MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)

Faculty of Engineering and Technology

Course Scheme and Syllabus

of

Master of Technology (Regular)
Power Systems Engineering

Effective from 2011-12

MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)
Faculty of Engineering and Technology

Two – Year (Regular) M Tech: Power Systems Engineering

Eligibility for Admission: A candidate for being eligible for admission to the Master of Technology in *Power Systems Engineering* in the faculty of engineering and technology should have passed B.Sc. (Engg.)/ B.Tech/ B.E. or any other equivalent degree in the relevant discipline / branch from any recognized Indian or foreign University.

A candidate should have at least 55% marks or equivalent CGPA in the qualifying examination (50% marks or equivalent CGPA for Scheduled Caste/Scheduled Tribes Candidates) on the basis of which the admission is being sought.

Overview of the Programme: The normal duration of programme shall be four Semesters for regular students. However, in exceptional circumstances, only dissertation work may be extended and has to be completed within five years from the date of enrolment for this programme. This extension requires the prior approval of the Vice-Chancellor of the University.

The complete programme comprises of 12 theory courses (08 Core and 04 elective) and 02 Lab courses followed by a seminar and the research/ project work in the form of a dissertation. Student has to obtain at least D Grade to pass the examination (both internal and external examination separately) for all the courses specified in the scheme of the programme. The degree will be awarded on the basis of cumulative marks obtained in all the four semesters and the division obtained will be as under:

MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)

Two – Year (Regular) M Tech: Power Systems Engineering

First Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Examination		External Examination /Viva-voce	Total Marks
		L	P		Assignment/ Lab Record	Teacher's Evaluation		
PSE-611	Advanced Power Systems Analysis	4	-	4	30	10	60	100
PSE-613	Power System Operation and Control	4	-	4	30	10	60	100
PSE-615	EHV-AC/DC Transmission	4	-	4	30	10	60	100
PSE-711/713/715	Elective-I	3	-	3	20	10	45	75
PSE-721/723/725	Elective-II	3	-	3	20	10	45	75
PSE-617	Power Systems SIM. Lab-I	-	2	2	15	10	25	50
Total Semester Credits = 20					**Total Semester Marks = 500**			

Second Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Examination		External Examination /Viva-voce	Total Marks
		L	P		Assignment/ Lab Record	Teacher's Evaluation		
PSE-612	Power Systems Dynamics and Stability	4	-	4	30	10	60	100
PSE-614	Power Systems Protection and Relaying	4	-	4	30	10	60	100
PSE-616	Flexible AC Transmission Systems	4	-	4	30	10	60	100
PSE-712/714/716	Elective-III	3	-	3	20	10	45	75
PSE-722/724/726	Elective-IV	3	-	3	20	10	45	75
PSE-618	Power Systems SIM. Lab- II	-	2	2	15	10	25	50
Total Semester Credits = 20					**Total Semester Marks = 500**			

Third Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Examination		External Examination /Viva-voce	Total Marks
		L	P		Assignment/ Lab Record	Teacher's Evaluation		
PSE-621	Operation of Restructured Power Systems	4	-	4	30	10	60	100
PSE-623	Distributed Generation	4	-	4	30	10	60	100
PSE-625	Seminar	-	2	2	25	25	-	50
Total Semester Credits = 10					**Total Semester Marks = 250**			

Fourth Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Examination		External Examination /Viva-voce	Total Marks
		L	P		Report	Supervisor (s) Evaluation		
PSE-628	Dissertation	-	16	16	75	75	250	400
Total Semester Credits = 16					**Total Semester Marks = 400**			

LIST OF ELECTIVES

ELECTIVE-I

1.	PSE-711	Transient in Power Systems
2.	PSE-713	Power Apparatus and Machines
3.	PSE-715	Systems Theory

ELECTIVE-II

1.	PSE-721	Power Quality
2.	PSE-723	Analysis of Inverters
3.	PSE-725	Control Systems Design

ELECTIVE-III

1.	PSE-712	Power Systems Planning
2.	PSE-714	Advanced Electrical Drives
3.	PSE-716	Power Electronics for Renewable Energy Systems

ELECTIVE-IV

1.	PSE-722	Electric Power Distribution Automation
2.	PSE-724	Wind Energy Conversion Systems
3.	PSE-726	Soft Computing Techniques

Internal Assessment/Examination: The internal evaluation for all theory courses (40% of the total marks) will be based on the evaluation of **three assignments** provided during the semester and assessment of the teacher concerned. Similarly, the internal evaluation for all Lab courses (50% of the total marks) will be based on the evaluation of lab record and assessment of the teacher concerned.

External Examination/Viva -voce: For all the theory courses, there will be **08 (Eight)** questions to be set by the external paper setter (nominated /approved by the competent authority) out of which the candidate will have to attempt only **05 (Five)** questions all carrying equal marks. Duration of each external examination will be **three hours**. Similarly, the external evaluation for all Lab courses (50% of the total marks) will be based on the evaluation/viva-voce conducted by an external examiner (from the relevant field) nominated/approved by the competent authority.

Evaluation of Seminar: The seminar topic should belong to the core area of specialization. Senior faculty will supervise the students in selecting and preparation of the same. The student will submit two copies of seminar report and shall make oral presentation as per time schedule decided by the faculty concerned. Internal Evaluation will be made on the basis of report, presentation and the discussion during the presentation.

Submission and Evaluation of Dissertation:

a) A dissertation supervisor (s) having at least post- graduate qualification, from industry/research organization shall be assigned to the student approved by the competent authority. *In no case, the candidate can have more than two dissertation supervisors.*

b) Dissertation work shall comprise of literature survey, problem formulation, methodology used, S/W, H/W tools used, Results and discussion followed by the conclusions & further scope of work in that area. Industry oriented projects may be encouraged for the purpose.

c) The submission of dissertation shall be allowed only after ensuring that the research work carried out by the candidate has attained the level of satisfaction of the 'Dissertation Supervisor (s)' and proof of communication/acceptance of the research paper (if any, and certified in the report) in the relevant refereed journal/ conference.

d) The final dissertation external examination in 4^{th} semester shall be taken by a panel of examiners comprising of concerned Supervisor (s), one external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of dissertation, one for each supervisor (s), examiner and the university/ department, are required to be submitted by the student before the final dissertation external examination. The candidate shall appear before the examining committee for oral examination and presentation on the scheduled date.

PSE-611 ADVANCED POWER SYSTEM ANALYSIS

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Topological Analysis of Power Networks: Review of matrix operations, graph theory, and various circuit incidence matrices, primitive network and matrices, Formation of various network matrices by singular transformation/non-singular transformation and interrelations.
Bus Impedance Algorithm: Partial network, building algorithm for bus impedance matrix, Addition of links, addition of branches, (considering mutual coupling) removal of links, modification of bus impedance matrix for network changes, Formation of bus admittance matrix and modification, Gauss elimination, Node elimination (Kron reduction), LU factorization, Schemes of Ordering, Sparsity, Calculation of Z bus elements for Y bus, Numerical examples

Balanced and unbalanced network elements: Representation of three phase network elements, representation under balanced and unbalanced excitation, transformation matrices, symmetrical components, sequence impedances, unbalanced elements, three phase power invariance.

Short circuit studies: Network representations for single line to ground fault, line to line fault, LL-G fault, and 3-phase faults, network short circuit studies using Z bus, Short circuit calculations for various types of faults in matrix form, numerical examples.

Load flow studies: Load flow and its importance. classification of buses, load flow techniques, Iterative solutions and computer flow charts using Gauss-Seidel and Newton-Raphson methods, Decoupled and fast decoupled methods, representation of regulating and off nominal ratio transformers and modification of Ybus, comparison of methods, numerical examples.

Introduction to AC-DC load flow problems: formation and solutions.

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

Introduction, Numerical Integration Methods: Euler and Fourth Order Runge-Kutta methods, Algorithm for simulation of SMIB and multi-machine system with classical synchronous machine model; Factors influencing transient stability, Numerical stability and implicit Integration methods.

Power system security: Power system security, Adding removing multiple lines, peace-wise solution of interconnected systems, analysis of single and multiple contingencies using Z bus, analysis with sensitivity factors, system reduction for contingency and fault analysis.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- G.W. Stagg & A.H EI-Abaid, 'Computer methods in Power system analysis', McGraw Hill, New York.
- M. A. Pai, 'Computer Techniques in Power System Analysis', 2nd Edi., TMH-New Delhi.
- Kusic., 'Computer-Aided Power System Analysis', Prentice Hall of India, New Delhi.
- John J.Grainger and W.D.Stevenson, 'Power System Analysis', McGraw Hill, New York, 1994.
- A.J. Wood & W.F. Wollenberg, 'Power Generation, Operation, and Control', 2nd Edn, John Wiley & Sons, New York, 1996.
- O.I. Elgerd, 'Electric Energy Systems Theory: An Introduction', McGraw Hill, New York, 1982.
- J. Arrillaga, C.P Arnold & Harker, 'Computer Modeling of Electrical Power Systems', John Wiley & Sons.
- Enrique Acha et al., 'FACTS: Modeling and Simulation in Power Networks', John Wiley and Sons Ltd., 2004.
- Kothari and Dhillon, 'Power Systems Optimization', PHI, 2004.

M TECH: POWER SYSTEMS ENGINEERING

PSE-613 POWER SYSTEM OPERATION & CONTROL

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Load Forecasting: 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 Commitment: 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.

Generation Scheduling: 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: 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: Introduction to state estimation, 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.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Allen J. Wood, and Bruce F. Wollenberg, “Power Generation, Operation and Control”, John Wiley & Sons, Inc., New York.
- Olle I. Elgerd, “Electric Energy Systems Theory – An Introduction”, Mc Graw-Hill Book Company, New York.
- John J. Grainger and William D. Stevenson, Jr., “Power System Analysis”, Mc Graw Hill Book Company, Inc., New York.
- PSR Murty, “Power System Operation and Control”, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
- IJ Nagrath & DP Kothari, “Power System Engineering, Tata McGraw Hill Publishing Co., Ltd. New Delhi.
- AK Mahalinabis, DP Kothari and SI Ahson, Computer-Aided Power System Analysis and Control, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
- Kothari and Dhillon, ‘Power Systems Optimization’, PHI, 2004.

- BR Gupta, “Generation of Electrical Energy”, S. Chand & Co. Ltd. N. Delhi.

M TECH: POWER SYSTEMS ENGINEERING

PSE-615 EHV AC/DC TRANSMISSION

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Line Parameters and properties: Role of EHV AC Transmission, standard transmission voltages, average value of line parameters, power handling capacity.Line parameters Properties of bundled conductors, resistance, induction and capacitance of bundled conductor lines, temperature rise of conductors and current carrying capacity. Voltage gradients on conductors: Charge potential relations for multi-conductor lines, surface voltage gradient on conductors, distribution of voltage gradient on sub conductors of bundle, voltage gradients on conductors in the presence of ground wires on towers, line loadability, effects of over load, reactive power limitations and over voltage problem.

Corona Effects: Corona loss, attenuation of traveling waves, audible noise, limits for audible noise, AN measurement and meters, Day night equivalent noise level, limits for radio interference fields, RI excitation function, measurements of RI, RIV, Excitation function.

Switching Over voltages: Origin of over voltages and their types, over voltages due to interruption of low inductive current and interruption of capacitive currents, Reduction of switching surges on EHV systems. Power frequency over voltages: Problems at power frequency, no-load voltage conditions and charging current, Double frequency transients- Abnormal switching transients- Current suppression- capacitance switching- Arcing ground-Transformer inrush current –Ferro resonance- neutral connections- Transients in switching a three phase reactor –Three phase capacitor.

Electrostatic Field of EHV Lines: 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.

General Aspects, Converter circuits and analysis: HVDC links - comparison –Economic, Technical performance – Reliability – Limitations - Properties of thyristor converter circuits- assumptions-Choice of best circuit for HVDC converters-Transformer connections - Analysis with gate control but no overlap less than 60 degrees- operation of inverters

Bridge converters-Analysis, Control, Protection and Harmonics Filters: Converter Inverter circuits for HVDC Transmission-basic means of control –Power reversal-desired features of control – actual control characteristics. Converter disturbance –bypass

action in bridges- commutation failure-basics of protection-DC Reactors-Voltage and current oscillations-Circuit breakers - Over voltage protection-Characteristics and uncharacteristic harmonics-troubles due to harmonics-harmonic filters-Converter charts of direct current and voltage- active and reactive power.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Begamudre, “EHV AC Transmission engineering”, Wiley Easter Ltd. 2nd Ed.
- Edison Electric Institute, “EHV transmission reference book”, GE Co.
- EPRI, Palo Alto, “Transmission line reference book 345 KV”.
- Rudenberg, “Transient performance of electric power systems” McGraw Hill.
- Kimbark,E.W., `Direct current transmission-Vol.1’,Wiley Interscience, New York, 1971
- Padiyar,K.R., `HVDC Transmission system’, Wiley Eastern Limited .,NewDelhi,1992.
- Arrilaga,J., `High Voltage Direct current transmission’,Peter Pereginver Ltd., London,UK.,1983.

M TECH: POWER SYSTEMS ENGINEERING

PSE-711 TRANSIENTS IN POWER SYSTEMS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Travelling Waves On Transmission Line: Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behaviour of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion – Multi-conductor system and Velocity wave.
Computation of Power System Transients: Statistical approach for transients calculations, principle of digital computation – Matrix method of solution, Modal analysis, Z-transforms, Computation using EMTP – Simulation of switches and non-linear elements.

Lightning, Switching And Temporary Over-voltages Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Switching: Short line or kilometric fault – Energizing transients - closing and re-closing of lines - line dropping, load rejection - Voltage induced by fault – Very Fast Transient Overvoltage (VFTO)

Behaviour of Winding Under Transient Condition: Initial and Final voltage distribution - Winding oscillation - traveling wave solution - Behaviour of the transformer core under surge condition – Rotating machine – Surge in generator and motor

Insulation Co-Ordination: Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level –overvoltage protective devices – lightning arresters, substation earthing, Protection of Power Systems against transients.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- I.V. Begley, 'Traveling waves in Transmission Systems', John Wiley (1933,51), Dover.
- R. Rudenberg. 'Electric Stroke waves in Power Systems', Harvard University Press, Cambridge, Massachusetts.
- Allan Greenwood, 'Electric Transients in Power Systems', Wiley Interscience.
- CS Indulkar and DP Kothari, 'Power System Transients, A Statistical Approach', Prentice-Hall of India Pvt Ltd., New Delhi. 110 001.
- VA Venikov, 'Transient phenomena in Electrical Power Systems', Pergamon Press, London.
- Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980..
- Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 1996.
- Naidu M S and Kamaraju V, "High Voltage Engineering", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
- Working Group 33/13-09 (1988), 'Very fast transient phenomena associated with Gas Insulated System', CIGRE, 33-13, pp. 1-20.

M TECH: POWER SYSTEMS ENGINEERING

PSE-713 POWER APPARATUS AND MACHINES

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Generalized Theory of Electrical Machines: Introduction, primitive model, transformation, voltage equations for induction and synchronous machines.

Induction Machines: Abnormal running operation, effect of space harmonics, slip power control, capacitor self-excitation of induction machines and its applications.

Transformers: Transformer as a mutually coupled circuit, equivalent circuit from coupled circuit approach.

Multi-circuit Transformers: Advantage, theory, equivalent circuit, regulation, three circuit transformers, three phase autotransformers: Connections and Analysis, Parallel operation of dissimilar transformers. Harmonics; Inrush current phenomenon, effect of load and three phase connections. Sequence impedances in transformers.

Special Machines: Servomotors, stepper motors, synchros, reluctance motors, permanent magnet synchronous machines, permanent magnet brushless DC motors .

Modeling and Analysis: Modeling and analysis of Induction and Synchronous Machines; Computer Simulations of Induction and Synchronous machines

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- MIT Staff, 'Magnetic Circuits and Transformers', MIT Press Cambridge.
- L.F Blume,'Transformer Engineering', John Wiley & Sons, Inc, N.Y.
- Fitzgerald & Kingsley, 'Electric Machinery' McGraw Hill Co. New Delhi.
- A Langsdorf, 'Theory of alternating current Machinery', McGraw Hill Co. New Delhi.
- PS Bimbhra 'Generalized Theory of Electrical Machines' Khanna Publishers, New Delhi.
- MG Say, 'Alternating Current Machines', ELBS
- Alger, 'Induction machines', Gordon and Breach Science Publishers, New York.
- Paul C. Krause, 'Analysis of Electric Machinery and Drives Systems, Krause, IEEE press.
- Chee-Mun Ong, 'Dynamic Simulation of Electric Machinery-Using MATLAB/Simulink, Prentice Hall.

M TECH: POWER SYSTEMS ENGINEERING

PSE-715 SYSTEMS THEORY

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

State Variable Representation: Introduction-Concept of State-State equation for Dynamic Systems-Time invariance and linearity-Nonuniqueness of state model-State Diagrams-Physical System and State Assignment.

Solution of State Equation: Existence and uniqueness of solutions to Continuous-time state equations-Solution of Nonlinear and Linear Time Varying State equations-Evaluation of matrix exponential-System modes-Role of Eigenvalues and Eigenvectors.

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

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

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

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

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

M TECH: POWER SYSTEMS ENGINEERING

PSE-721 POWER QUALITY

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction: Introduction – Characterisation of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Non linear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

Non-Linear Loads: Single phase static and rotating AC/DC converters, Three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

Measurement and Analysis Methods: Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

Analysis And Conventional Mitigation Methods: 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.

Power Quality Improvement: Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters –Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC –control strategies: P-Q theory, Synchronous detection method – Custom power park –Status of application of custom power devices.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002

- G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition)
- R. C. Dugan, 'Power Quality - R.C. Duggan
- A. J. Arrilega and Watson, ' Power system harmonics
- Derek A. Paice Power electronic converter harmonics

M TECH: POWER SYSTEMS ENGINEERING

PSE-723 ANALYSIS OF INVERTERS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Analysis Of Inverters: 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.

Three Phase Voltage Source Inverters: 80 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques.

Current Source Inverters: operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters – Auto sequential current source inverter (ASCI) – current pulsations – comparison of current source inverter and voltage source inverters

Multilevel Inverters: Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters

Resonant Inverters: Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC – link inverters.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- M. H. Rashid, 'Power Electronics Circuits, Devices and Applications', Prentice Hall India, Third Edition, New Delhi, 2004.
- Jai P.Agrawal, "Power Electronics Systems", Pearson Education, Second Edition, 2002.
- Bimal K.Bose, 'Modern Power Electronics and AC Drives", Pearson Education', Second Edition, 2003.
- Ned Mohan,Undeland and Robbin, 'Power Electronics: converters, Application and design', John Wiley and sons.Inc,Newyork,1995.

- Philip T. Krein, ‘Elements of Power Electronics’, Oxford University Press -1998.
- P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998.
- P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003

M TECH: POWER SYSTEMS ENGINEERING

PSE-725 CONTROL SYSTEM DESIGN

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Conventional Design Methods: Design specifications- PID controllers and compensators- Root locus based design- Bode based design-Design examples

Design In Discrete Domain: Sample and Hold-Digital equivalents-Impulse and step invariant transformations-Methods of discretisation-Effect of sampling- Direct discrete design – discrete root locus
Design examples

Optimal Control: Formation of optimal control problems-results of Calculus of variations- Hamiltonian formulation-solution of optimal control problems- Evaluation of Riccati's equation
State and output Regulator problems-Design examples

Discrete State Variable Design: Discrete pole placement- state and output feedback-estimated state feedback-discrete optimal control- dynamic programming-Design examples

State Estimation: State Estimation Problem -State estimation- Luenberger's observer-noise characteristics- Kalman-Bucy filter-Separation Theorem-Controller Design-Wiener filter-Design examples.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- M. Gopal "Modern control system Theory" New Age International, 2005.
- Benjamin C. Kuo "Digital control systems", Oxford University Press, 2004.
- G. F. Franklin, J. D. Powell and A. E. Naeini "Feedback Control of Dynamic Systems", PHI (Pearson), 2002.
- Graham C. Goodwin, Stefan F. Graebe and Mario E. Salgado "Control system Design", PHI (Pearson), 2003.
- G. F. Franklin, J. D. Powell and M Workman, "Digital Control of Dynamic Systems", PHI (Pearson), 2002.
- B.D.O. Anderson and J.B. Moore., 'Optimal Filtering', Prentice hall Inc., N.J., 1979.
- Loan D. Landau, Gianluca Zito," Digital Control Systems, Design, Identification and Implementation", Springer, 2006.

M TECH: POWER SYSTEMS ENGINEERING

PSE-617 POWER SYSTEM SIMULATION LABORATORY-I

Internal Assessment/Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

LIST OF EXPERIMENTS

1. Formulation of Bus Incidence matrices, A,B,C using MATLAB
2. Formulation of Ybus with matrix A and using direct approach/Formulation of Jacobian matrix.
3. Power flow analysis by Newton-Raphson method
4. Power flow analysis by Fast decoupled method
5. Formulation of Zbus using Zbus building algorithm
6. Short circuit studies using Zbus
7. Load frequency control for multi-area system using SIMULINK
8. Contingency analysis: Generator shift factors and line outage distribution factors
9. Economic dispatch using lambda-iteration method
10. Unit commitment: Priority-list schemes and dynamic programming

M TECH: POWER SYSTEMS ENGINEERING

PSE-612 POWER SYSTEM DYNAMICS & STABILITY

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Synchronous machine modeling for stability studies: Basic equations of a synchronous machine, the dq0 transformation, per unit representation, equivalent circuits for direct and quadrature axes, steady state analysis, transient performance, magnetic saturation`, equations of motion, swing equation, simplified model with ammortisseurs neglected, constant flux linkage model.

Modeling of Excitation and speed governing systems: Elements of excitation systems, types of excitation system, dc,ac and static excitation systems, system representation by block diagram and state equations, prime mover control system, Schematic of a hydroelectric plant, classical transfer function of a hydraulic turbine (no derivation), special characteristic of hydraulic turbine, electrical analogue of hydraulic turbine, Governor for Hydraulic Turbine: Requirement for a transient droop, Block diagram of governor with transient droop compensation, Steam turbine modelling: Single reheat tandem compounded type only and IEEE block diagram for dynamic simulation; generic speed-governing system model for normal speed/load control function.

Small signal stability of power systems: 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 eigenvectors, modal matrices, eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics, effects Of excitation System, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System Stabiliser, analysis of stability with numerical a example, multi-machine systems.

Voltage Stability: Basic concepts related to voltage stability, voltage collapse, voltage stability analysis – static and dynamic analysis, the continuation power flow analysis, prevention of voltage collapse.

Sub-synchronous Oscillations: Turbine generator tortional characteristics, tortional interaction with power systems controls, subsynchronous oscillations, tortional interaction between closely coupled units, hydro-generator tortional characteristics.

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

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- P. Kundur, 'Power System Stability and Control', Mc Graw Hill.

- K.R. Padiyar, ‘Power System Dynamics’ BS Publications.
- P.M Anderson and A.A Fouad ‘Power System Control and Stability’ Iowa State Uni. Press.
- Sauer and Pai, Power System Dynamics and Stability, Peasson Edu.

M TECH: POWER SYSTEMS ENGINEERING

PSE-614 POWER SYSTEM PROTECTION AND RELAYING

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Equipment Protection :Types of transformers – Phasor diagram for a three – Phase transformer-Equivalent circuit of transformer – Types of faults in transformers- Over – current protection Percentage Differential Protection of Transformers - Inrush phenomenon-High resistance Ground Faults in Transformers - Inter-turn faults in transformers - Incipient faults in transformers - Phenomenon of over-fluxing in transformers - Transformer protection application chart .Electrical circuit of the generator –Various faults and abnormal operating conditions-rotor fault –Abnormal operating conditions; numerical examples for typical transformer and generator protection schemes.

Static Relays and Microprocessors based Relays: Over current relays: Instantaneous over current relays, definite time overcorrect relays, directional overcorrect relay, comparison with conventional relays, differential relays, operating and restraining characteristics, types of differential relays, comparison with conventional relays, distance relays, impedance relays, reactance relays, mho relay quadrilateral relays, elliptical relays, comparison with conventional relays.

Over Current Protection: Time–Current characteristics-Current setting – Time setting-Over current protective schemes - Reverse power or directional relay - Protection of parallel feeders - Protection of ring feeders - Earth fault and phase fault protection - Combined Earth fault and phase fault protection scheme - Phase fault protective scheme directional earth fault relay - Static over current relays; numerical example for a radial feeder

Distance and Carrier Protection of Transmission Lines:
Braw back of over – Current protection – Introduction to distance relay – Simple impedance relay – Reactance relay – mho relays comparison of distance relay – Distance protection of a three – Phase line-reasons for inaccuracy of distance relay reach - Three stepped distance protection - Trip contact configuration for the three - Stepped distance protection - Three-stepped protection of three-phase line against all ten shunt faults - Impedance seen from relay side - Three-stepped protection of double end fed lines-need for carrier – Aided protection – Various options for a carrier –Coupling and trapping the carrier into the desired line section - Unit type carrier aided directional comparison relaying – Carrier aided distance schemes for acceleration of zone II.; numerical example for a typical distance protection scheme for a transmission line.

Bus bar Protection: Introduction – Differential protection of busbars-external and internal fault - Actual behaviors of a protective CT - Circuit model of a saturated CT - External fault with one CT saturation :need for high impedance – Minimum internal fault that can be detected by the high – Stability ratio of high impedance busbar differential scheme - Supervisory relay-protection of three – Phase busbars-Numerical examples on design of high impedance busbar differential scheme.

Numerical Protection: Introduction – Block diagram of numerical relay - Sampling theorem- Correlation with a reference wave – Least error squared (LES) technique - Digital filtering-numerical over - Current protection – Numerical transformer differential protection-Numerical distance protection of transmission line

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- TSM Rao, “Power System Protection – Static Relays”, Tata McGraw Hill.
- S.P Patra, S.K Basu and S. Choudhary, “Power System Protection”, Oxford IBH Pub.
- B. Ravindernath and M. Chander, “Power System Protection and Switchgear”, Wiley Eastern Ltd.
- Badri Ram and Vishwakarma, Power System Protection and Switchgear, TATA McGraw Hill.
- Y.G. Paithankar and S.R Bhide, “Fundamentals of Power System Protection”,
- Power Systems Protection, IEEE Series, 4 volumes.

M TECH: POWER SYSTEMS ENGINEERING

PSE-616 FLEXIBLE AC TRANSMISSION SYSTEMS

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Introduction and FACTS general concepts: Reactive power control in electrical power transmission lines -Uncompensated transmission line - series compensation and shunt compensation – Basic concepts of series, shunt, and combination of series and shunt compensators, their description and definitions.

Static Shunt Compensator (SVC) and Applications: objectives of shunt compensation, methods of controllable VAR generation, SVC, Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator –Modelling of SVC for power flow and transient stability – Applications: Enhancement of transient stability – Steady state power transfer – Enhancement of power system damping – Prevention of voltage instability, Static VAR systems.

Static Series Compensators, TCSC and Applications: Objectives of series compensation, Operation of the TCSC – Different modes of operation – Modelling of TCSC and their comparison, Variable reactance model, Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit – Enhancement of system damping-SSR Mitigation.

Voltage Source Converter Based FACTS Controllers: Static Synchronous Compensator (STATCOM) – Principle of operation – V-I Characteristics. Comparison with SVC, Applications: Steady state power transfer-Enhancement of transient stability - Prevention of voltage instability. SSSC-operation of SSSC and the control of power flow –Modelling of SSSC in load flow and transient stability studies, comparison with TCSC, Applications: SSR Mitigation-UPFC and IPFC operating principles and their characteristics, control structure, applications.

Co-Ordination of FACTS Controllers: Controller interactions – SVC – SVC interaction – Co-ordination of multiple controllers using linear control techniques – Control coordination using genetic algorithms.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Narain G. Hingorani, “Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems”, Standard Publishers Distributors, Delhi- 110 006.
- Y. H. Song, ‘Flexible AC Transmission Systems (FACTS)’, (IEEE Series).
- T. J. E. Miller, ‘Reactive Power Control in Power Systems’, Wiley.
- R.Mohan Mathur, Rajiv K.Varma, “Thyristor – Based Facts Controllers for Electrical Transmission Systems”, IEEE press and John Wiley & Sons, Inc.
- K.R.Padiyar,” FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Limited, Publishers, New Delhi, 2008.
- A.T.John, “Flexible A.C. Transmission Systems”, Institution of Electrical and Electronic Engineers (IEEE), 1999.
- V.K.Sood, HVDC and FACTS controllers – Applications of Static Converters in Power System, APRIL 2004 , Kluwer Academic Publishers.
- Enrique Acha et al., ‘FACTS modeling and Simulation in Power Networks’, John Wiley and Sons, 2004.
- K. K. Sen and M. L. Sen, ‘Introduction of FACTS Controllers’, Wiley IEEE, 2009

M TECH: POWER SYSTEMS ENGINEERING

PSE-712 POWER SYSTEM PLANNING

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Load Forecasting: 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: 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: Deterministic contingency analysis-probabilistic load flow-Fuzzy load flow probabilistic transmission system reliability analysis-Determination of reliability indices like LOLP and expected value of demand not served.

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

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Proceeding of work shop on energy systems planning & manufacturing CI.
- R.L .Sullivan, " Power System Planning",.
- Roy Billinton and Allan Ronald, "Power System Reliability."
- Turan Gonen, Electric power distribution system Engineering 'McGraw Hill,1986

M TECH: POWER SYSTEMS ENGINEERING

PSE-714 ADVANCED ELECTRIC DRIVES

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Motor drive – Selection of drives – Power converters – DC motor speed control – Filed and armature control – Four-quadrant operation – Phase-controlled converters – 1- phase and 3-phase – Steady-state analysis of 3-phase converter – Controlled DC motor drive – Transfer functions of the subsystems – Design of controllers – Two-quadrant DC motor drive with field weakening – Four-quadrant DC motor drive – Chopper-controlled DC motor drive – Steady-state analysis – Closed-loop operation – PWM current controller – Hysteresis current controller.

3-phase induction motor – Equivalent circuit – Steady-state performance equations – Dynamic modeling of induction machines – 3-phase to 2-phase transformation – Power-equivalence – Generalized model in arbitrary reference frame – stator reference frame model –Rotor reference frame model – Synchronously rotating reference frames model – Equations in flux linkages.

Phase controlled induction motor drives – Stator voltage control – Closed loop operation – Slip-energy recovery scheme – Closed loop control – Static scherbius drive – Stator frequency control – Constant volts/Hz control – Constant slip-speed control – Constant air gap flux control – control of harmonics – Phase shifting control – Pulse-width modulation – Flux weakening operation – current source induction motor (CSIM) drives – closed loop CSIM drive system.

Vector controlled induction motor drives – Direct vector control – Vector control with space vector modulation – Indirect vector control scheme – flux weakening operation – Direct torque control (DTC) – Permanent magnet synchronous motor (PMSM) drives – Vector control – Sensor less PMSM drive – permanent magnet brushless DC motor drive.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Electric Motor Drives – Modeling, Analysis and Control by R.Krishnan, Pearson Education.
- Modern Power Electronics and AC drives by Bimal K. Bose, Pearson Education.
- Fundamentals of Electrical Drives by Gopal K. Dubey, Narosa Publishing House

M TECH: POWER SYSTEMS ENGINEERING

PSE-716 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

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

POWER CONVERTERS: 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, three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

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

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Rashid .M. H “power electronics Hand book”, Academic press, 2001.
- Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
- Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
- Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
- Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.
- Thomas Acremann, ‘Wind Power In Power Systems’, Wiley, 2005.

M TECH: POWER SYSTEMS ENGINEERING

PSE-722 Electric Power Distribution Automation

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction: Why distribution automation, power delivery systems, control hierarchy, DA concept, distribution automation system, basic architectures and implementation strategies for DA.

Central Control and Management: Why power stystem control, operation environment of distribution networks, evolution of Distribution management systems, basic distribution management function, basis of a real time control system, outage management, decision support applications, database structures and interfaces.

Distribution Automation and Control Functions: Introduction, Demand side management, Voltage/Var control, fault detection, restoration function, reconfiguration of distribution systems, power quality.

Intelligent Systems in Distribution Automation: Distribution automation function, artificial intelligent methods, intelligent systems in DA, fault detection, classification and location in distribution systems.

Renewable Energy Options and Technology: Distributed generation, classification of renewable energy, renewable energy options, other non-renewable energy sources, distributed generation concepts and bemefits, examples.

Distribution management Systems: DMS and EMS, function of EMS, SCADA, remote terminal units, distribution management systems, Distribution system analysis, Feeder automation, load management systems, GIS, customer information system, automatic meter reading, advance billiong, advances in AMR technology, cost benefit analysis in DS.

Communication System for Control and Automation: Communication and distribution automation, DA communication and link options, wireless communication, wire communication, DA communication and control, DA communication architecture, DA communication user interface.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books

- James A. Momoh, "Electric Power Diustribution Automation, Protection and Control, CRC Press, taylor and Francis, 2008.
- James N-Green and R. Wilson, 'Control and Automation of Electric Power Distribution Systems', CRC Press, Taylor and Franscis, 2007.

M TECH: POWER SYSTEMS ENGINEERING

PSE-724 Wind Energy conversion Systems

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

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

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

Fixed Speed Systems: 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 for Steady state and Transient stability analysis.

Variable Speed Systems: 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: Stand alone and Grid Connected WECS system-Grid connection Issues-Machine side & Grid side controllers-WECS in various countries

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books

- L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
- Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
- E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge,1976.
- S.Heir "Grid Integration of WECS", Wiley 1998.

M TECH: POWER SYSTEMS ENGINEERING

PSE-726 Soft Computing Techniques

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

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

Artificial Neural Networks: 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.

Fuzzy Logic System: 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.

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

Applications: 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.

Recommended Books

- Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
- KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
- KLIR G.J. & FOLGER T.A. "Fuzzy sets, uncertainty and Information", Prentice-Hall of India Pvt. Ltd., 1993.
- Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
- Driankov, Hellendroon, "Introduction to Fuzzy Control", Narosa Publishers.
- S.Rajasekharan, G.A.Vijayalakshmi Pai, Neural Network, Fuzzy Logic and
- Genetic Algorithms Synthesis and Applications, Prentice Hall India.
- S.N.Sivanandam, S.N.Deepa, Principles of Soft Computing, Wiley India.

M TECH: POWER SYSTEMS ENGINEERING

PSE-618 POWER SYSTEM SIMULATION LABORATORY-II

Internal Assessment/Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

LIST OF EXPERIMENTS

1 Small-signal stability analysis of multi-machine configuration with classical machine model using Power System Toolbox
2 Transient stability study for multi-machine system using power system toolbox/SIMULINK
3 Learning power world simulator package and utilizing its capability for load flow studies, voltage stability studies, ATC etc.
4 Load flow analysis with FACTS devices
5 Transient stability analysis using Range-Kutta method
6 Available Transfer Capability calculation using an existing load flow program, power world simulator.
7 PV/QV analysis using power world simulator
8 Optimal power flow study using MATPOWER/Power World Simulator/GAMS.
9 Available transfer capability determination with DC and AC PTDFs using MATLB program.
10 Learning PSAT toolbox (available freely on waterloo site) and using for stability studies.

M TECH: POWER SYSTEMS ENGINEERING

PSE-621 OPERATION OF RESTRUCTURED POWER SYSTEMS

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Deregulation of Electricity Supply Industries: What is deregulation?, different entities in deregulated electricity markets, background of deregulation around the world, benefits from competitive electricity markets, different key issues of competitive electricity markets, market Clearing Price(MCP) - Market operations: Day-ahead and Hour-Ahead Markets, Elastic and Inelastic demand, technical challenges, Power System Restructuring and electricity reforms in India, key features of electricity act 2003.

Market Models: Market Models based on energy trading, contractual agreement: Pool & Bilateral models, different independent models, role of ISO, market power, Bidding and auction mechanisms, optimal power flow, economical load dispatch and unit commitment in deregulated environment, market models in Indian market context, and power trading in India.

Transmission Open Access and pricing issues: Power wheeling, transmission open access, cost component in transmission pricing, basic objectives, different methods of transmission pricing, Short run and long run marginal transmission price structure, development in international transmission pricing, reactive power pricing structure, and its calculation for generator's reactive support, numerical examples, impact of FACTS devices on transmission pricing.

Transmission congestion management:, Transmission congestion, impact of transmission congestion, different methods of congestion management, financial transmission right, flow gate rights, market power and congestion issues, numerical examples, international experiences of transmission congestion management, security management: spinning reserves, interruptible load options.

Available transfer capability determination: Definitions, principles of ATC determination, factors affecting ATC, static and dynamic ATC, static ATC determination using DC power transfer distribution factors, AC power transfer distribution factors, ATC with line outage contingencies, LODFs with DC and AC, dynamic ATC and its determination, ATC enhancement with FACTS controllers, numerical examples.

Ancillary Services management: Description of ancillary services, types of ancillary services, ancillary service management in US, UK, Austrailia, Sweden etc., reactive power as an ancillary service and its management, AGC as an ancillary service, AGC pricing, spinning reserve, black start capability, ancillary services auction.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- Lio Lee Lai, Power System restructuring and deregulation. John Wiley and Sons, UK. 2001.
- K. Bhattacharya, MHT Bollen and J.C Doolder, Operation of Restructured Power Systems, Kluwer Academic Publishers, USA, 2001.
- M. Shahidehpour et al., 'Market Operations in Electric Power Systems', John Wiley and Sons, 2002.
- M. Shahedehpor, 'Restructured Electric Power Systems,: Operation, trading and volatility', Marcel Dekker, Inc.
- M. Ilic, 'Power Systems Restructuring-Engineering and Economics', Kluwer Int. Series, 2000.
- A.J Wood and B.F Wollenberg. Power System Operation and Control, John Wiley and Sons.
- S.A Soman, S.A Khaperde, Shubha Pandit, Computational Methods for large Sparse Power System Analysis: An Object Oriented Approach. Kluwer Academic Publishers.
- Understanding electric utilities and de-regulation, Lorrin Philipson, H. Lee Willis, Marcel Dekker Pub., 1998.
- Power system economics: designing markets for electricity Steven Stoft, John Wiley & Sons, 2002

M TECH: POWER SYSTEMS ENGINEERING

PSE-623 DISTRIBUTED POWER GENERATION

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Photo-voltaic, Fuel cells and MHD: Basic characteristics of sunlight- solar energy resource- photovoltaic cell – cell efficiency- characteristics- equivalent circuit- photo voltaic for battery charging- charge regulators- PV modules- battery backup- limitations- equipments and systems- types of fuel cells -losses in fuel cells- MHD generators- application of MHD generation.

Wind Turbines and Embedded generation: Wind Source-wind statistics- energy in the wind- aerodynamics- rotor types – forces developed by blades- aerodynamic models- braking systems-tower- control and monitoring system- power performance- Wind driven induction generators-power circle diagram-steady state performance-modelling-integration issues-impact on central generation-transmission and distribution systems-wind farm electrical design.

Isolated generation: Wind -diesel systems-fuel savings- permanent magnet alternators-modelling-steady state equivalent circuit- self excited induction generators – integrated wind -solar systems.

Other Renewable Sources and Bio fuels: Micro- hydel electric systems-power potential -scheme layout-generation efficiency and turbine part flow isolated and parallel operation of generators- geothermal-tidal and OTEC systems-classification of bio fuels- Conversion process- applications.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- John F.Walker & Jenkins ,N., ` Wind Energy Technology', John Wiley and sons, Chichester, U.K.,1997.
- Van Overstraeton R. J and Mertens R P., ` Physics, Technology and use of Photovoltaics', Adem Hilger, Bristol, 1996.
- Sukhatme,S.P.,`Solar Energy- Principles of Thermal Collection and Storage' Tata Mc-Graw-Hill, New Delhi.
- S.L.Soo, 'Direct Energy Conversion', Prentice Hall Publication.
- Freries L.L., 'Wind Energy Conversion Systems', Prentice Hall U .K., 1990.
- Kreith,F., and Kreider,J.F., 'Principles of Solar engineering', Mc-Graw-Hill, Book Co.
- Imamura M. S.et.al., 'Photo voltaic System Technology, European Hand Book',H S., Stephen and Associate, 1992.
- James Larminie, Andrew Dicks,Fuel Cell Systems', John Wiley and Sons Ltd
- Chapman and E.J.Womack, 'MHD Power Generation Engineering Aspects',Hall Publication.
- H. Lee Willis, and W. G. Scott, ‘Distributed Power Generation’, Marcel Dekker, Inc. 2000.

M TECH: POWER SYSTEMS ENGINEERING

PSE – 625 SEMINAR

Internal Assessment/Evaluation: 50 Marks

The student is required to deliver a seminar on some emerging topics of Manufacturing Systems Engineering. Senior faculty will supervise the students in selecting and preparation of the same. The student will submit two copies of seminar report and shall make oral presentation as per time schedule decided by the faculty concerned. Internal Evaluation will be made on the basis of report, presentation and the discussion during the presentation.

M TECH: POWER SYSTEMS ENGINEERING

PSE – 628 DISSERTATION

Internal Assessment/Evaluation: 150 Marks
External Examination: 250 Marks

The primary objective of this course is to enhance the student ability to analyze and carry out independent investigations etc. Each student will carry out independent work which should involve creativity, innovation and ingenuity. A dissertation supervisor (s) having at least post- graduate qualification, from industry/research organization shall be assigned to the student approved by the competent authority. *In no case, the candidate can have more than two dissertation supervisors.* Dissertation work shall comprise of literature survey, problem formulation, methodology used, S/W, H/W tools used, Results and discussion followed by the conclusions & further scope of work in that area. Industry oriented projects may be encouraged for the purpose.

The submission of dissertation shall be allowed only after ensuring that the research work carried out by the candidate has attained the level of satisfaction of the 'Dissertation Supervisor (s)' and proof of communication/acceptance of the research paper (if any, and certified in the report) in the relevant refereed journal/ conference. The final dissertation external examination in 4^{th} semester shall be taken by a panel of examiners comprising of concerned Supervisor (s), one external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of dissertation, one for each supervisor (s), examiner and the university/ department, are required to be submitted by the student before the final dissertation external examination. The candidate shall appear before the examining committee for oral examination and presentation on the scheduled date.

M TECH: POWER SYSTEMS ENGINEERING

PSE-611 ADVANCED POWER SYSTEM ANALYSIS

Recommended Books:

- G.W. Stagg & A.H EI-Abaid, 'Computer methods in Power system analysis', McGraw Hill, New York.
- M. A. Pai, 'Computer Techniques in Power System Analysis', 2nd Edi., TMH-New Delhi.
- John J.Grainger and W.D.Stevenson, 'Power System Analysis', McGraw Hill, New York, 1994.
- A.J. Wood & W.F. Wollenberg, 'Power Generation, Operation, and Control', 2nd Edn, John Wiley & Sons, New York, 1996.
- O.I. Elgerd, 'Electric Energy Systems Theory: An Introduction', McGraw Hill, New York, 1982.
- Kothari and Dhillon, 'Power Systems Optimization', PHI, 2004.

PSE-613 POWER SYSTEM OPERATION & CONTROL

Recommended Books:

- Allen J. Wood, and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., New York.
- PSR Murty, "Power System Operation and Control", Tata McGraw-Hill Publishing Company Ltd., New Delhi.
- IJ Nagrath & DP Kothari, "Power System Engineering, Tata McGraw Hill Publishing Co., Ltd. New Delhi.
- AK Mahalinabis, DP Kothari and SI Ahson, Computer-Aided Power System Analysis and Control, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
- BR Gupta, "Generation of Electrical Energy", S. Chand & Co. Ltd. N. Delhi.

PSE-615 EHV AC/DC TRANSMISSION

Recommended Books:

- Begamudre, "EHV AC Transmission engineering", Wiley Easter Ltd. 2nd Ed.
- Kimbark,E.W., `Direct current transmission-Vol.1',Wiley Interscience, New York, 1971
- Padiyar,K.R., `HVDC Transmission system', Wiley Eastern Limited .,NewDelhi,1992.
- Arrilaga,J., `High Voltage Direct current transmission',Peter Pereginver Ltd., London,UK.,1983.

PSE-711 TRANSIENTS IN POWER SYSTEMS

Recommended Books:

- R. Rudenberg. 'Electric Stroke waves in Power Systems', Harvard University Press, Cambridge, Massachusetts.
- Allan Greenwood, 'Electric Transients in Power Systems', Wiley Interscience.
- CS Indulkar and DP Kothari, 'Power System Transients, A Statistical Approach', Prentice-Hall of India Pvt Ltd., New Delhi. 110 001.
- Klaus Ragaller, "Surges in High Voltage Networks", Plenum Press, New York, 1980..
- Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., 1996.

PSE-713 POWER APPARATUS AND MACHINES

Recommended Books:

- A Langsdorf, 'Theory of alternating current Machinery', McGraw Hill Co. New Delhi.
- PS Bimbhra 'Generalized Theory of Electrical Machines' Khanna Publishers, New Delhi.
- MG Say, 'Alternating Current Machines', ELBS
- Paul C. Krause, 'Analysis of Electric Machinery and Drives Systems, Krause, IEEE press.
- Chee-Mun Ong, 'Dynamic Simulation of Electric Machinery-Using MATLAB/Simulink, Prentice Hall.

PSE-715 SYSTEMS THEORY

Recommended Books:

- M. Gopal, "Modern Control System Theory", New Age International, 2005.
- K. Ogatta, "Modern Control Engineering", PHI, 2002.
- D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
- John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
- Z. Bubnicki, "Modern Control Theory", Springer, 2005.

PSE-721 POWER QUALITY

Recommended Books:

- Arindam Ghosh “Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, 2002
- G.T.Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1994(2nd edition)
- R. C. Dugan, ‘Power Quality - R.C. Duggan
- A. J. Arrilega and Watson, ‘ Power system harmonics

PSE-723 ANALYSIS OF INVERTERS

Recommended Books:

- M. H. Rashid, ‘Power Electronics Circuits, Devices and Applications’, Prentice Hall India, Third Edition, New Delhi, 2004.
- Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002.
- Bimal K.Bose, ‘Modern Power Electronics and AC Drives”, Pearson Education’, Second Edition, 2003.
- P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003

PSE-725 CONTROL SYSTEM DESIGN

Recommended Books:

- M. Gopal “Modern control system Theory” New Age International, 2005.
- Benjamin C. Kuo “Digital control systems”, Oxford University Press, 2004.
- G. F. Franklin, J. D. Powell and M Workman, “Digital Control of Dynamic Systems”, PHI (Pearson), 2002.

PSE-612 POWER SYSTEM DYNAMICS & STABILITY

Recommended Books:

- P. Kundur, ‘Power System Stability and Control’, Mc Graw Hill.
- K.R. Padiyar, ‘Power System Dynamics’ BS Publications.
- Sauer and Pai, Power System Dynamics and Stability, Peasson Edu.

PSE-614 POWER SYSTEM PROTECTION AND RELAYING

Recommended Books:

- TSM Rao, "Power System Protection – Static Relays", Tata McGraw Hill.
- B. Ravindernath and M. Chander, "Power System Protection and Switchgear", Wiley Eastern Ltd.
- Badri Ram and Vishwakarma, Power System Protection and Switchgear, TATA McGraw Hill.
- Power Systems Protection, IEEE Series, 4 volumes.

PSE-616 FLEXIBLE AC TRANSMISSION SYSTEMS

Recommended Books:

- Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006.
- Y. H. Song, 'Flexible AC Transmission Systems (FACTS)', (IEEE Series).
- T. J. E. Miller, 'Reactive Power Control in Power Systems', Wiley.
- R.Mohan Mathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers for Electrical Transmission Systems", IEEE press and John Wiley & Sons, Inc.
- K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International (P) Limited, Publishers, New Delhi, 2008.

PSE-712 POWER SYSTEM PLANNING

Recommended Books:

- R.L .Sullivan, " Power System Planning",.
- Roy Billinton and Allan Ronald, "Power System Reliability."
- Turan Gonen, Electric power distribution system Engineering 'McGraw Hill,1986

PSE-714 ADVANCED ELECTRIC DRIVES

Recommended Books:

- Electric Motor Drives – Modeling, Analysis and Control by R.Krishnan, Pearson Education.
- Modern Power Electronics and AC drives by Bimal K. Bose, Pearson Education.
- Fundamentals of Electrical Drives by Gopal K. Dubey, Narosa Publishing House

PSE-716 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

Recommended Books:

- Rai. G.D, “Non conventional energy sources”, Khanna publishes, 1993.
- Non-conventional Energy sources B.H.Khan Tata McGraw-hill Publishing Company, New Delhi.
- Thomas Acremann, ‘Wind Power In Power Systems’, Wiley, 2005.

PSE-722 Electric Power Distribution Automation

Recommended Books

- James A. Momoh, "Electric Power Diustribution Automation, Protection and Control, CRC Press, taylor and Francis, 2008.
- James N-Green and R. Wilson, ‘Control and Automation of Electric Power Distribution Systems’, CRC Press, Taylor and Franscis, 2007.

PSE-724 Wind Energy conversion Systems

Recommended Books

- L.L.Freris “Wind Energy conversion Systems”, Prentice Hall, 1990
- Ion Boldea, “Variable speed generators”, Taylor & Francis group, 2006.

- E.W.Golding “The generation of Electricity by wind power”, Redwood burn Ltd., Trowbridge,1976.

PSE-726 Soft Computing Techniques

Recommended Books

- Jacek.M.Zurada, "Introduction to Artificial Neural Systems", Jaico Publishing House, 1999.
- KOSKO,B. "Neural Networks And Fuzzy Systems", Prentice-Hall of India Pvt. Ltd., 1994.
- Zimmerman H.J. "Fuzzy set theory-and its Applications"-Kluwer Academic Publishers, 1994.
- S.N.Sivanandam, S.N.Deepa, Principles of Soft Computing, Wiley India.

PSE-621 OPERATION OF RESTRUCTURED POWER SYSTEMS

Recommended Books:

- Lio Lee Lai, Power System restructuring and deregulation. John Wiley and Sons, UK. 2001.
- K. Bhattacharya, MHT Bollen and J.C Doolder, Operation of Restructured Power Systems, Kluwer Academic Publishers, USA, 2001.
- M. Shahidehpour et al., ‘Market Operations in Electric Power Systems’, John Wiley and Sons, 2002.
- M. Shahedehpor, ‘Restructured Electric Power Systems,: Operation, trading and volatility’, Marcel Dekker, Inc.
- M. Ilic, ‘Power Systems Restructuring-Engineering and Economics’, Kluwer Int. Series, 2000.

PSE-623 DISTRIBUTED POWER GENERATION

Recommended Books:

- John F.Walker & Jenkins ,N., ` Wind Energy Technology', John Wiley and sons, Chichester, U.K.,1997.
- Freries L.L., 'Wind Energy Conversion Systems', Prentice Hall U .K., 1990.
- Kreith,F., and Kreider,J.F., 'Principles of Solar engineering', Mc-Graw-Hill, Book Co.
- Imamura M. S.et.al., 'Photo voltaic System Technology, European Hand Book',H S., Stephen and Associate, 1992.
- H. Lee Willis, and W. G. Scott, ‘Distributed Power Generation’, Marcel Dekker, Inc. 2000.