back propagation algorithm - multilayer feed forward network - memory models - bi-directional associative memory - Hopfield network.

APPLICATIONS TO POWER SYSTEM PROBLEMS (09)

Application of neural networks to load forecasting - contingency analysis - VAR control -economic load dispatch.

INTRODUCTION TO FUZZY LOGIC (09)

Crispness - vagueness - fuzziness - uncertainty - fuzzy set theory fuzzy sets - fuzzy set operations - fuzzy measures - fuzzy relations - fuzzy function - structure of fuzzy logic controller – fuzzification models - data base - rule base - inference engine defuzzification module.

APPLICATIONS TO POWER SYSTEMS (09)

Decision making in power system control through fuzzy set theory - use of fuzzy set models of LP in power systems scheduling problems - fuzzy logic based power system stabilizer.

GENETIC ALGORITHM AND ITS APPLICATIONS TO POWER SYSTEMS (09)

Introduction - simple genetic algorithm - reproduction - crossover - mutation – advanced operators in genetic search - applications to voltage control and stability studies.

Total: 45 Hrs.

Reference Books

1. *James A. Freeman and Skapura.B.M,* ***"Neural Networks - Algorithms Applications and Programming Techniques"****, Addison Wesley, 1991.*
2. *George Klir and Tina Folger.A,* ***"Fuzzy sets, Uncertainty and Information",*** *Prentice Hall of India, 2006.*
3. *Zimmerman.H.J,,* ***"Fuzzy Set Theory and its Applications",*** *Kluwer Academic Press, Third edition, 1996.*
4. *IEEE Tutorial on* ***"Application of Neural Network to Power Systems",*** *1996.*
5. *Loi Lei Lai,* ***"Intelligent System Applications in Power Engineering",*** *John Wiley & Sons Ltd., 1998.*

12PS25 POWER SYSTEM OPTIMIZATION

L	T	P	C
3	0	0	3

REVIEW OF POWER SYSTEMS (09)

Generator Operating Cost- Economic Load Dispatch- Without and with loss-Loss Coefficient using Sensitivity Factors-Economic Dispatch for Active and Reactive Power Balance- Economic Dispatch using Loss Formula which is Function of Real and Reactive Power-Optimal Power Flow Based on Gradient Method-Newton Method.

MULTIOBJECTIVE GENERATION SCHEDULING (09)

Multiobjective optimization-Weighting Method-Min –Max Optimum-å Constraint Method-Weighted Min-Max method-Utility Function Method-Global criterion method-Fuzzy set theory in Power System-Thermal Plant-Active and Reactive Power Balance.

STOCHASTIC MULTIOBJECTIVE GENERATION SCHEDULING (09)

Multiobjective Stochastic Optimal thermal Power Dispatch- å Constraint Method-Surrogate worth Tradeoff method-Weighting Method –Risk/Dispersion method-ANN methods-Economic- Emission Load Dispatch.

EVOLUTIONARY PROGRAMMING FOR GENERATION SCHEDULING (09)

Introduction to GA-Economic Dispatch Problem-GA Solution Methodology-GA Solution Based on Real Power Search.

ADVANCED OPTIMIZATION (09)

Swarm Intelligence-Ant Colony –Fish Flock-Particle Swarm Optimization – Multi Objective PSO- Tabu Search.

Total: 45 Hrs.

Reference Books

1. *Kothari D.P. and Dhillon .J.S.**"Power System Optimization",** Prentice Hall of India, New Delhi, 2004.*
2. *Kennedy J. and Eberhart.R.C, **"SwarmIntelligence",** SanFrancisco, CA, Morgan Kaufmann, 2001.*
3. *Glover, F., **"Tabu Search-Part II",** ORSA J.Comput.,1990, 2,(1), pp.4-32.*

12PS26 ENERGY AUDITING AND MANAGEMENT

L	T	P	C
3	0	0	3

BASIC PRINCIPLES OF ENERGY AUDIT (09)

Energy audit – definition, concept, type of audit, energy index, cost index, pie charts, Sankey diagrams, load profiles, Energy conservation schemes – Energy audit of industries – energy saving potential, energy audit of process industry, thermal power station, building energy audit.

ENERGY MANAGEMENT (09)

Principles of energy management, organizing energy management program, initiating, planning, controlling, promoting, monitoring, reporting – Energy manager, Qualities and functions, Language, Questionnaire – check list for top management.

ENERGY EFFICIENT MOTORS (09)

Energy efficient motors, factors affecting deficiency, loss distribution, constructional details, characteristics – variable speed, variable duty cycle systems, RMS hp- voltage variation –voltage unbalance – over motoring – motor energy audit.

POWER FACTOR IMPROVEMENT, LIGHTING AND ENERGY INSTRUMENTS (09)

Power factor - methods of improvement, location of capacitors, Pf with non linear loads, effect of harmonics on p.f, p.f motor controllers – Good lighting system design and practice, lighting control, lighting energy audit – Energy Instruments – watt meter, data loggers, thermocouples, pyrometers, lux meters, tongue testers, application of PLC's.

ECONOMIC ASPECTS AND ANALYSIS (09)

Economics analysis – Depreciation Methods, time value of money, rate of return, present worth method, replacement analysis, life cycle costing analysis - Energy efficient motors - calculation of simple payback method, net present worth method- Power factor correction, lighting – Applications of life cycle costing analysis, return on investment.

Total : 45 Hrs.

Reference Books

1. *Murphy W.R. and G.Mckay Butter worth , **"Energy Management"**, Heinemann Publications.*
2. *Paul o' Callaghan, **"Energy Management",** Mc-Graw Hill Book Company – 1st edition; 1998.*
3. *John.C.Andreas, **"Energy Efficient Electric Motors",** Marcel Dekker Inc Ltd – 2nd edition; 1995.*
4. *W.C.Turner, **"Energy Management Handbook",** John Wiley and Sons, Fifth edition, 2009.*
5. ***"Energy Management and Good Lighting Practice: fuel efficiency"** – booklet 12 – EEO.*

12PS27 ADVANCED ELECTRIC DRIVES AND CONTROLS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

INTRODUCTION (09)

Need for advanced controls - Principle factor affecting the choice of drive – Parameter identification techniques for electric motors – Electromagnetic compatibility of electric drives – Different options for an adjustable speed electric drive – Simulation of electrical drives – Advanced control strategies for electrical drives – DSP based control of electric drives.

DSP CONTROLLERS AND INSTRUCTION SET (09)

TMS 320 family overview – 320 C24X Series of DSP controllers – Architecture overview – C24X CPU internal bus structure – Memory – Central processing unit – Memory and I/O spaces – Overview of Memory and I/O spaces – Program control –Address modes – System configuration and interrupts – Clocks and low power modes –Digital input/ output (I/O). Instruction set: Assembly language instructions – Instruction set summary – Instruction description – Accumulator, arithmetic and logic instructions – Auxiliary register and data page pointer instructions – TREG, PREG, and Multiply instructions – Branch instructions – Control instructions – I/O and memory instructions.

PWM INVETER CONTROL (09)

Inverter – Operation principle – Inverter switching – Unipolar – Bipolar – Inverter dead time– inverter modulation – Different types – Sine Triangle – Analysis of Sine Triangle Modulation – Trapezoidal Modulation – Third harmonic Modulation – Analysis of Third Harmonic Modulation – Output filter requirement for different PWM techniques.

SPACE VECTOR MODULATION (09)

Concept of a Space Vector – dq0 Components for Three-phase sine wave source/1evel –dq0 Components for Voltage Source Inverter (VSI) operated in Square Wave Mode –Synchronously rotating reference frame – Space Vector Modulation (SVM) – Principle –SVM compared to regular sampled PWM Phase Lag reference for SVM – Naturally sampled SVM – Analytical solution for SVM – Harmonic losses for SVM – Placement of Zero Space Vector – Discontinuous Modulation – Phase Lag reference for discontinuous PWM.

NEURAL NETWORK AND FUZZY CONTROLLERS (09)

Current and speed control of Induction Motor – Current control algorithm – Sensorless motion control strategy – Induction Motor Controller using VHDL design. Fuzzy Logic Control of a Synchronous Generator – System representation – VHDL Modelling –FPGA implementation.

Total : 45 Hrs.

Reference Books

1. *Bimal K. Bose,* ***"Power Electronics and Variable Frequency Drives – Technology and Applications",*** *IEEE Press, 1997.*
2. *Grafame Holmes. D and Thomas A. Lipo,* ***"Pulse Width Modulation for Power Converters – Principles and Practice",*** *IEEE Press, 2003.*

3. *Peter Vas,* ***"Vector Control of AC Machines",*** *Oxford University Press, 1990.*

4. *Hamid A. Toliyat and Steven G.Campbell,* ***"DSP based Electromechanical Motion Control",*** *CRC Press 2004.*

5. *Ned Mohan****, "Advanced Electric Drives: Analysis, Control and Modelling using SIMULINK"****, John Wiley & Sons Ltd., 2001.*

12PS28 POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

HIGH POWER DEVICES AND THREE PHASE CONVERTERS (09)

High power devices for power system controllers – Characteristics - Converters configurations for large power control. Properties of three phase converters - Current and voltage harmonics - Effects of source and load impedance - choice of best circuit of power system.

CONVERTER CONTROL (09)

Gate control - Basic means of control - Control characteristics – stability of control- Reactive power control.

HVDC SYSTEMS (08)

Application of converters in HVDC system - Static VAR control - Sources of reactive power -Harmonics and filters.

WIND ENERGY AND PV ENERGY CONVERSION SYSTEM (10)

Basic components - Generator control – Harmonics - Power factor improvement. Different schemes for PV energy conversion - DC and AC power conditioners - Synchronized operation with grid supply - Harmonic problems.

POWER FLOW ANALYSIS (09)

Component models - Converter model - Analysis of converter - Transient and Dynamic stability analysis - Protection.

Total : 45 Hrs.

Reference Books

1. *Padiyar.K.R.**,"HVDC Power Transmission System"**, Wiley Eastern Limited, New Delhi, 2011.*
2. *Rai.G.D., **"Solar Energy Utilization",** Khanna Publishers, New Delhi, 2005.*
3. *Daniel, Haunt.V, **"Wind Power-A Handbook of WECS",**Van Nostrand Co.,New York, 1981.*
4. *Rakesh Das Bagamudre, **"Extra High Voltage AC Transmission Engineering",** New Age International Ltd., Third Edition, 2006.*
5. *R.Sastry Vedam, S.Sarma, **" Power Quality VAR compensation in Power systems",** CRC Press,2009.*

12PS29 FLEXIBLE AC TRANSMISSION SYSTEMS

(Common to PSE and PED)

L	T	P	C
3	0	0	3

INTRODUCTION (09)

FACTS-a toolkit, Basic concepts of static VAR compensator,Resonance damper, Thyristor controlled series capacitor,Static condenser, Phase angle regulator, and other controllers.

SERIES COMPENSATION SCHEMES (09)

Sub-Synchronous resonance,Torsional interaction,torsional torque,Compensation of conventional, ASC,NGH damping schemes,Modelling and control of thyristor controlled series compensators.

UNIFIED POWER FLOW CONTROL (09)

Introduction , Implementation of power flow control using conventional thyristor.Unified power flow concept, implementation of unified power flow controller.

DESIGN OF FACTS CONTROLLERS (09)

Approximate multi model decomposition,Variable structure FACTS controllers for Power system transient Stability, Non linear variable -structure control, variable structure series capacitor control and Variable structure series resistor control, Modeling and methods of analysis of FACTS controllers.

STATIC VAR COMPENSATION (09)

Basic concepts, Thysistor controlled reactor (TCR), Thyristor switched reactor (TSR), Thyristor Switched capacitor (TSC), Saturated reactor (SR), Fixed Capacitor (FC).

Total : 45 Hrs.

Reference Books

1. *Hingorani Narin G., Gyugyi Laszlo,* ***"Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems",*** *Wiley-IEEE Press, 2000.*
2. *Narin G.Hingorani,* ***"Flexible AC Transmission",*** *IEE Spectrum,April1993, pp 40-45.*
3. *Narin G.Hingorani,* ***"High Power Electronics and Flexible AC Transmission Systems",*** *IEEE High Power Engineering Review,1998.*
4. *Narin G.Hingorani,* ***"Power Electronics in Electric Utilities:Role of Power Eletronics in future power systems",*** *proc.of IEEE,Vol.76.no.4, April 1988.*
5. *Einar V.Larsen, Juan J.Sanchez-gasca and Joe H.chow* ***"Concepts for design of FACTS controller to damp power swings",*** *IEEE Trans on Power System vol 10, no2, May 1995.*

12PS30 EHV AC TRANSMISSION SYSTEMS

L	T	P	C
3	0	0	3

INTRODUCTION (09)

Standard transmission voltages – different configurations of EHV and UHV lines –average values of line parameters – power handling capacity and line loss – costs of transmission lines and equipment – mechanical considerations in line performance.

CALCULATION OF LINE PARAMETERS (09)

Calculation of resistance, inductance and capacitance for multi-conductor lines –calculation of sequence inductances and capacitances – line parameters for different modes of propagation – resistance and inductance of ground return, numerical example involving a typical 400/220kV line using line constant program.

VOLTAGE GRADIENTS OF CONDUCTORS (09)

Charge-potential relations for multi-conductor lines – surface voltage gradient on conductors – gradient factors and their use – distribution of voltage gradient on subconductors of bundle - voltage gradients on conductors in the presence of ground wires on towers.

CORONA EFFECTS (09)

Power losses and audible losses: I2R loss and corona loss - audible noise generation and characteristics - limits for audible noise - Day-Night equivalent noise level- radio interference**:** corona pulse generation and properties - limits for radio interference fields.

ELECTROSTATIC FIELD OF EHV LINES (09)

Effect of EHV line on heavy vehicles - calculation of electrostatic field of AC lines- effect of high field on humans, animals, and plants - measurement of electrostatic fields -electrostatic Induction in un - energised circuit of a D/C line - induced voltages in insulated ground wires - electromagnetic interference.

Total: 45 Hrs.

Reference Books

1. *Rakosh Das Begamudre,* ***"Extra High Voltage AC Transmission Engineering",****Second Edition, New Age International Pvt. Ltd., 2006.*
2. ***Power Engineer's Handbook****, Revised and Enlarged 6th Edition, TNEB Engineers'Association, October 2002.*
3. ***Microtran Power System Analysis Corporation****, Microtran Reference Manual,Vancouver Canada. (Website: www.microtran.com), 2002.*

12PS31 HIGH VOLTAGE AND INSULATION SYSTEMS

L	T	P	C
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INSULATING MATERIALS IN POWER SYSTEM (08)

Review of insulating materials Gases, Vacuum, liquids and solids- characterization of insulation condition – permittivity, capacitance, resistivity and insulation resistance, dielectric dissipation factors- partial discharges sources, forms and effects- ageing effects- electrical breakdown and operating stresses- standards relating to insulating materials.

BREAKDOWN MECHANISMS OF SOLID, LIQUID AND GASEOUS DIELECTRICS (09)

Introduction to insulation systems used in high voltage power apparatus - breakdown mechanisms of solid, liquid, gas and vacuum insulation.

BASIC METHODS OF GENERATION AND MEASUREMENT OFTEST HIGH VOLTAGES (10)

Generation of high alternating voltages: cascaded transformers and series resonant circuit- Generation of high dc voltages: rectifier circuit and voltage multiplier circuit- Generation of impulse voltages: multistage impulse generator circuit- Generation of impulse currents – Measurement of high ac, dc and impulse voltages: voltage divider circuits- Digital Storage Oscilloscope for impulse voltage and current measurements.

INSULATION TESTING OF ELECTRICAL EQUIPMENTS (10)

Necessity for high voltage testing - testing of distribution and power transformers - voltage transformers -current transformers - bushings – overhead line and substation insulators - surge arresters – high voltagecables - circuit breakers and isolators – IEC and Indian standards.

NON-DESTRUCTIVE TESTING (08)

Insulation resistance measurement- Measurement of tan delta and capacitance of dielectrics - grounded objects like transformers and alternators – Measurement of Partial discharges - location and easurement ofdischarges in electrical equipment –Dissolved gas in oil measurement.

Total: 45 Hrs.

Reference Books

1. *Adrianus,J.Dekker,* ***"Electrical Engineering Materials"****, Prentice Hall of India, New Delhi, 1979.*
2. *Kuffel,E. and Zaengl, W.S.,* ***"High Voltage Engineering Fundamentals"****, Pergamon Press, Oxford, New York, 2000.*
3. *Naidu,M.S. and Kamaraju,V.,* ***"High Voltage Engineering"****, Tata McGraw Hill,New Delhi, 2009.*
4. *R.E.James and Q.Su,* ***"Condition assessment of high voltage insulation in power system equipment"****, IETPower and Energy Series 53, 2008.*
5. *Gallagher,T.J., and Permain,A.,* ***"High Voltage Measurement, Testing and Design"****, John Wiley Sons, New York, 1983.*
6. *IEC & IS Standards on testing.*

12PS32 POWER SYSTEM SECURITY

L	T	P	C
3	0	0	3

BASICS OF POWER SYSTEM SECURITY (09)

Factors affecting power system security, decomposition and multilevel approach, state Estimation, system monitoring, security assessment and security enhancement.

POWER SYSTEM STATE ESTIMATION (09)

Maximum likelihood weighted least-square estimation, state estimation, detection and Identification of bad measurements, estimation of quantities not being measure, network observability and pseudo measurements.

SECURITY ASSESSMENT (09)

Detection of network problems, network equivalent for external system, network Sensitivity methods, calculation of network sensitivity factors, fast contingency Algorithms, contingency ranking, dynamic security indices.

SECURITY ENHANCEMENT (09)

Correcting the generator dispatch by sensitivity methods, compensated factors, security Constrained optimization, preventive, emergency and restorative control through LP Method.

RECENT TECHNIQUES (09)

Voltage security assessment-Transient Security assessment-methods-Comparison.

Total: 45 Hrs.

Reference Books

1. *Wood, A.J. and Wollenberg, B.F.,* ***"Power generation, Operation and Control",*** *John Wiley and Sons,1984.*
2. *Wood, A.J. and Woolenberg,* ***"Power generation operation for security"*** *– John Wiley and sons, 1989.*
3. *Abdullah Khan, M (Editor****), "Real time control of power system for security"****, vol.2, Proceedings of summer school, College of Engineering, Madras, 1976.*
4. *Handsching.E,* ***"Real time control of Electric Power Systems"****, Elsevier publishing Co., Amsterdam, 1972.*

12PS33 POWER SYSTEM RESTRUCTURING AND DEREGULATION

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FUNDAMENTALS AND ARCHITECTURE OF POWER MARKETS (09)

Deregulation of Electric utilities: Introduction-Unbundling-Wheeling- Reform motivations-Fundamentals of Deregulated Markets – Types (Future, Day-ahead and Spot) – Participating in Markets (Consumer and Producer Perspective) – bilateral markets – pool markets. Independent System Operator (ISO)-components-types of ISO - role of ISO - Lessons and Operating Experiences of Deregulated Electricity Markets in various Countries (UK, Australia, Europe, US, Asia).

TECHNICAL CHALLENGES (09)

Total Transfer Capability – Limitations - Margins – Available transfer capability (ATC) – Procedure - Methods to compute ATC – Static and Dynamic ATC – Effect of contingency analysis – Case Study. Concept of Congestion Management – Bid, Zonal and Node Congestion Principles - Inter and Intra zonal congestion – Generation Rescheduling - Transmission congestion contracts – Case Study.

TRANSMISSION NETWORKS AND SYSTEM SECURITY SERVICES (09)

Transmission expansion in the New Environment – Introduction – Role of transmission planning – Physical Transmission Rights – Limitations – Flow gate - Financial Transmission Rights – Losses – Managing Transmission Risks – Hedging – Investment. Ancillary Services – Introduction – Describing Needs – Compulsory and Demand-side provision – Buying and Selling Ancillary Services – Standards.

MARKET PRICING (09)

Transmission pricing in open access system – Introduction – Spot Pricing – Uniform Pricing – Zonal Pricing – Locational Marginal Pricing – Congestion Pricing – Ramping and Opportunity Costs. Embedded cost based transmission pricing methods (Postage stamp, Contract path and MW-mile) – Incremental cost based transmission pricing methods (Short run marginal cost, Long run marginal cost) - Pricing of Losses on Lines and Nodes.

INDIAN POWER MARKET (09)

Current Scenario – Regions – Restructuring Choices – Statewise Operating Strategies - Salient features of Indian Electricity Act 2003 – Transmission System Operator – Regulatory and Policy development in Indian power Sector – Opportunities for IPP and Capacity Power Producer. Availability based tariff – Necessity – Working Mechanism – Beneficiaries – Day Scheduling Process – Deviation from Schedule – Unscheduled Interchange Rate – System Marginal Rate – Trading Surplus Generation – Applications.

Total:45 Hrs.

Reference Books

1. *Kankar Bhattacharya, Math H.J. Bollen And Jaap E. Daalder,* ***"Operation Of Restructured Power Systems",*** *Kluwer Academic Publishers, 2001.*
2. *Loi Lei Lai,* ***"Power system Restructuring and Deregulation",*** *John Wiley sons, 2001.*
3. *Shahidehpour.M and Alomoush.M,* ***"Restructuring Electrical Power Systems",*** *Marcel Decker Inc., 2001.*
4. *Steven Stoft,* ***" Power System Economics",*** *Wiley – IEEE Press, 2002.*
5. *Daniel S. Kirschen and GoranStrbac,* ***" Fundamentals of Power System Economics",*** *John Wiley & Sons Ltd., 2004.*
6. *Web Sites: www.pjm.com, www.caiso.com, www.midwestiso.com.*

12PS34 WIND ENERGY CONVERSION SYSTEMS

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INTRODUCTION (09)

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine.

WIND TURBINES (09)

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yawcontrol-Pitch angle control-stall control-Schemes for maximum power extraction.

FIXED SPEED SYSTEMS (09)

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator-Model of Wind Speed- Model wind turbine rotor - Drive Train model-Generator model forSteady state and Transient stability analysis.

VARIABLE SPEED SYSTEMS (09)

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.

GRID CONNECTED SYSTEMS (09)

Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side &Grid side controllers-WECS in various countries.

Total: 45 Hrs.

Reference Books

1. *Freris L.L.,* ***"Wind Energy conversion Systems",*** *Prentice Hall, 1990.*
2. *Ion Boldea,* ***"Variable speed generators",*** *Taylor & Francis group, 2006.*
3. *Golding E.W.* ***"The Generation of Electricity by Wind Power",*** *Redwood burn Ltd., Trowbridge, 1976.*
4. *Heir S.* ***"Grid Integration of WECS",*** *Wiley 1998.*

12PS35 POWER ELECTRONICS FOR RENEWABLE ENERGY

L	T	P	C
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RENEWABLE ENERGY SOURCES AND THEIR ENVIRONMENTAL IMPACTS (09)

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION (09)

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG,SCIG and DFIG.

POWER CONVERTERS (09)

Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing

Wind: three phase AC voltage controllers- AC-DC-AC converters: PWM Inverters, Grid Interactive Inverters-matrix converters.

ANALYSIS OF WIND AND PV SYSTEMS (09)

Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS Grid Integrated solar system.

HYBRID RENEWABLE ENERGY SYSTEMS (09)

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).

Total: 45 Hrs.

Reference Books

1. *Rashid .M. H* ***"Power electronics Hand book",*** *Academic press, 2001.*
2. *Rai. G.D,* ***"Non conventional energy sources",*** *Khanna publishers, 2004.*
3. *Rai. G.D,"* ***Solar energy utilization",*** *Khanna publishers, 2005.*
4. *Gray, L. Johnson,* ***"Wind energy system",*** *Prentice hall linc, 1995.*
5. *B.H.Khan,* ***"Non-conventional Energy sources",*** *Tata McGraw-hill Publishing Company, New Delhi, 2006.*

12PS36 FEM MODELING OF HIGH VOLTAGE APPARATUS AND SYSTEMS

L	T	P	C
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GENERAL CONCEPT (08)

Introduction to Finite Element method – Discretisation - Advantages and disadvantages - History of development and applications - Recent trends.

VARIATIONAL AND WEIGHTED RESIDUAL FORMULATION (10)

Boundary value problem - Approximate method of solution - Review of variational calculus - The Euler - Lagrange equation - Boundary conditions - Method of weighted residuals - Rayleigh Ritz and Galerkin methods of finite element formulations.

GENERAL APPROACH TO FIELD ANALYSIS (09)

Problem definition - Field properties - Maxwell's equations in the Dynamic, Quasi-static and static cases - Static fields in unbounded regions - Continuity conditions of fields at a medium discontinuity.

ELEMENT SHAPE FUNCTIONS (08)

Parametric functions - Shape functions for 1-D, 2-D and 3-D simplex and complex elements - Asymmetric elements - Isoparametric element formulations.

FIELD MODELING OF HIGH VOLTAGE APPARATUS (10)

Finite element formulation for interior and exterior problems - Static electric field and magnetic field problems - Eddy current problems - Field computation in high voltage apparatus - Electro thermal analysis - Transient field analysis.

Total: 45 Hrs.

Reference Books

1. *Charles W.Steels,* ***'Numerical Computation of Electric and Magnetic fields'****, Van Nostrand Reinhold Company, New York, 1987.*
2. *Larry J. Segerlind****, 'Applied Finite Element Analysis'****, John Wiley, New York, 1984.*
3. *Zienkiewicz.O.C.,* ***'The Finite Element Method'****, Tata McGraw Hill Publishing Co., New Delhi, 2000.*
4. *Reddy.J.N.,* ***'An Introduction to the Finite Element Method'****, McGraw Hill Book Co., New York, 1984.*
5. *Chari.M.V.K. and Sylvester.P.P.,* ***'Finite Elements in Electrical and Magnetic Field Problems****, John Wiley & Sons, New York, 1980.*
6. *Csendes.Z.J. and Hamann.J.R.,* ***"Surge Arrester Voltage Distribution Analysis by FEM",*** *IEEE Trans. on Power Apparatus and Systems, Vol.100, No.4, PP.1806-1811.*

12PS37 MODEL PREDICTIVE CONTROL

(Common to PSE and PED)

L	T	P	C
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BASICS (09)

Model predictive control-introduction model predictive control strategy- Model predictive control elements –predictive model process model-objective function-control law –state space formulation.

LINEAR CONTROL (09)

Model predictive control Schemes –Dynamic matrix control- Model algorithmic control-predictive functional control-Formulation of generalized Model predictive control-closed loop relationships.

NON-LINEAR CONTROL (09)

Non-linear Model predictive control- Non-linear Model predictive control vs. linear Model predictive control-Non-linear models-solution of non-linear model predictive control-technique for Non-linear Model predictive control-stability of Non-linear Model predictive control.

IMPLEMENTATION (09)

Methods of implementing Model predictive control-Model predictive control and multi parametric programming-implementation of model predictive control for uncertain systems-closed loop min-max model predictive control implementation of model predictive control and dead time consideration.

APPLICATIONS (09)

Case study model predictive control on a chip-FPGA implementation of MPC –FPGA implementation of MPC for petrochemical process.

Total : 45 Hrs.

Reference Books

1. *E.F.Camacho and C.Bordons,* ***"Model Predictive Control****", Springer,2nd Edition,2004.*
2. *Keck Voontuing, jan Maciefouski, Being Fan Wu,* ***"Multiplexed Model Predictive Control",*** *Department of Engg, Univ, 2006.*
3. *Carlos E.Garcia et.al.,* ***"Model predictive control: Theory and Practice",*** *A survey, Springer, 2004.*

12PS38 VIRTUAL INSTRUMENTATION

(Common to PSE and PED)

L	T	P	C
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REVIEW OF VIRTUAL INSTRUMENTATION (09)

Historical Perspective - Advantages etc - Block diagram and architecture of a virtual instrument.

DATA FLOW TECHNIQUES (09)

Graphical programming in data flow - comparison with conventional programming.

VI PROGRAMMING TECHNIQUE (09)

VIS and Sub-VIS - Loops and charts- Arrays - Clusters - Graphs - Case and sequence structures - Formula nodes - Local and global variables - String and file I/O.

DATA ACQUISITION AND INSTRUMENT INTERFACE (09)

ADC - DAC - DIO - Counters and timers - PC hard ware structure - Timing - interrupts - DMA - Software and hardware installation - Current loop - RS –232 C / RS – 485- GPIB- USB and PCMCIA.

ANALYSIS TOOLS AND APPLICATIONS (09)

Some tools from the advanced analysis tools relevant to the discipline may be included Eg. Fourier transform - Power spectrum - Correlation methods - Windowing and filtering. VI application in various fields – VISA and IVI – Image acquisition and processing.

Total : 45 Hrs.

Reference Books

1. *Jovitha Jerome,* ***" Virtual Instrumentation using labview"*** *, Prentice Hall,India,2010.*
2. *Sanjav Gupta and Joseph John,* ***"Virtual Instrumentation using Labview",*** *Tata McGraw Hill, May 2010.*
3. *Cory L.Clark,* ***"LabVIEW Digital Signal Processing and Digital Communications",*** *Tata McGraw Hill, 2005.*
4. *Gray Johnson,'****Lab VIEW Graphical Programming'*** *4th Edition., McGraw Hill, August-2006.*
5. *Jeffrey Travis,* ***'LabVIEW for Everyone'****, 3rd Edition, Prentice Hall, 2006.*

12PS39 ADVANCED POWER SYSTEM DYNAMICS

L	T	P	C
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TRANSIENT STABILITY ANALYSIS (09)

Review of numerical integration methods: Euler and Fourth Order Runge-Kuttamethods, Numerical stability and implicit methods, Simulation of Power System Dynamicresponse: Structure of Power system Model, Synchronous machine representation:equations of motion, rotor circuit equations, stator voltage equations, Thevenin's andNorton's equivalent circuits, Excitation system representation, Transmission network andload representation, Overall system equations and their solution: Partitioned – Explicitand Simultaneous-implicit approaches, treatment of discontinuities, Simplified Transient Stability Simulation using implicit integration method..

SUBSYNCHRONOUS OSCILLATIONS (09)

Introduction – Turbine Generator Torsional Characteristics: Shaft system model –Examples of torsional characteristics – Torsional Interaction with Power SystemControls: Interaction with generator excitation controls – Interaction with speedgovernors – Interaction with nearby DC converters.

SUBSYSNCHRONOUS RESONANCE (09)

Subsysnchronous Resonance (SSR): Characteristics of series –**C**ompensatedtransmission systems – Self-excitation due to induction generator effect – Torsionalinteraction resulting in SSR – Analytical Methods – Numerical examples illustratinginstability of subsynchronous oscillations – Impact of Network-Switching Disturbances:Steady-state switching – Successive network-Switching disturbances – TorsionalInteraction Between Closely Coupled Units; time-domain simulation of subsynchronous resonance – EMTP with detailed synchronous machine model

TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS (09)

Review of transmission aspects – Generation Aspects: Review of synchronous machinetheory – Voltage and frequency controllers – Limiting devices affecting voltage stability –Voltage-reactive power characteristics of synchronous generators – Capability curves –Effect of machine limitation on deliverable power – Load Aspects – Voltage dependenceof loads – Load restoration dynamics – Induction motors – Load tap changers –Thermostatic load recovery – General aggregate load models.

TRANSIENT STABILITY ENHANCEMENT (09)

Principle behind transient stability enhancement methods: high-speed fault clearing,reduction of transmission system reactance, regulated shunt compensation, dynamicbraking, reactor switching, independent pole-operation of circuit-breakers, single-poleswitching, fast-valving, high-speed excitation systems; NGH damper scheme.

Total: 45 Hrs.

Reference Books

1. *Kundur P., Neal J Balu, M.G. Lauby,* ***"Power System Stability and Control",*** *McGraw-Hill, 1994.*
2. *Dommel H.W. and Sato N.,* ***"Fast Transient Stability Solutions,"*** *IEEE Trans., Vol.PAS-91, pp, 1643-1650, July/August 1972.*
3. *Dommel H.W., EMTP Theory Book, Microtran* ***Power System AnalysisCorporation****, Second Edition, 1996.*
5. *CutsemT.V. and .Vournas C.,* ***"Voltage Stability of Electric Power Systems",*** *Kluwer Publishers, 1998.*

12PS40 PARTIAL DISCHARGES IN ELECTRICAL POWER APPARATUS

L	T	P	C
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PHENOMENON OF PARTIAL DISCHARGE (PD) (08)

Introduction, Definition of terms, typical electrode configurations with PD, internal discharges and surface discharges, external discharges, equivalent circuits, PD characteristics of parameters, wave-form and characteristics of an individual PD pulse, train of PD current pulses, train of PD pulses in relation to the temporarily assigned instantaneous value of the high voltage, non electrical PD characteristics parameters.

FUNDAMENTALS OF PD MEASURING TECHNIQUES (10)

Wave form and spectrum of PD, PD charge measuring equipments, integration in the frequency domain, selectively wide band system, narrow band system, integration in the time domain with very large wide band systems, measuring impedance or coupling4 terminal device, PD measuring circuits, calibration, calibration pulses, calibration of PD measuring setup, calibration of the complete test set up, uncertainty of measurements.

SCREENING AND FILTERING PROBLEMS DURING PARTIAL DISCHARGE MEASUREMENTS (08)

Need for screening, design of screens, completely enclosed screen, screen interruptions, effect of corners, cavity resonance, design of filters, measurement of screening efficiency, lead through bushings.

EFFECTS OF PD ON ELECTRICAL INSULATING MATERIALS (09)

Effects of PD - gaseous insulating materials, liquid insulating materials, solid insulating materials, surface discharges, internal discharges, mixed dielectrics. Evaluation of PD-Relation between measured and actual charge, relation between the time-dependent occurrence of PD, and the extent of damage due to it.

MEASUREMENT AND LOCATION OF PD (10)

Need for PD measurement, Development of PD measurement technique in cables, problems during PD measurements on long cables, reflection and superposition effects, damping, National and International specifications, Specifications for test methods, permissible PD magnitudes, Location of PD, methods of locating PD, PD location according to pulse spacing method.

Total: 45 Hrs.

Reference Books

1. *Kreuger F. H.* ***"Partial Discharge Measurements",*** *Butterworths, 1989,*
2. *Dieter Konig & Y Narayan Rao,* ***"PD in Electrical Apparatus"****, VDE - Verlag, 1993.*
3. *IEC – Publication 270,* ***"Partial Discharge Measurements"****, 1981.*
4. *Kuffel E, Zaengl W. S, Kuffel J,* ***"High Voltage Engineering",*** *Oxford, Pergamon, 2000.*
5. *C.L.Wadhwa,* ***"High Voltage Engineering****", New Aye International Publishers New Delhi, 2007.*

12PS41 DISTRIBUTED AUTOMATION

L	T	P	C
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DISTRIBUTION AUTOMATION AND THE UTILITY SYSTEM (08)

Introduction to Distribution Automation(DA)- control system interfaces-control and data requirements-centralized(vs) decentralized control- DA system-DA hardware-DAS software.

DISTRIBUTION AUTOMATION FUNCTIONS (09)

DA capabilities- Automation system computer facilities-management processes-information management-system reliability management-system efficiency management-voltage management-load management.

COMMUNICATION SYSTEMS (10)

DA communication requirements- communication reliability-cost effectiveness-data requirements-two way capability-ability to communicate during outages and faults- ease of operation and maintenance-conforming to the architecture of flow.

Distribution line carrier-ripple control-Zero crossing technique-telephone, cableTV, radio, AM broadcast, FM SCA,VHF radio, microwave satellite, fiber optics-Hybrid communication systems used in field tests.

ECONOMIC EVALUATION METHODS (09)

Development and evaluation of alternate plans-Select study area –select study period-project load growth-Develop alternatives-calculate operating and maintenance costs-Evaluate alternatives.

ECONOMIC COMPARISON (09)

Economic comparison of alternate plans-Classification of expenses and capital expenditures-Comparison of revenue requirements of alternative plans-Book life and continuing plant analysis-year by year revenue requirement analysis, Short term analysis-end of study adjustment-Break even analysis, sensitivity analysis- computational aids.

Total: 45 Hrs.

Reference Books

1. *IEEE Tutorial course* ***"Distribution Automation".***
2. *IEEE Working Group on* ***"Distribution Automation".***