ELECTRICAL ENGINEERING DEPARTMENT

M.Tech. (E.P.S.) Full Time

Course Code	Name of the Course	Teaching Scheme				Evaluation Scheme								Credits
						Theory				Practical				
		Theory Hrs /week	Tutorial Hrs/week	Practical Hrs/week	Total	IE	ME	ESE	Min.Passing Marks	Internal	External	Min.Passing Marks	Total	
Sem I														
EP101	Energy Management and Auditing	3	1	--	4	15	15	70	50	--	--	--	100	4
EP102	Application of Power Electronics in Power Systems	3	1	--	4	15	15	70	50	--	--	--	100	4
EP103	Power System Dynamics	3	1	--	4	15	15	70	50	--	--	--	100	4
EP104	Elective – I	3	1	--	4	15	15	70	50	--	--	--	100	4
EP105	Lab Practice - I	--	--	2	2	--	--	--	--	25	25	25	50	2
Total		12	4	2	18	60	60	280	200	25	25	25	450	18
Sem II														
EP201	Advanced Power Electronics	3	1	--	4	15	15	70	50	--	--	--	100	4
EP202	Advanced Power System Protection	3	1	--	4	15	15	70	50	--	--	--	100	4
EP203	Elective – II	3	1	--	4	15	15	70	50	--	--	--	100	4
EP204	Elective - III	3	1	--	4	15	15	70	50	--	--	--	100	4
EP205	Lab Practice - II	--	--	2	2	--	--	--	--	25	25	25	50	2
Total		12	4	2	18	60	60	280	200	25	25	25	450	18

Sem III														
EP301	**Research Methodology**	**3**	**1**	**--**	**4**	**15**	**15**	**70**	**50**	**--**	**--**	**--**	**100**	**4**
EP302	**Industrial Training**	**---**	**---**	**2**	**2**	**---**	**---**	**---**	**---**	**100**	**--**	**50**	**100**	**6**
EP303	**Renewable Energy Systems**	**3**	**1**	**-**	**4**	**15**	**15**	**70**	**50**	**-**	**-**	**-**	**100**	**4**
EP304	**Dissertation Phase - I**	**---**	**---**	**4**	**4**	**---**	**---**	**---**	**---**	**100**	**---**	**---**	**100**	**10**
	Total	**6**	**2**	**6**	**14**	**30**	**30**	**140**	**100**	**200**	**---**	**50**	**400**	**24**
Sem IV														
EP401	**Dissertation Phase - II**	**---**	**---**	**6**	**6**	**---**	**---**	**---**	**---**	**100**	**200**	**---**	**300**	**20**
Total		**---**	**---**	**6**	**6**	**---**	**---**	**---**	**---**	**100**	**200**	**---**	**300**	**20**

IE :Internal Evaluation **ME: Mid-Term Evaluation** **ESE: End Sem. Examination**

LIST OF ELECTIVES

Elective- I - EP104	Elective II- EP203	Elective - III - EP204
Electrical Power Quality	Computer Applications in Power Systems	AI Techniques to Power System
Processor Applications in Power Systems	Advanced Electrical Drives	Power System Deregulation
Power system Optimization	Power System Planning & Reliability	Advanced Control System

Note:

1. Lab Practice-I, Lab Practice-II will consist of practical's / assignments based on theory of first and second semester courses respectively.
2. Dissertation (Phase-I): Student has to submit the report and deliver the seminar based on Dissertation topic. It is to be evaluated by three member's panel of examiners headed by HOD; wherein guide should be one of the members of the panel. Last date of submission of report shall be one week before the end of semester.
3. Dissertation (Phase-II): Internal assessment of dissertation is to be carried out by the committee constituted by HOD; wherein guide should be one of the members. External assessment of Dissertation (complete work) is to be carried out by panel of examiner consisting of internal (guide) and external examiner. Candidate shall present the entire work of Dissertation, followed by viva-voce. Last date of submission of dissertation shall be the end of the semester.
4. All the courses shall be within the setting, moderation and valuation jurisdiction of the Board of Studies in ELECTRICAL ENGINEERING.
5. **Duration of ESE for all courses shall be 3 Hrs.**

SUMMERY

SR.NO.	SEMESTER	NO. OF THEORY COURSES	NO. OF LABS/ PRACT	TEACHING HOURS (TH) (L+T)	TEACHING HOURS (PRACT)	TOTAL CREDITS	MAX. THEORY MARKS	MAX. PRACT MARKS	MAX. MARKS TOTAL
1	I	4	1	16	2	18	400	50	450
2	II	4	1	16	2	18	400	50	450
3	III	2	2	8	6	24	200	200	400
4	IV	----	1	----	6	20	----	300	300
TOTAL		**10**	**5**	**40**	**16**	**80**	**1000**	**600**	**1600**

EP101 Energy Management and Auditing

Teaching Scheme	**: 03 L + 01 T = 04**	**Credit: 04**
Evaluation Scheme	**: 15 IE + 15 ME+70 ESE**	**Total Marks: 100**
Duration of ESE	**: 3 Hrs.**	

Energy Scenario: Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance

Energy Management & Audit: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit Instruments energy management, Roles and responsibilities of energy Manager and Accountability, Financial analysis techniques, Financing options, Energy performance contracts and role of ESCOs. Defining monitoring & targeting, Elements of monitoring & targeting, Data and information-analysis, Techniques energy consumption, Production, Cumulative sum of differences.

Energy Efficiency in Electrical system: Electricity billing, Electrical load management and maximum demand Control, Maximum demand controllers; Power factor improvement, Automatic power factor controllers, efficient operation of transformers, Energy efficient transformers; Induction motors efficiency, motor retrofitting, energy efficient motors, Soft starters, Variable speed drives; Performance evaluation of fans and pumps, Flow control strategies and energy conservation opportunities in fans and pumps, Energy efficiency measures in lighting system, Electronic ballast, Occupancy sensors, and Energy efficient lighting controls. Factors affecting selection of DG system, Energy performance assessment of diesel conservation avenues

Energy Conservation in Thermal Systems Types of boilers, Combustion in boilers, Performances evaluation, Feed water treatment, Blow down, Energy conservation opportunities in boiler, Properties of steam, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system, Identifying opportunities for energy savings. Classification, General fuel economy measures in furnaces, Excess air, Heat Distribution, Temperature control, Draft control, Waste heat recovery. Insulation-types and application, Economic thickness of insulation, Heat savings and application criteria. Introduction, Mechanism of fluidized bed combustion, Advantages, Types of FBC boilers, Operational features, Retrofitting FBC system to conventional boilers, saving potential. HVAC system: Coefficient of performance, Capacity, Factors affecting Refrigeration and Air conditioning system performance and savings opportunities. Classification and Advantages of Waste Heat Recovery system, analysis of Waste heat recovery for Energy saving opportunities

Energy Performance Assessment: On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, Fans and pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method. Financial Analysis: simple payback period, NPV, IRR,

Text Books:

1. Handbook of Electrical Installation Practice. , By Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook., By Anil Valia, Lighting System
3. Energy Management Handbook., By W.C. Turner, JohnWiley and Sons
4. Handbook on Energy Audits and Management. Edited by Amit Kumar Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles., By C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook., Dale R. Patrick, Stephen Fardo, Ray E.Richardson,Fairmont Press
7. Handbook of Energy Audits., By Albert Thumann,William J. Younger, Terry Niehus, CRC Press

EP102 Application of Power Electronics in Power Systems

Teaching Scheme : 03 L + 01 T = 04 **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE **Total Marks: 100**
Duration of ESE : 3 Hrs.

Introduction: Steady state and dynamic problems in AC systems- Transmission interconnections- Flow of power in an AC system- Loading capability- Power flow and dynamic stability considerations of a transmission interconnection- Relative importance of controllable parameters.

FACTS Controllers- Basic types of FACTS controllers- Brief description and definitions- Benefits from FACTS technology- HVDC or FACTS.

Static shunt compensators and Static series compensation: Objectives of shunt compensation- Methods of controllable VAR generation- Objectives of series compensation- Variable impedance type series compensation (only TCSC), Switching converter type series compensation (only SSSC) Static voltage and phase angle regulators- Objectives of voltage and phase angle regulators- TCVR and TCPAR, Switching converter based voltage and phase angle regulators.

Load compensation using DSTATCOM- Compensating single phase loads- Ideal three phase shunt compensator structure-Series compensation of power distribution system- Rectifier supported DVR- DC Capacitor supported DVR- Fundamental Frequency series compensator characteristic

Unified Power Quality Conditioner: UPQC configuration-Right shunt UPQC characteristic- Left shunt UPQC characteristic

HVDC: Development of HVDC Technology, DC versus AC Transmission, Selection of Converter Configuration. Rectifier And Inverter Operation, Digital Simulation of Converters, Control of HVDC Converters and Systems, Individual Phase Control, Equidistant Firing Controls, Higher Level Controls.

Text Books

1. Narain G. Hingorani and Laszlo Gyugyi, “Understanding FACTS Concepts and Technology of Flexible AC Transmission Systems,” IEEE Press.
2. Arindam Ghosh and Gerard Ledwich, “ Power Quality Enhancement Using Custom Power Devices,” Kluwer Academic Publishers
3. Roger C. Dugan, Mark F. McGranaghan and H.WayneBeaty “Electrical Power System Quality”, McGraw Hill
4. J. Arrillaga, N.R.Watson and S. Chen “ Power System Quality Assessment,” John Wiley & Sons

5. Yong Hua Song "Flexible AC transmission system" Institution of Electrical Engineers, London
6. Jos Arrillaga and Neville R Watson "Power System Harmonics" Wiley Publications
7. G. T. Heydt , "Electric Power Quality," Stars in a Circle Publications

EP103 Power System Dynamics

Teaching Scheme : 03 L + 01 T = 04 **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE **Total Marks: 100**
Duration of ESE : 3 Hrs.

Review of Classical Methods: System model, states of operation and system security, steady state stability, transient stability, simple representation of excitation control.

Dynamics of Synchronous Generator Connected to Infinite Bus: System model, simplified synchronous machine model, calculation of Initial conditions, system simulation, improved model of synchronous machine, inclusion of SVC model.

Analysis of Single Machine: Small signal analysis, applications of Routh-Hurwitz criterion, analysis of synchronizing and damping torque, state equation for small signal model.

Power System Stabilizers: Basic concepts of control signals in PSS, structure and tuning, field implementation, PSS design and application, future trends.

Multi-machine System: Simplified model, improved model of the system for linear load, Inclusion of dynamics of load and SVC, introduction to analysis of large power system.

Voltage Stability : Definition, factors affecting voltage instability and collapse, analysis and comparison of angle and voltage stability, analysis and comparison voltage instability and collapse, control of voltage instability.

Islanding: Necessity for islanding, methods, use, advantages and disadvantages, implication on power system dynamic performance.

Text Book:

1. K.R. Padiyar, Power System Dynamics- B.S. Publications
2. Kundur, Power System Stability and Dynamics –TMH , New Delhi
3. E.W. Kimbark, Power System Stability –, IEEE press, N.Y, Vol. 3.
4. Anderson & Foud Power System Control and Stability – Vol. – I –, IEEE Press, New York.
5. C. W. Taylor, Power System Voltage Stability –McGraw Hill International student edition

EP104 Elective-I

Teaching Scheme : 03 L + 01 T = 04 **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE **Total Marks: 100**
Duration of ESE : 3 Hrs.

I) Electrical Power Quality

INTRODUCTION: Characterization 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, Nonlinear 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: PQ theory, Synchronous detection method – Custom power park –Status of application of custom power devices.

Text Books:

1. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002.
2. Heydt.G.T, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition)
3. Dugan.R.C, "Electrical Power System Quality", TMH, 2008.
4. Arrillga.A.J and Neville R.Watson, Power System Harmonics, John Wiley second Edition, 2003.
5. Derek A. Paice, "Power electronic converter harmonics", John Wiley & sons, 1999.

II) Processor Application in Power System

Introduction: Review of microprocessor, microcontroller and digital signal processors architecture, Fixed and floating-point processors Number formats and operations: Fixed point 16 bit numbers representations of signed integers and fraction, Floating Point Numbers.

Review of commonly used DSP processors in power electronics applications: introductions toTMS320F2812 and TMS320C2000 processors

DSP Architecture: peripherals and programming Introduction to Digital control using DSP, Overview of TMS320C2000 Digital signal controller family – Features, Architecture, Interrupt and Reset, Memory map - On-chip memories: Flash, RAM, and Boot ROM – External memory Interface. Clock system- Digital I/O -CPU Timers – Analog to Digital Converter (ADC), Pulse Width Modulator (PWM), High Resolution PWM, Capture Module, Quadrature Encoder Pulse Module. Controller Area Network, Serial Communication Interface, Serial Peripheral Interface C and Multi-channel Buffered Serial port. Programming: assembler, linker processes, code structure, Code composer studio, Mathematical tools for Real Time DSP implementation.

Review of numerical integration: Euler's implicit and explicit method, Heun's Method, Trapezoidal Method. Implementation of low pass filter. Review of reference frame transformation theory. Design of controllers for closed loop applications in power electronics: PI, Type II and Type III controllers

DSP Applications in Power Electronics: Speed control of Induction motor, BLDC motor, Digital control of DC/DC converter, LED Lighting. DSP Applications in Power Systems Issues of harmonics and unbalanced currents in power systems, Implementation of Active filters in DSP under balanced and unbalanced condition, harmonic oscillator and 3 phase lock loop, Static VAR Compensator, Hardware in Loop simulations. Design of a DSP controlled Solar PV based Converter/Inverter system:
FPGA- Field Programmable gate Array

Text Books:

1. Power Electronics, Converters, Applications & Design, N.Mohan, T.M.Undeland, W.P. Robbins, Wiley India Pvt.Ltd.
2. Modern Power Electronics and AC Drives, B. K Bose, Perason Education
3. Hamid Toliyat and Steven Campbell, DSP Based Electromechanical Motion Control, CRC Press
4. Sen M. Kuo and Woon-SengGan Digital Signal Processors - Architectures, Implementations, and Applications, Prentice Hall
5. Code Composer Studio v4
6. www.ti.com

III) Power System Optimization

Introduction to Optimization and Classical Optimization Techniques: Single variable optimization, multivariable optimization without constraints, multivariable optimization with equality constraints, multivariable optimization with inequality constraints.

Linear Programming Problem: Standard form, simplex method, big-M method.

Non-Linear Programming Problem: Uni-modal function, elimination methods – unrestricted search, Fibonacci method, direct search method – random and grid search methods, indirect search methods – steepest descent and conjugate gradient method.

Dynamic Programming: Multistage decision process, concept of sub-optimization and principle of optimality, LP as a case of dynamic programming.

Genetic Algorithm: Introduction to genetic algorithm, working principle, coding of variables, fitness function, GA operators, similarities and differences between GA and traditional methods, unconstrained and constrained optimization using GA.

Applications to Power System: Unit commitment problem, economic load scheduling, reactive power optimization, optimal power flow problem, optimum generation planning, network planning by mathematical optimization.

Text Books:

1. Optimization – Theory and Applications, S. S. Rao, Wiley Eastern Ltd.
2. Power System Optimization, D. P. Kothari and J. S. Dhillon, Prentice Hall of India
3. Modern Power System Planning, X. Wang and J. R. McDonald, McGraw Hill Book Company
4. Optimization for Engineering Design – Algorithms and Examples , Kalyanmoy Deb Prentice-Hall of India Private Limited.-2004
5. Operations Research – An Introduction, Hamdi Taha, Pearson Education

EP105 Lab Practice -I

Teaching Scheme : 02 PR **Credit: 02**
Evaluation Scheme : 25 IE +25 EX **Total Marks: 50**

Practical / assignments will be based on courses of Sem- I,

EP201 Advanced power Electronics

Teaching Scheme : 03 L + 01 T = 04 **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE **Total Marks: 100**
Duration of ESE : 3 Hrs.

Overview of Power Semiconductor Devices, DC-DC Converters- Principle of Operation of Buck, Boost, Buck-Boost, flyback, forward, push-pull, half bridge and isolated converters

Input and output filter design, multi output operation of isolated converters

Design of transformers and inductors, modeling of the converters using state averaging techniques

Resonant inverters: DC link inverters, modified circuit topologies for DC link voltage clamping, voltage control-PWM techniques, quasi resonant inverters

DC-DC converters- series resonant and parallel resonant, application of zero voltage and zero current switching for DC-DC converters (buck and boost), inverters for induction heating and UPS

Text Books

1. Mohan N, Undeland T.M., Robbins W. P., Power Electronics, Converters, Applications and Design, John Wiley & Sons, 1995
2. Rashid M. H., Power Electronics, Circuit, Devices and Applications, Prentice-Hall of India, 3rd Edition 2000
3. Lander C. W., Power Electronics, McGraw Hill, 1993
4. Bausier R., Seguier G., Power Electronic Converters, Springer-Verlag, 1987
5. D.M. Mitchell, DC-DC Switching Regulator analysis, TMH, 1987

EP202 Advanced Power System Protection

Teaching Scheme : 03 L + 01 T = 04 **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE **Total Marks: 100**
Duration of ESE : 3 Hrs.

Introduction: Evolution of Digital Relays from Electromechanical Relays, Performance and Operational Characteristics of Digital Protection.

Mathematical Background to Protection Algorithms: Finite Difference Techniques, Interpolation Formulas: Forward, Backward and Central Difference Interpolation, Numerical Differentiation, Curve Fitting and Smoothing, Least Squares Method, Fourier analysis, Fourier series and Fourier Transform, Walsh Function Analysis.

Basic Elements Of Digital Protection: Signal Conditioning: Transducers, Surge Protection, Analog Filtering, Analog Multiplexers, Conversion Subsystem: The Sampling Theorem, Signal Aliasing Error, Sample And Hold Circuits, Multiplexers, Analog To Digital Conversion, Digital Filtering Concepts, The Digital Relay As A Unit Consisting Of Hardware And Software.

Sinusoidal Wave Based Algorithms: Sample and First Derivative (Mann and Morrison) Algorithm. Fourier and Walsh Based Algorithms: Fourier Algorithm: Full Cycle Window Algorithm, Fractional Cycle Window Algorithm. Walsh Function Based Algorithm. Least Squares Based Algorithms. Differential Equation Based Algorithms.

Traveling Wave Based Techniques: Digital Differential Protection of Transformers Digital Line Differential Protection

Recent Advances in Digital Protection of Power Systems

Text Books

1. A.T. Jones and S. K. Salman: Digital Protection of Power System, Peter Peregrinus-IEE-(UK) 1995.
2. Y. G. Paithankar, S.R. Bhide, Fundamentals of Power System Protection, PHI, 2nd edition, 2010.
3. A.G. Phadke and J.S Thorp, 'Computer Relaying for Power systems', Wiley/research studies press, 2009
4. A.G. Phadke and J.S Thorp, 'Synchronized phasor Measurements and their Applications', Spinger 2008.
5. R.G. Lyons,' Understanding Digital Signal Processing', Pearson, 2002.

EP203 Elective-II

Teaching Scheme : 03 L + 01 T = 04 **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE **Total Marks: 100**
Duration of ESE : 3 Hrs.

I) Computer Applications in Power Systems

Introduction: Graph of a power system, incidence matrices, primitive network, formation of network matrices by singular and nonsingular transformation

Representation of power system for computerized analysis: mathematical model of synchronous generator for steady state and transient analysis, transformer with tap changer, transmission line, phase shifter and loads

Algorithm for formation of bus impedance matrix, modification for changes in the network. Incidence and network matrices for three phase network, transformation matrices, algorithm for formation of bus impedance matrix for three phase networks.

Short Circuit Studies: Symmetrical component, short circuit analysis of power systems using bus impedance matrix. Short circuit calculations for balanced and unbalanced faults.

Load Flow Analysis: Types of buses, load flow equations, power flow solution through GS and NR methods, decoupled and fast decoupled methods, sparsity, introduction to AC-DC load flow.

Transient stability Analysis: including synchronous machines, system network and loads, solution of swing equation by Euler's, Euler's modified and RK2 methods.

Economic Load Scheduling: Unit commitment, transmission loss, load scheduling considering transmission losses, unit commitment by dynamic programming method, hydrothermal scheduling.

Text Books

1. Computer Methods in Power System Analysis, G.W. Stagg & A.H.El-Abiad, McGraw Hill
2. Power System Analysis, Hadi Saadat, Tata McGraw Hill
3. Modern Power System Analysis (3rd Edn.), Kothari & Nagrath, TMH.-2004
4. Advanced Power System Analysis and Dynamics, L. P. Singh, WEL-2002.

II) Advanced Electrical Drives

Fundamentals of Electrical Drives: Dynamics of electrical drives, components of load torque,classification of load torque, concept of multi-quadrant operation, steady-state stability criteria.

DC Drives with phase controlled converters: 1-phase fully controlled converter fed separatelyexcited DC motor, modes of operation, steady-state motor performance equations, mode identification, speed-torque characteristics, operation with controlled fly-wheeling; operation with 1-phase half controlled converter; 3-phase fully controlled converter fed separately excited motor; Pulse width modulated rectifiers, equal pulse-width modulation, sinusoidal pulse width modulation; current control; multi-quadrant operation of fully-controlled converter fed DC motor; Dual converters based drives; Closed loop control of DC drives.

DC drives with dc-dc converters: Principle of Motoring operation of separately excited and seriesmotor with DC-DC converter, Steady-state analysis for time ratio control and current limit control; Regenerative braking; Dynamic and composite braking; multi-quadrant operation with dc-dc converters

Fundamental of Induction Motor (IM) and its control: Review of IM: Steady-state analysis of anInduction motor; Starting and Braking methods; Speed control methods: variable terminal voltage, variable frequency control, rotor resistance control, injection of voltage in the rotor circuit; operation with a current source: operation with fixed frequency, variable frequency control.

Control of IM with solid state converters: Control of IM using VSI : Six step inverter, PWMinverter, braking and multi-quadrant control, VVVF control Control of IM using CSI:Three-phase CSI, Braking, PWM in a thyristor CS inverter, PWM with GTO based CSI, Variable frequency drives, Comparison of CSI and VSI based drives. Current controlled PWM inverters:

AC voltage controllers: AC voltage controller circuits, four quadrant control and closed-loopoperation; fan/pump and crane/hoist drives; ac voltage controller starters

Slip power controlled IM drives:analysis of stator rotor resistance control, Static scherbius drive: power factor considerations, rating and applications, performance

Synchronous motor drives: Wound field cylindrical rotor motor, equivalent circuits, operation withconstant voltage and frequency response : motoring and regenerative braking operations, power factor control and V-curves, operation with current source; Wound field salient pole motor; operation with variable voltage source and constant frequency; Starting and braking when fed from constant frequency source; brushless excitation of wound field machines; Permanent magnet motor operating from a fixed frequency source; Operation with non-sinusoidal supplies.

Text Books

1. Power semiconductor controlled drives, Prentice Hall, New Jersey, 1989- G.K. Dubey
2. Fundamentals of Electrical Drives', Narosa, N. Delhi and Toppan Singapore, 1994- G.K. Dubey
3. Modern Power Electronics and AC Drives, Prentice Hall India, New Delhi, 2002- B.K. Bose
4. Power Electronics - circuits, devices and applications, Prentice Hall of India, 2nd ed., 2000- Muhammad H. Rashid
5. Thyristor DC Drives, John Wiley and Sons Ltd., April 1981- P.C. Sen

III) Power System Planning & Reliability

Load Forecasting : Introduction, Factors affecting Load Forecasting, Load Research, Load Growth Characteristics, Classification of Load and Its Characteristics, Load Forecasting Methods - (i) Extrapolation (ii) Co-Relation Techniques, Energy Forecasting, Peak Load Forecasting, Reactive Load Forecasting, Non-Weather sensitive load Forecasting, Weather sensitive load Forecasting, Annual Forecasting, Monthly Forecasting, Total Forecasting.

System Planning : Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.

Reliability : Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost.

Generation Planning and Reliability : Objectives & Factors affecting Generation Planning, Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches), Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods. Interconnected System, Factors Affecting Interconnection under Emergency Assistance

Transmission Planning and Reliability: Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability

Distribution Planning and Reliability: Radial Networks–Introduction, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices. Parallel & Meshed Networks - Introduction, Basic Evaluation Techniques, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Weather Effects, Breaker Failure

Text Books

1. Reliability Evaluation of Power System - Roy Billinton& Ronald N. Allan, Springer Publication
2. Power System Planning - R.L. Sullivan, Tata McGraw Hill Publishing Company Ltd.
3. Modern Power System Planning – X. Wang & J.R. McDonald, McGraw Hill Book Company
4. Electrical Power Distribution Engineering - T. Gönen, McGraw Hill Book Company
5. Generation of Electrical Energy – B.R. Gupta, S. Chand Publications
6. Electrical Power Distribution A.S. Pabla, Tata McGraw Hill Publishing CompanyLtd.
7. Electricity Economics & Planning – T.W.Berrie, Peter Peregrinus Ltd., London

EP204 Elective-III

Teaching Scheme : 03 L + 01 T = 04 **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE **Total Marks: 100**
Duration of ESE : 3 Hrs.

I) AI Techniques to Power System

Introduction to Artificial Intelligence: Introduction, Fuzzy systems, Artificial Neural Network(ANN), Expert Systems, Genetic Algorithm, Evolutionary Programming. Biological neurons: Function of single biological neuron, function of artificial neuron, Basic terminology related to artificial neuron. Characteristics of ANN, Typical applications of ANN such as classification, pattern recognition, forecasting Properties, strength of NN,

Different Architectures of ANN and Learning Processes: Different architectures of Neural Network, types of activation function, concept of Learning with a Teacher, Learning without a Teacher, Learning Tasks (Any two learning methods and applications)

Single Layer Network and Multi-layer Network: Single Layer Perceptron: architecture–training algorithm, Least – Mean square algorithm, learning curves, Learning Rate, Annealing techniques. Feed forward Neural Network(MLP) , Back propagation algorithm. Limitation of Back propagation algorithm. Concept of learning rate, momentum coefficient, Generalization capacity

Fuzzy Mathematics: Basic concept of Fuzzy Logic, Fuzzy set–Basic definition–Membership function, Operations of fuzzy sets.

Fuzzy Theory: Fuzzy relations - Fuzzy graphs - Fuzzy analysis–Propositional logic, predictive logic, Fuzzy set theory.

AI Applications in Power Systems: Application of ANN and Fuzzy logic in Power System Planning, Operation and control – load forecasting, Unit Commitment, Load Dispatch and Protection

Text Books

1. Simon Haykin, "Neural Networks: A Comprehensive Foundation", 2nd Edition, Pearson Education.
2. Zimmermann, H. J., 'Fuzzy Set Theory and Its Applications', 2nd Edition, Kluwer Academic Publishers
3. El Hawaray "Electrical Power Applications with Fuzzy systems", IEEE Press.
4. Power System Optimization- D. P. Kothari, J. S. Dhillon, PHI
5. M.Ganesh,"Introduction to fuzzy sets and fuzzy logic" Prentice Hall India
6. Kelvin Waruicke, Arthur Ekwlle, Raj Agarwal, "AI Techniques in Power System", IEEE London U.K
7. S. Rajsekaram, G. A. Vijayalaxmi Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms

Synthesis & Applications", Practice Hall India
8. S. N. Sivanandam, S. Sumathi, S. N. Deepa, "Introduction to Neural Network Using MATLAB 6.0", Tata McGraw Hill
9. George Klir& Tina. A. Folger, 'Fuzzy Sets, Uncertainty and Information', Prentice Hall of India Pvt. Ltd
10. G. F. Luger and W. A. Stubblefield, Artificial Intelligence. Redwood City, CA: Benjamin Cummings, 1993.

II) Power System Deregulation

Fundamentals of Restructured System: History of power system restructuring, concept of power system deregulation, regulation vs. deregulation, entities in deregulated system, market architecture, ancillary services

Models of Restructuring: Pool Co and bilateral contractual models, ISO based markets models, reactive power balancing market, day ahead and hour ahead markets

Transmission Pricing: Cost components in transmission pricing, embedded cost based transmission-pricing methods, Postage Stamp, MW-Mile, incremental cost based or location marginal pricing (LMP), Tracing of power.

Transmission Open Access Issues: Available Transfer Capability (ATC) - definition and methods of determination, transmission network congestion, congestion management techniques.

Power Sector Restructuring in India: Electricity Act 2003, Evaluation of integrated, monopoly, state owned electricity boards, introduction to various institutions in Indian power sector & their role. Challenges before the Indian power sector, planning commission CEA, NT, PFC, ministry of power, SEBS.

Text Books

1. Electric Utility Planning and regulation – Edward Kahn , University of California- 2005
2. Various Indian Electricity Acts 1). Indian Electricity Act , 1910
3. The Electricity Supply Act , 1998 proposed Electricity Bill 2001
4. Electrical Energy Utilization And Conservation: - S.C. Tripathi(TMH Pub.)-2003
5. http://www.nptel.iitm.ac.in/

III) Advance Control System

Introduction: Review of State Variable Analysis, Controllability and Observability

Digital Control Systems: Models of Digital Control Devices, State Description of Digital Processors and Sampled Continuous Time Plants, Discretisation of Digital Continuous Time State Equations, Solution of State Difference Equation.

Controllability and Observability Tests For Digital Control Systems, Stability of Discrete Time Systems, Pulse Transfer Function and Its Realization, Stability Improvement By State Feedback, Pole-Placement Design And State Observers

Lyapunov Stability Analysis: Basic Concepts, Stability Definitions, Stability Theorems, Lyapunov Functions for Linear and Non Linear Systems

Optimal Control: Parameter Optimization Techniques, Lagrange Parameters Techniques, Calculus Of Variation, Unconstrained And Constrained Minimization Of Functional, Two Point Boundary Value Problems, Pontrygin's Minimum Principle, Optimal Regulator And Tracking Problems, Optimal Digital Control System

Text/ Reference Books

1. M.Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, New Delhi, 1997
2. D.E. Kirk, Optimal Control Theory, Prentice Hall, 1970
3. M.Gopal, Digital Control Engineering, Wiley Eastern, 1988

EP205 Lab Practice -II

Teaching Scheme : 02 PR **Credit: 02**
Evaluation Scheme : 25 IE + 25 EX **Total Marks: 50**
Duration of ESE : 3 Hrs.

Practical's / assignments will be based on courses of Sem - II

EP301 Research Methodology

Teaching Scheme : 03 L + 01 T = 04 **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE **Total Marks: 100**
Duration of ESE : 3 Hrs.

Introduction: Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches , Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India

Defining Research Problem: Introduction, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem

Research Design: Introduction, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, and Basic Principles of Experimental Designs.

Measurement and scaling Technique: Measurement in Research, Measurement Scales, Sources of Error in Measurement, Tests of Sound Measurement, Technique of Developing Measurement Tools, Scaling, Meaning of Scaling, Scale Classification Bases, Important Scaling Techniques, Scale Construction Techniques

Methods of Data Collection and Data Analysis: Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method, Processing Operations , Some Problems in Processing , Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes.

Testing Hypotheses: Basic Concepts Concerning Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses

Interpretation and Report Writing: Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report , Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report.

Text Book

1. Research Methodology : Methods and Techniques , C.R. Kothari , New Age International (P) Limited, Publishers-2004
2. Theories of Engg Experimentation by H.Schank Junior.

EP302 Industrial Training

Teaching Scheme : 02 PR — **Credit: 06**
Evaluation Scheme : 100 IE — **Total Marks: 100**

Industrial training of 15 Days should be in power system related industry. Student should submit the training report and present seminar on industrial training undergone.

EP303 Renewable Energy Systems

Teaching Scheme : 03 L + 01 T = 04 — **Credit: 04**
Evaluation Scheme : 15 IE + 15 ME+70 ESE — **Total Marks: 100**
Duration of ESE : 3 Hrs.

Energy Scenario: Classification of Energy Sources, Energy resources (Conventional and nonconventional), Energy needs of India, and energy consumption patterns. Worldwide Potentials of these sources. Energy efficiency and energy security. Energy and its environmental impacts. Global environmental concern, Kyoto Protocol, Concept of Clean Development Mechanism (CDM) and Prototype Carbon Funds (PCF).Factors favoring and against renewable energy sources.

Solar Energy: Solar thermal Systems: Types of collectors, Collection systems, efficiency calculations, applications. Photo voltaic (PV) technology: Present status, - solar cells , cell technologies, characteristics of PV systems, equivalent circuit, array design , building integrated PV system, its components , sizing and economics. Peak power operation. Standalone and grid interactive systems.

Wind Energy: Wind Energy: wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, Types of Turbine, Turbine rating Choice of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connected operation.

Other energy sources: Biomass–various resources, energy contents, technological advancements, conversion of biomass in other form of energy – solid, liquid and gases. Gasifiers, Biomass fired boilers, Cofiring, Generation from municipal solid waste, Issues in harnessing these sources. Hydro energy – feasibility of small, mini and micro hydel plants scheme layout economics. Tidal and wave energy, Geothermal and Ocean-thermal energy conversion (OTEC) systems – schemes, feasibility and viability.

Energy storage and hybrid system configurations: Energy storage: Battery–types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Fly wheel- energy relations, components, benefits over battery. Fuel Cell energy storage systems. Ultra Capacitors.

Grid Integration : Standalone systems, Hybrid systems–hybrid with diesel, with fuel cell, solar-wind, wind –hydro systems, mode controller, load sharing, system sizing. Hybrid system economics. Grid integration with the system: Interface requirements, Stable operation, Transient-safety, Operating limits of voltage, frequency, stability margin, energy storage, and load scheduling.

Effect on power quality - harmonic distortion, voltage transients and sags, voltage flickers. Dynamic reactive power support. Systems stiffness.

Text Books

1. Renewable energy technologies - R. Ramesh, Narosa Publication.
2. Energy Technology – S. Rao, Parulkar 3.
3. Non-conventional Energy Systems – Mittal, Wheelers Publication.
4. Wind and solar systems by Mukund Patel, CRC Press.
5. Solar Photovoltaics for terrestrials ,Tapan Bhattacharya.
6. Wind Energy Technology – Njenkins, John Wiley & Sons,
7. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern.
8. Solar Energy – S.P. Sukhatme, Tata McGraw Hill.
9. Solar Energy – S. Bandopadhay, Universal Publishing.
10. Guide book for National Certification Examination for EM/EA – Book 1

EP304 Dissertation Phase - I

Teaching Scheme **: 04 PR** **Credit: 10**
Evaluation Scheme **: 100 IE** **Total Marks: 100**

Student has to submit the report and deliver the seminar based on Dissertation topic. It is to be evaluated by three member's panel of examiners headed by HOD wherein guide should be one of the members of the panel. Last date of submission of report shall be one week before the end of semester.

EP401 Dissertation Phase - II

Teaching Scheme **: 06 PR** **Credit: 20**
Evaluation Scheme **: 100 IE+ 200 Ex.** **Total Marks: 300**

Internal assessment of dissertation is to be carried out by the committee constituted by HOD wherein guide should be one of the members. External assessment of Dissertation (complete work) is to be carried out by panel of examiner consisting of internal (guide) and external examiner. Candidate shall present the entire work of Dissertation, followed by viva-voce. Last date of submission of dissertation shall be the end of the semester.