ANNA UNIVERSITY TIRUCHIRAPPALLI
Tiruchirappalli – 620 024
Regulations 2008
Curriculum

M.E. POWER SYSTEMS ENGINEERING

SEMESTER I

S.No.	Subject Code	Subject	L	T	P	C
Theory						
1	**MA5121**	Applied Mathematics for Electrical Engineers	3	1	0	4
2	**CI5101**	Linear and Non-linear Systems Theory	3	1	0	4
3	**PS5101**	Power Electronics in Power Systems	3	0	0	3
4	**PS5102**	Power System Analysis	3	1	0	4
5	**PS5103**	Power System Operation	3	0	0	3
6	**E1******	Elective I	3	0	0	3
					Total	**21**

SEMESTER II

S.No.	Subject Code	Subject	L	T	P	C
Theory						
1	**PS5151**	Power System Protection	3	0	0	3
2	**PS5152**	Power System Dynamics	3	1	0	4
3	**PS5153**	Power System Control	3	1	0	4
4	**PS5154**	Transients in Power Systems	3	0	0	3
5	**E2******	Elective II	3	0	0	3
6	**E3******	Elective III	3	0	0	3
Practical						
7	**PS5155**	Power System Simulation Laboratory	0	0	3	2
					Total	**22**

SEMESTER III

S.No.	Subject Code	Subject	L	T	P	C
Theory						
1	**E4******	Elective IV	3	0	0	3
2	**E5******	Elective V	3	0	0	3
3	**E6******	Elective VI	3	0	0	3
Practical						
4	**PS5251**	Project Work Phase I	0	0	12	6
					Total	**15**

SEMESTER IV

S.No.	Subject Code	Subject	L	T	P	C
Practical						
1	**PS5251**	Project Work Phase II	0	0	24	12
					Total	**12**

Total Credits to be Earned for the Award of the Degree = 70

LIST OF ELECTIVES

S.No.	Subject Code	Subject	L	T	P	C
Theory						
1	**PS5001**	Artificial Intelligence Application to Power Systems	3	0	0	3
2	**PS5002**	High Voltage Direct Current Transmission	3	0	0	3
3	**PS5003**	Flexible AC Transmission Systems	3	0	0	3
4	**PS5004**	Computer Network Engineering	3	0	0	3
5	**PS5005**	Advanced Power System Dynamics	3	0	0	3
6	**PS5051**	Intelligent Control	3	0	0	3
7	**PS5052**	High Voltage Switchgear	3	0	0	3
8	**PS5053**	EHV Power Transmission	3	0	0	3
9	**CI5102**	Digital Signal Processing	3	0	0	3

ANNA UNIVERSITY TIRUCHIRAPPALLI
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Regulations 2008
Syllabus

M.E. POWER SYSTEMS ENGINEERING

SEMESTER I

MA5121 – APPLIED MATHEMATICS FOR ELECTRICAL ENGINEERS

L	T	P	C
3	1	0	4

UNIT I ADVANCED MATRIX THEORY **9**

Matrix norms - Jordan canonical form - generalized eigenvectors - singular value decomposition - Pseudo inverse - least square approximations - QR algorithm.

UNIT II CALCULUS OF VARIATIONS **9**

Variation and its properties - Euler's equation - functional dependent on first and higher order derivatives - functional dependent on functions of several independent variables - some applications - direct methods - Ritz and Kantorovich methods.

UNIT III LINEAR PROGRAMMING **9**

Basic concepts - graphical and simplex methods - transportation problem - assignment problem.

UNIT IV DYNAMIC PROGRAMMING **9**

Elements of the dynamic programming model - optimality principle - examples of dynamic programming models and their solutions.

UNIT V RANDOM PROCESSES **9**

Classification - stationary random processes - auto correlation - cross correlations - power spectral density - linear system with random input - Gaussian process.

L: 45 T: 15 Total: 60

REFERENCES

1. D.W. Lewis, 'Matrix Theory', Allied Publishers, 1995.
2. R. Bronson, 'Matrix Operations, Schaums Outline Series', McGraw-Hill, New York. 1989.
3. Elsgoltis, 'Differential Equations and Calculus of Variations', MIR Publishers, Moscow, 1970.
4. A.S. Gupta, 'Calculus of Variations with Applications', Prentice Hall of India, 1999.
5. H.A. Taha, 'Operations Research - An Introduction', MacMillan Publishing Co., 1982.
6. P.K. Gupta and D.S. Hira, 'Operations Research', S.Chand & Co., 1999.
7. M.K. Ochi, 'Applied Probability and Stochastic Processes', John Wiley & Sons, 1992.
8. P.Z. Peebles Jr., 'Probability Random Variables and Random Signal Principles', McGraw-Hill Inc., 1993.

CI5101 – LINEAR AND NON-LINEAR SYSTEMS THEORY

L	T	P	C
3	1	0	4

UNIT I PHYSICAL SYSTEMS AND STATE ASSIGNMENT 9

Systems - electrical - mechanical - hydraulic - pneumatic - thermal systems - modelling of some typical systems like D.C. Machines - inverted pendulum.

UNIT II STATE SPACE ANALYSIS 9

Realisation of state models - non-uniqueness - minimal realisation - balanced realisation - solution of state equations - state transition matrix and its properties - free and forced responses - properties - controllability and observability - stabilisability and detectability - Kalman decomposition.

UNIT III MIMO SYSTEMS - FREQUENCY DOMAIN DESCRIPTIONS 9

Properties of transfer functions - impulse response matrices - poles and zeros of transfer function matrices - critical frequencies - resonance - steady state and dynamic response - bandwidth - Nyquist plots - singular value analysis.

UNIT IV NON-LINEAR SYSTEMS 9

Types of non-linearity - typical examples - equivalent linearization - phase plane analysis - limit cycles - describing functions - analysis using describing functions - jump resonance.

UNIT V STABILITY 9

Stability concepts - equilibrium points - BIBO and asymptotic stability - direct method of Liapunov - application to non-linear problems - frequency domain stability criteria - Popov's method and its extensions.

L: 45 T: 15 Total: 60

REFERENCES

1. M. Gopal, 'Modern Control Engineering', Wiley, 1996.
2. J.S. Bay, 'Linear State Space Systems', McGraw-Hill, 1999.
3. Eroni-Umez and Eroni, 'System dynamics & Control', Thomson Brooks / Cole, 1998.
4. K. Ogatta, 'Modern Control Engineering', Pearson Education, Low Priced Edition, 1997.
5. G.J. Thaler, 'Automatic control systems', Jaico publishers, 1993.
6. John S. Bay, 'Linear State Space Systems', McGraw-Hill International Edition, 1999.

PS5101 – POWER ELECTRONICS IN POWER SYSTEMS

L	T	P	C
3	0	0	3

UNIT I POWER DEVICES 9

Basic concept of power electronics - different types of power electronic devices - diodes - transistors and SCR - MOSFET - IGBT and GTO's.

UNIT II A.C. TO D.C. CONVERTERS 9

Single phase and three phase bridge rectifiers - half controlled and fully controlled converters with R, RL, and RLE loads - free wheeling diodes - dual converter - sequence control of converters - inverter operation - input harmonics and out put ripple - smoothing inductance - power factor improvement effect of source impedance - overlap - inverter limit.

UNIT III D.C. TO A.C. CONVERTERS 9

General topology of single phase and three phase voltage source and current source inverters - need for feedback diodes in anti parallel with switches - multi quadrant chopper viewed as a single phase inverter - configuration of single phase voltage source inverter - half and full bridge - selection of switching frequency and switching device - voltage control and PWM strategies.

UNIT IV STATIC REACTIVE POWER COMPENSATION 9

Shunt reactive power compensation - fixed capacitor banks - switched capacitors - static reactor compensator - thyristor controlled shunt reactors (TCR) - thyristor controlled transformer - FACTS technology - applications of static thyristor controlled shunt compensators for load compensation - static var systems for voltage control - power factor control - harmonic control of converter fed systems.

UNIT V POWER QUALITY 9

Power quality - terms and definitions - transients - impulsive and oscillatory transients - harmonic distortion - harmonic indices - total harmonic distortion - total demand distortion - locating harmonic sources harmonics from commercial and industrial loads - devices for controlling harmonics passive and active filters - harmonic filter design.

Total: 45

REFERENCES

1. N. Mohan, T.M. Undeland and W.P. Robbins, 'Power Electronics: Converter, Applications and Design', John Wiley and Sons, 1989.
2. M.H. Rashid, 'Power Electronics', Prentice Hall of India, 1994.
3. B.K. Bose, 'Power Electronics and A.C. Drives', Prentice Hall, 1986.
4. Roger C. Dugan, Mark F. McGranaghan, Surya Santaso and H. Wayne Beaty, 'Electrical Power Systems Quality', Second Edition, McGraw-Hill, 2002.
5. T.J.E. Miller, 'Static Reactive Power Compensation', John Wiley and Sons, New York, 1982.
6. R. Mohan Mathur and Rajiv K. Varma, 'Thyristor Based FACTS controllers for Electrical Transmission Systems', IEEE Press, 1999.

PS5102 – 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 model in real variable form - Newton's method for solution - adjustment of P-V buses - fast decoupled power flow method - sensitivity factors for P-V bus adjustment - net interchange power control in multi-area power flow analysis - assessment of available transfer capability (ATC) using power flow method - continuation power flow method.

UNIT III SHORT CIRCUIT ANALYSIS 9

Review of 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 012 frame and abc frame using Thevenin's equivalent and Z_{BUS} matrix for different faults.

UNIT IV OPTIMAL POWER FLOW 9

Introduction - 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 A.C. power flow variables and detailed cost functions - security constrained optimal power flow - interior point algorithm - bus incremental costs.

UNIT V VOLTAGE STABILITY ANALYSIS - STEADY STATE 9

Transmission system aspects - SLIB system - maximum deliverable power - power-voltage relationship - generator reactive power requirement - network versus load P-V characteristics - instability scenario - effect of compensation and series - shunt - SVC - V-Q curves - effect of adjustable transformer ratios.

L: 45 T: 15 Total: 60

REFERENCES

1. G.W. Stagg, A. H. El Abiad, 'Computer Methods in Power System Analysis', McGraw-Hill, 1968.
2. O.I. Elgerd, 'Electrical Energy Systems Theory - An Introduction', Tata McGraw-Hill, 2002.
3. P. Kundur, 'Power System Stability and Control', McGraw-Hill, 1994.
4. T.V. Cutsem and C. Vournas, 'Voltage Stability of Electric Power Systems', Kluwer Publishers, 1998.
5. A.J. Wood and B.F. Wollenberg, 'Power Generation Operation and Control', John Wiley and Sons, New York, 1996.

PS5103 – POWER SYSTEM OPERATION

L	T	P	C
3	0	0	3

UNIT I LOAD FORECASTING 9

Introduction - estimation of average and trend terms - estimation of periodic components - estimation of stochastic components - time series approach - auto-regressive model - auto-regressive moving - average models - Kalman filtering approach - on-line techniques for non stationary load prediction.

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 λ.

UNIT III GENERATION SCHEDULING - THERMAL SYSTEM 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 - economic dispatch using dynamic programming - transmission system effects - a two generator system - coordination equations - incremental losses and penalty factors.

UNIT IV GENERATION SCHEDULING - HYDRO THERMAL SYSTEMS 9

Long range hydro-scheduling - short range hydro scheduling - hydro electric plant models - scheduling problems - the short term hydrothermal scheduling problem - short term hydro-scheduling - a gradient approach - hydro units in series (hydraulically coupled) - pumped - storage hydro-scheduling with a λ-γ iteration - dynamic programming solution to the hydro thermal scheduling problem.

UNIT V INTERCHANGE OF POWER AND ENERGY 9

Economy interchange between interconnected utilities - interchange evaluation with unit commitment - multiple - utility interchange transactions - power pools - the energy broker system - allocating pool savings - transmission effects and issues - transfer limitations - wheeling - rates for transmission services in multiparty utility transactions - transactions involving non-utility parties.

Total: 45

REFERENCES

1. Allen J. Wood and Bruce F. Wollenberg, ‘Power Generation, Operation and Control’, John Wiley and Sons, New York, 1996.
2. A.K. Mahalanabis, D.P. Kothari and S.I. Ahson, ‘Computer Aided Power System Analysis and Control’, Tata McGraw-Hill, 1988.

SEMESTER II

PS5151 – POWER SYSTEM PROTECTION

L	T	P	C
3	0	0	3

UNIT I RELAYS 9

General philosophy of protection - characteristic function of protective relays - basic relay elements and relay terminology - basic construction of static relays - non-critical switching circuits.

UNIT II PROTECTION OF POWER APPARATUS 9

Protection of generators stator phase fault protection - loss of excitation protection - generator off - line protection - transformer protection - factors affecting differential protection - magnetizing inrush current - application and connection of transformer differential relays - transformers over current protection - example motor protection.

UNIT III PROTECTION OF TRANSMISSION SYSTEMS 9

Bus protection - typical bus arrangements - transformer - bus combination - bus differential systems - line protection - classification of lines and feeders - techniques applicable for line protection - distance protection for phase faults - fault resistance and relaying - long line protection - backup remote local and breaker failure.

UNIT IV PROTECTION OF REACTORS, BOOSTERS AND CAPACITORS 9

Placement of reactors in power system - types of reactor - reactor rating application and protection - booster in the power system - transformer tap changing - protection of boosters - capacitors in an interconnected power system - series - shunt - series shunt connections - protection of capacitors.

UNIT V DIGITAL PROTECTION 9

Digital signal processing - digital filtering in protection relays - digital data transmission - numeric relay hardware - relay algorithms - distance relays - direction comparison relays - differential relays - software considerations - numeric relay testing - concepts of modern coordinated control system.

Total: 45

REFERENCES

1. Stanley H. Horowitz (Ed), ‘Protecting Relaying for Power Systems’, IEEE Press, 1980.
2. Y.G. Paithankar and S.R Bhide, ‘Fundamentals of Power System Protection’, Prentice Hall of India, 2003
3. Y.G. Paithankar, ‘Principles of Power System Protection’, Marcel Dekker Inc., 1998.
4. P. Kundur, ‘Power System Stability and Control’, McGraw-Hill, 1993.
5. Badri Ram and D.N. Vishwakarma, ‘Power System Protection and Switchgear’, Tata McGraw-Hill, 2002.
6. J.L. Blackburn, ‘Power System Protection: Principles and Applications’, Marcel Dekker, New York, 1998

PS5152 – POWER SYSTEM DYNAMICS

L	T	P	C
3	1	0	4

UNIT I SYNCHRONOUS MACHINE MODELLING 9

Schematic diagram - physical description - armature and field structure - machines with multiple pole pairs - M.M.F. 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 trans formation - per unit representation - summary of per unit equations in L_{ad}-reciprocal per unit system - equivalent circuits for direct and quadrature axes - steady state 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 - H-constant calculation - representation in system studies - synchronous machine representation in stability studies - simplified model with amortisseurs neglected - alternate form of machine equations - phasor diagram for transient conditions - classical model with amortisseur windings neglected.

UNIT II MODELLING OF EXCITATION AND SPEED GOVERNING SYSTEMS 9

Excitation system modelling - excitation system requirements - elements of excitation system - types of excitation system - rotating rectifier and potential source controlled rectifier systems - hardware block diagram and IEEE(1992) type ST1A block diagram - 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 - geneneric 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 - state-space representation - stability of dynamic system - linearisation - Eigen properties of the state matrix - Eigen values and Eigen vectors - modal matrices - Eigen value and stability - mode shape and participation factor - single-machine infinitie 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 WITH 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 stabilizer - 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 TRANSIENT STABILITY ANALYSIS 9

Introduction - factors influencing transient stability - numerical integration methods - Euler and fourth order Runge-Kutta methods - numerical stability and implicit methods - simulation of power system dynamic response - structure of power system model - synchronous machine representation - equations of motion - rotor circuit equations - stator voltage equations - Thevenin's and Norton's equivalent circuits - excitation system representation - transmission network and load representation - overall system equations and their solution - partitioned - explicit and simultaneous - implicit approaches - treatment of discontinuities - simplified transient stability simulation using simultaneous - implicit method [4] - principle behind transient stability enhancement methods - high-speed fault clearing - reduction of transmission system reactance - regulated shunt compensation - dynamic braking - reactor switching - independent pole-operation of circuit-breakers - single-pole switching - fast-valving - high-speed excitation systems.

L: 45 T: 15 Total: 60

REFERENCES

1. P. Kundur, ‘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, page 1904-1915, November/December, 1973, on Turbine-Governor Model.
3. P.M Anderson and A.A. Fouad, ‘Power System Control and Stability’, Iowa State University Press, Ames, Iowa, 1978.
4. H.W. Dommel and N. Sato, ‘Fast Transient Stability Solutions,’ IEEE Trans., Vol. PAS-91, page 1643-1650, July/August 1972.

PS5153 – POWER SYSTEM CONTROL

L	T	P	C
3	1	0	4

UNIT I AUTOMATIC GENERATION CONTROL 9

Fundamentals of speed governing - control of generating unit power output - composite regulating characteristic of power systems - response rates of turbine - governing systems - fundamentals of automatic generation control - implementation of AGC - development of state variable model for a two area power system for use in simulation of AGC - under frequency load shedding and computation of settings for under frequency relays.

UNIT II REACTIVE POWER AND VOLTAGE CONTROL 9

Modelling of AVR loops - components - stability compensation - production and absorption of reactive power - methods of voltage control - shunt reactors - shunt capacitors - series capacitors - synchronous condensers - static var systems - principle of transmission system compensation - modeling of reactive compensating devices - application of tap changing transformers to transmission systems - distribution system voltage regulation - modeling of transformer ULTC control systems.

UNIT III SECURITY CONTOL OF POWER SYSTEMS 9

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 IV STATE ESTIMATION 9

Maximum likelihood weighted least - squares estimation - concepts - matrix formulation - example for weighted least - squares state estimation - state estimation of an A.C. network - development of method - typical results of state estimation on an A.C. 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.

UNIT V POWER SYTEM CONTROL UNDER DEREGULATED ENVIRONMENT 9

New system structures under competition - classification of operational tasks in today's power industry - temporal decomposition within the real time operation - classification of operational tasks in the competitive industry - meeting predicted demand in today's industry - meeting demand in the new industry - balancing supply and demand in real time - load frequency control under deregulated environment.

L: 45 T: 15 Total: 60

REFERENCES

1. O.I. Elgerd, ‘Electric Energy System Theory - An Introduction’, Tata McGraw-Hill, 2002.
2. P. Kundur, ‘Power System Stability and Control’, EPRI Publications, California, 1994.
3. Allen J. Wood and Bruce F. Woolenberg, ‘Power Generation Operation and Control’, John Wiley and Sons, New York, 1996.
4. A.K. Mahalanabis, D.P. Kothari and S.I Ahson, ‘Computer Aided Power System Analysis and Control’, Tata McGraw-Hill, 1984.
5. Marija Ilic, F. Galiana and L. Fink, ‘Power System Restructuring: Engineering and Economics’ Kluwer Academic Publishers, 2000.
6. Vaibhav Donde, M.A. Pai and Ian A. Hiskens, ‘Simulation and Optimization in an AGC system after deregulation’, IEEE transactions on Power Systems Vol: 16, No.3, 2001.

PS5154 – TRANSIENTS IN POWER SYSTEMS

L	T	P	C
3	0	0	3

UNIT I LIGHTNING SURGES 9

Review of various types of power system transients - effect of transients on power systems - relevance of the study and computation of power system transients - electrification of thunderclouds - lightning current stages - lightning current parameters and their values - stroke to tower and midspan - induced lightning surges.

UNIT II SWITCHING SURGES 9

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 systems - switching - harmonics.

UNIT III COMPUTATION OF TRANSIENTS IN CONVERSION EQUIPMENT 9

Traveling wave method - Beweley's Lattice diagram - analysis in time and frequency domain - Eigen value approach - Z-transform.

UNIT IV INSULATION CO ORDINATION 9

Over voltage protective devices - shielding wires - rods gaps - surge diverters - principles of insulation coordination - recent advancements in insulation coordination - design of EHV system - insulation coordination as applied to transformer - substations.

UNIT V CASE STUDIES - SIMULATION OF ELECTROMAGNETIC TRANSIENTS 9

(i) Energisation of a single phase 0.95 pf load from a non ideal source and a realistic line representation.

(ii) Energisation of a single phase 15 mile long line from an ideal voltage source (equivalent-Π) - lumped and distributed parameter representation.

(iii) Energisation of a 3 phase, 15 mile distributed parameter line connected to a transformer and RL load - (three phase closure simulations).

(iv) Same as above but only one phase closed.

(v) Energisation of a 120 mile transposed line from an ideal voltage source (Adequate model needed)

Total: 45

REFERENCES

1. Allan Greenwood, 'Electrical Transients in Power Systems', Willey Interscience, New York, 1971.
2. Klaus Ragaller, 'Surges in High Voltage Networks', Plenum Press, New York, 1980.
3. W. Diesendorf, 'Over Voltage on High Voltage Systems', Renselaer Bookstore, Troy New York, 1971.
4. H.A. Peterson, 'Transient in Power Systems', Dover Publication, New York, 1963.
5. Rakosh das Begamudre, 'Extra High Voltage AC Transmission Engineering', Wiley Eastern Ltd, 1990.
6. C.S. Indulkar and D.P. Kothari, 'Power System Transients' - A Statistical approach, Prentice Hall, 1996.

RS5155 – POWER SYSTEM SIMULATION LABORATORY

L	T	P	C
0	0	3	

LIST OF EXPERIMENTS

1. Power flow analysis - Gauss-Seidel - Newton Raphson methods
2. Fast decoupled power flow and continuation power flow analysis
3. Contingency analysis - generator shift factors and line outage distribution factors
4. Small signal stability analysis - SMIB and multi machine configuration
5. Transient stability analysis of multi-machine configuration
6. Economic dispatch with line flow constraints
7. Unit commitment - priority-list schemes and dynamic programming
8. Coordination of over current and distance relays for radial line protection
9. Induction motor starting analysis
10. Analysis of switching surge using EMTP.

Total: 45

PS5251 – PROJECT WORK (PHASE I)

L	T	P	C
0	0	12	6

PS5251 – PROJECT WORK (PHASE II)

L	T	P	C
0	0	24	12

ELECTIVES

PS5001 – ARTIFICIAL INTELLIGENCE APPLICATION TO POWER SYSTEMS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION TO NEURAL NETWORKS 9

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

UNIT II APPLICATIONS TO POWER SYSTEM PROBLEMS 9

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

UNIT III INTRODUCTION TO FUZZY LOGIC 9

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.

UNIT IV APPLICATIONS TO POWER SYSTEMS 9

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.

UNIT V GENETIC ALGORITHM AND ITS APPLICATIONS TO POWER SYSTEMS 9

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

Total: 45

REFERENCES

1. James A. Freeman and B.M. Skapura ‘Neural Networks - Algorithms Applications and Programming Techniques’, Addison Wesley, 1990.
2. George Klir and A. Tina Folger, ‘Fuzzy sets, Uncertainty and Information’, Prentice Hall of India, 1993.
3. H.J. Zimmerman, ‘Fuzzy Set Theory and its Applications’, Kluwer Academic Publishers, 1994.
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.

PS5002 – HIGH VOLTAGE DIRECT CURRENT TRANSMISSION

L	T	P	C
3	0	0	3

UNIT I D.C. POWER TRANSMISSION TECHNOLOGY 9

Introduction - comparison of A.C. and D.C. transmission application of D.C. transmission - description of D.C. transmission system planning for HVDC transmission - modern trends in D.C. transmission.

UNIT II ANALYSIS OF HVDC CONVERTERS 9

Pulse number - choice of converter configuration - simplified analysis of Graetz circuit - converter bridge characteristics - characteristics of a twelve pulse converter - detailed analysis of converters.

UNIT III CONVERTER AND HVDC SYSTEM CONTROL 9

General principles of D.C. link control - converter control characteristics - system control hierarchy - firing angle control - current and extinction angle control - starting and stopping of D.C. link-power control - higher level controllers - telecommunication requirements.

UNIT IV HARMONICS AND FILTERS 9

Introduction - generation of harmonics - design of A.C. filters - D.C. filters - carrier frequency and RI noise.

UNIT V SIMULATION OF HVDC SYSTEMS 9

Introduction - system simulation - philosophy and tools - HVDC system simulation - modeling of HVDC systems for digital dynamic simulation.

L: 45 Total: 45

REFERENCES

1. K.R. Padiyar, ‘HVDC Power Transmission System’, Wiley Eastern Ltd., First Edition, 1990.
2. Edward Wilson Kimbark, ‘Direct Current Transmission’, Vol.I, Wiley Interscience, New York, 1971.
3. Rakosh Das Begamudre, ‘Extra High Voltage AC Transmission Engineering’ New Age International Publishers, 1990.
4. J. Arrillaga, ‘High Voltage Direct Current Transmission’, Peter Pregrinus, London, 1983.

PS5003 – FLEXIBLE AC TRANSMISSION SYSTEMS

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 9

Reactive power control in electrical power transmission lines - uncompensated line - series compensation - basic concepts of SVC - thyristor controlled series capacitor - unified power flow controller.

UNIT II STATICVAR COMPENSATOR AND APPLICATIONS 9

Voltage control by SVC - advantages of slope in dynamic characteristics - influence of SVC on system voltage - design of SVC voltage regulator - applications enhancement of transient stability - steady state power transfer - enhancement of power damping - prevention of voltage instability.

UNIT III TCSC 9

Operation of the TCSC - different modes of operation - modelling of TCSC variable reactance model - modelling for stability studies - applications - improvement of system stability limit - enhancement of system damping - voltage collapse prevention.

UNIT IV EMERING FACTS CONTROLLER 9

STATCOM - principle of operation - VI characteristics - UPFC - principle of operation - modes of operation - applications - modelling of UPFC for power flow studies.

UNIT V COORDINATION OF FACTS CONTROLLER 9

Controller interactions - SVC - SVC interaction coordination of multiple controllers using LC tech - control coordination using GA.

Total: 45

REFERENCES

1. R. Mohan Mathur and Rajiv K. Varma, ‘Thyristor - Based FACTS Controller for Electrical Transmission Systems’, Wiley Interscience, IEEE Press, 2002.
2. Narin G. Hingorani and L. Gyuguyi, ‘Understanding FACTS Concepts and Technology of FACTS’, IEEE Press, 2000.

PS5004 – COMPUTER NETWORK ENGINEERING

L	T	P	C
3	0	0	3

UNIT I PROTOCOLS AND ARCHITECTURES 10

Protocols - layered approach - OSI model - DoD model - hierarchical approach - local network technology - bus/tree topology - ring topology - medium access protocols - details of IEEE 802 standards.

UNIT II NETWORK ACCESS PROTOCOL AND INTERNETWORKING 9

Circuit switched network access - packet switched network access - broadcast network access - principle of internetworking - bridges - gateways - X-75 - internet protocols - ISO internet protocol standard.

UNIT III TRANSPORT PROTOCOL AND ROUTING TECHNIQUES 9

Transport service protocol mechanisms - network service - transport standards - internet transport protocols - wireless UDP - overview of routing techniques.

UNIT IV PRESENTATION/APPLICATION PROTOCOLS 9

File transfer protocols - world wide web - electronic mail - overview of ISDN - ISDN protocols.

UNIT V NETWORK MANAGEMENT 8

Architecture of network management - fault management - congestion control algorithms - security management.

Total: 45

TEXT BOOKS

1. Stallings, ‘Data and Computer Communication ‘, Maxwell & Macmillan, 1988.
2. S. Andrew Tannenbaum, ‘Computer Networks ‘, Third Edition, Prentice Hall of India, 1997.

REFERENCES

1. Stallings, ‘Data and Computer Communication: Architectures, Protocols and Standards’, IEEE Computer Society, 1987.
2. A.S. Kernel Texpian, ‘Communication Network Management’, Prentice Hall, 1992.
3. Uylers Black, ‘Network Management’, Standards, McGraw-Hill, 1995.
4. Commer and Stevens, ‘Internetworking with TCP/IP Vol. III: Client Server Programming and Application’, Prentice Hall, USA, 1994.

PS5005 – ADVANCED POWER SYSTEM DYNAMICS

L	T	P	C
3	0	0	33

UNIT I SUBSYNCHRONOUS OSCILLATIONS 9

Review of power system dynamics - classification - modelling and analysis methods introduction - turbine-generator torsional characteristics - shaft system model - examples of torsional characteristics - torsional interaction with power system controls - interaction with generator excitation controls - interaction with speed governors - interaction with nearby D.C. converters.

UNIT II SUBSYNCHRONOUS RESONANCE (SSR) 9

Subsynchronous resonance (SSR) - characteristics of series - compensated transmission systems - self-excitation due to induction generator effect - torsional interaction resulting in SSR - analytical methods - numerical examples illustrating instability of subsynchronous oscillations - impact of network - switching disturbances - steady state switching - successive network - switching disturbances - torsional interaction between closely coupled units - counter measures for subsynchronous resonance.

UNIT III TRANSMISSION, GENERATION AND LOAD ASPECTS OF VOLTAGE STABILITY ANALYSIS 9

Review of transmission aspects - generation aspects - review of synchronous machine theory - 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 dependence of loads - load restoration dynamics - induction motors - load tap changers - thermostatic load recovery - general aggregate load models.

UNIT IV SYSTEM MODELLING FOR VOLTAGE STABILITY 9

General dynamic model - network modeling with a detailed example - time-scale decomposition - equilibrium equations for voltage stability studies - illustration using a detailed example.

UNIT V LOADABILITY, SENSITIVITY, BIFURCATION ANALYSIS AND COUNTER MEASURES 9

Loadability limits - sensitivity analysis - bifurcation analysis - instability mechanisms - classification of instability mechanisms - examples of short-term and long-term instabilities - countermeasures for voltage instability.

Total: 45

REFERENCES

1. P. Kundur, ‘Power System Stability and Control’, McGraw-Hill, 1993
2. H.W. Dommel, ‘Electromagnetic Transients Program’, Reference Manual prepared for Bonneville Power Administration, U.S.A, 1986.
3. T.V. Cutsem and C. Vournas, ‘Voltage Stability of Power Systems’, Kluwer Academic Publishers, 1998.

PS5051 – INTELLIGENT CONTROL

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 II ARTIFICIAL 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 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 ant-colony search techniques for solving optimization problems.

UNIT IV 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 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

REFERENCES

1. Jacek M. Zurada, ‘Introduction to Artificial Neural Systems’, Jaico Publishing House, 1999.
2. B. Kosko, ‘Neural Networks and Fuzzy Systems’, Prentice Hall of India, 1994.
3. G.J. Klir and T.A. Folger, ‘Fuzzy Sets, Uncertainty and Information’, Prentice Hall of India, 1993.
4. H.J. Zimmerman ‘Fuzzy Set Theory and its Applications’, Kluwer Academic Publishers, 1994.
5. D. Driankov, H. Hellendoorn and M. Reinfrank, ‘An Introduction to Fuzzy Control’, Narosa Publishing House, 1993.

PS5052 – HIGH VOLTAGE SWITCHGEAR

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 7

Insulation of switchgear - rated and tested voltage coordination between inner and external insulation - insulation clearances in air, oil SF_6 and vacuum - bushing insulation - solid insulating materials - dielectric and mechanical strength consideration.

UNIT II CIRCUIT INTERRUPTION 10

Switchgear terminology - arc characteristics - direct and alternating current interruption - arc quenching phenomena - computer simulation of arc models - transient re-striking voltage - RRRV recovery voltage - current chopping - capacitive current breaking - auto re-closing.

UNIT III SHORT CIRCUIT CALCULATIONS AND RATING OF CIRCUIT BREAKERS 10

Types of faults in power systems - short circuit current and short circuit MVA calculations for different types of faults - rating of circuit breakers - symmetrical and asymmetrical ratings.

UNIT IV CIRCUIT BREAKERS 10

Classification of circuit breakers - design - construction and operating principles of bulk oil, minimum oil, airblast, SF_6 and vacuum circuit breakers - comparison of different types of circuit breakers.

UNIT V TESTING OF CIRCUIT BREAKERS 8

Type tests and routine tests - short circuit testing - synthetic testing of circuit breakers - recent advancements in high voltage circuit breakers - diagnosis.

L: 45 Total: 45

REFERENCES

1. A. Chunikhin and M. Zhavoronkov, ‘High Voltage Switchgear Analysis and Design’, Mir Publishers, Moscow, 1989.
2. E. Kuffel, W.S. Zaengl and J. Kuffel, ‘High Voltage Engineering Fundamentals, Newness’, Second Edition, Butterworth-Heinemann Publishers, 2000
3. C.H. Flursscheim (Editor), ‘Power Circuit Breaker-Theory and Design’, IEE Monograph Series 17, Peter Peregrinus Ltd., Southgate House, Stevenage, Herts, SC1 1HQ, England, 1977.
4. S. Ananthakrishnan and K.P. Guruprasad, ‘Transient Recovery Voltage and Circuit Breakers’, Tata McGraw-Hill, 1999.
5. IEEE Standard Collection, ‘Surge Protection C62’, 1995 Editions, IEEE, USA.
6. Funio Nakanishi, ‘Switching Phenomena in High Voltage Circuit Breakers’, Marcel Dekker Inc., New York, 1991.

PS5053 – EHV POWER TRANSMISSION

L	T	P	C
3	0	0	3

UNIT I INTRODUCTION 6

Standard transmission voltages - average values of line parameters - power handling capacity and line loss - costs of transmission lines and equipment - mechanical considerations in line performance.

UNIT II CALCULATION OF LINE PARAMETERS 8

Calculation of resistance - inductance and capacitance - calculation of sequence inductances and capacitances - line parameters for modes of propagation.

UNIT III VOLTAGE GRADIENTS OF CONDUCTORS 9

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

UNIT IV CORONA EFFECTS 12

Power losses and audible losses - I^2R loss and corona loss - attenuation of traveling waves due to 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 - the CIGRE formula - the RI excitation function - measurement of RI, RIV and excitation function - design of filter.

UNIT V ELECTROSTATIC FIELD OF EHV LINES 10

Capacitance of long object - calculation of electrostatic field of A.C. lines effect of high field on humans, animals, and plants - meters and measurement of electrostatic fields - electrostatic induction in unenergised circuit of a D.C. line - induced voltages in insulated ground wires - electromagnetic interference.

Total: 45

REFERENCE

1. Rakosh Das Begamudre, ‘Extra High Voltage AC Transmission Engineering’, New Age International Publishers, Second Edition, 1990.

CI5102 – DIGITAL SIGNAL PROCESSING

L	T	P	C
3	0	0	3

UNIT I DISCRETE TIME SIGNALS AND SYSTEMS 9

Representation of discrete time signal - classifications - discrete time - system - basic operations on sequence - linear - time invariant - causal - stable - solution to difference equation - convolution sum - correlation - discrete time Fourier series - discrete time Fourier transform.

UNIT II FOURIER AND STRUCTURE REALIZATION 9

Discrete Fourier transform - properties - fast Fourier transform - Z-transform - structure realization - direct form - lattice structure for FIR filter - lattice structure for IIR Filter.

UNIT III FILTERS 9

FIR Filter - windowing technique - optimum equiripple linear phase FIR filter - IIR filter - bilinear transformation technique - impulse invariance method - Butterworth filter - Tchebyshev filter.

UNIT IV MULTISTAGE REPRESENTATION 9

Sampling of band pass signal - antialiasing filter - decimation by an integer factor - interpolation by an integer factor - sampling rate conversion - implementation of digital filter banks - sub-band coding - quadrature mirror filter - A/D conversion - quantization - coding - D/A conversion - introduction to wavelets.

UNIT V DIGITAL SIGNAL PROCESSORS 9

Fundamentals of fixed point DSP architecture - fixed point number representation and computation - fundamentals of floating point DSP architecture - floating point number representation and computation - study of TMS 320 C 50 processor - basic programming - addition - subtraction - multiplication - convolution - correlation - study of TMS 320 C 54 processor - basic programming - addition - subtraction - multiplication - convolution - correlation.

Total: 45

REFERENCES

1. John G. Proakis and Dimitris G. Manolakis, ‘Digital Signal Processing: Principles, Algorithms and Applications’, Prentice Hall of India.
2. S. Salivahanan, A. Vallavaraj and C. Gnanapriya ‘Digital Signal Processing’, Tata McGraw-Hill, 2000.
3. A.V. Oppenheim and R.W. Schafer ‘Digital Signal Processing’, Prentice Hall, Inc, New Jersey, 1975.
4. Rabiner and Gold, ‘Theory and Application of Digital Signal Processing’, A comprehensive, Industrial - Strength DSP reference book, Prentice Hall.
5. B. Venkatramani and M. Bhaskar, ‘Digital Signal Processors Architecture, Programming and Applications’, Tata McGraw-Hill, 2002.