GONDWANA UNIVERSITY, GADCHIROLI

TEACHING AND EXAMINATION SCHEME (SEMESTER PATTERN CHOICE BASED CREDIT SYSTEM)

PROGRAM : MASTER OF TECHNOLOGY IN ELECTRICAL POWER SYSTEM

PROGRAM CODE : EP

FACULTY : ENGINEERING AND TECHNOLOGY

DURATION : TWO YEARS

I- SEMESTER

Unique Subject Code (USC)	Course type	Subject	Teaching Scheme				Examination Scheme									
			Hours per week				Theory						Practical			
			L	Field Work/ Assignment/ Tutorial	P	No. of Credits	Duration of Paper (Hrs.)	Max. Marks			Total	Min. Passing Marks	Max. Marks	Max. Marks	Total	Min. Passing Marks
								ESE	MSE	IE			TW	PE		
PEPS11	**C**	Energy Management and Auditing	3	2	-	3+1	3	70	10	20	**100**	50	-	-	-	-
PEPS12	**C**	Application of Power Electronics in Power System	3	2	-	3+1	3	70	10	20	**100**	50	-	-	-	-
PEPS13	**C**	Power System Dynamics	3	2	-	3+1	3	70	10	20	**100**	50	-	-	-	-
PEPS14x	**P**	Elective – I	3	2	-	3+1	3	70	10	20	**100**	50	-	-	-	-
Laboratories/ Practical																

PEPS15	**C**	Lab Practice – I	-	-	2	1	-	-	-	-	-	-	50	50	**100**	50
PEPS16	**E**	Seminar	-	-	2	1							50	-	**50**	25
TOTAL			12	08	4	18	-	**400**					**150**			
SEMESTER TOTAL			**24**			**18**	**550**									

Elective – I (x) : (A) Electrical Power Quality (B) Processor Applications in Power Systems
(C) Power system Optimization (D) EHV Transmission (E) Switchgear and Protection

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DURATION : TWO YEARS

II– SEMESTER

Unique Subject Code (USC)	Course type	Subject	Teaching Scheme				Examination Scheme									
			Hours per week			No. of Credits	Theory						Practical			
			L	Field Work / Assignment/ Tutorial	P		Duration of Paper (Hrs.)	Max. Marks			Total	Min. Passing Marks	Max. Marks	Max. Marks	Total	Min. Passing Marks
									Sessional							
								ESE	MSE	IE			TW	PEE		
PEPS21	C	Advanced Power Electronics	3	2	-	3+1	3	70	10	20	**100**	50	-	-	-	-
PEPS22	C	Advanced Power System Protection	3	2	-	3+1	3	70	10	20	**100**	50	-	-	-	-
PEPS23	C	Renewable Energy System	3	2		3+1	3	70	10	20	**100**	50				
PEPS24x	P	Elective – II	3	2	-	3+1	3	70	10	20	**100**	50	-	-	-	-
Laboratories/ Practical																

PEPS25	**C**	Lab Practice – II	-	-	2	1	-	-	-	-	-	-	50	50	**100**	50
PEPS26	**E**	Seminar	-	-	2	1							50	-	**50**	25
TOTAL			12	08	4	18	-	**400**					**150**			
SEMESTER TOTAL			**24**			**18**	**550**									

Elective – II (x) : (A) Computer Applications in Power Systems (B) Advanced Electrical Drives

(C) Power System Planning & Reliability (D)High Voltage Engineering (E) Power system Design

GONDWANA UNIVERSITY, GADCHIROLI

TEACHING AND EXAMINATION SCHEME (SEMESTER PATTERN CHOICE BASED CREDIT SYSTEM)

PROGRAM : MASTER OF TECHNOLOGY IN ELECTRICAL POWER SYSTEM

PROGRAM CODE : EP

FACULTY : ENGINEERING AND TECHNOLOGY

DURATION : TWO YEARS

III– SEMESTER

Unique Subject Code (USC)	Course type	Subject	Teaching Scheme				Examination Scheme									
			Hours per week			No. of Credits	Theory						Practical			
			L	Field Work/ Assignment/ Tutorial	P		Duration of Paper (Hrs.)	Max. Marks			Total	Min. Passing Marks	Max. Marks	Max. Marks	Total	Min. Passing Marks
									Sessional							
								ESE	MSE	IE			TW	PEE		
PEPS31	C	Self Study Course	-	8	-	4	3	70	10	20	**100**	50	-	-	-	
PEPS32X	P	Elective III	3	2	-	3+1	3	70	10	20	**100**	50	-	-	-	-
Laboratories/ Practical																
PEPS33	E	Industrial Training	-	5	-	5	-	-	-	-	-	-	150	50	**200**	100
PEPS34	E	Pre-Dissertation	-	6	-	5	-	-	-	-	-	-	100	50	**150**	75
TOTAL			3	21	-	18	-	**200**					**350**			

SEMESTER TOTAL	**24**	**18**	**550**

Elective – III (x) : (A) AI Techniques to Power System (B) Power System Deregulation

(C) Advanced Control System (D)Generation Planning and load dispatch (E) PLC & SCADA

GONDWANA UNIVERSITY, GADCHIROLI

TEACHING AND EXAMINATION SCHEME (SEMESTER PATTERN CHOICE BASED CREDIT SYSTEM)

PROGRAM : MASTER OF TECHNOLOGY IN ELECTRICAL POWER SYSTEM

PROGRAM CODE : EP

FACULTY : ENGINEERING AND TECHNOLOGY

DURATION : TWO YEARS

IV– SEMESTER

Unique Subject Code (USC)	Course type	Subject	Teaching Scheme				Examination Scheme									
			Hours per week			No. of Credits	Theory						Practical			
			L	Field Work/ Assignment/ Tutorial	P		Duration of Paper (Hrs.)	Max. Marks			Total	Min. Passing Marks	Max. Marks	Max. Marks	Total	Min. Passing Marks
								ESE	Sessional MSE	Sessional IE			TW	PEE		
PEPS41	**E**	Final Dissertation	-	24	-	18	-	-	-	-	-	-	150	200	**350**	175
TOTAL			-	24		18	-	**-**				-	**350**			-
SEMESTER TOTAL			**24**			**18**	**350**									

Semester I

Energy Management and Auditing

Subject Code	**: PEPS11**		
Teaching Scheme	**: 03 L + 02 T = 05**	**Credits**	**: 04**
Evaluation Scheme	**: 20 IE + 10 ME+70 ESE**	**Total Marks**	**: 100**
Duration of ESE	**: 3hrs.**		

Unit 1:

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

Unit 2:

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.

Unit 3:

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

Unit 4:

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

Unit 5:

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

Application of Power Electronics in Power Systems

Subject Code	**: PEPS12**		
Teaching Scheme	**: 03 L + 02 T = 05**	**Credits**	**: 04**
Evaluation Scheme	**: 15 IE + 15 ME+70 ESE**	**Total Marks**	**: 100**
Duration of ESE	**: 3hrs.**		

Unit 1:

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.

Unit 2:

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

Unit 3:

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.

Unit 4:

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

Unit 5:

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

Power System Dynamics

Subject Code	**: PEPS13**		
Teaching Scheme	**: 03 L + 02 T = 05**	**Credits**	**: 04**
Evaluation Scheme	**: 15 IE + 15 ME+70 ESE**	**Total Marks**	**: 100**
Duration of ESE	**: 3hrs.**		

Unit 1:
Review of Classical Methods: System model, states of operation and system security, steady state stability, transient stability, simple representation of excitation control.

Unit 2:
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.

Unit 3:
Analysis of Single Machine: Small signal analysis, applications of Routh-Hurwitz criterion, analysis of synchronizing and damping torque, state equation for small signal model.

Unit 4:
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.

Unit 5:
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. Prabha Kundur, Power SystemStability 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

Elective -I

Subject Code	**: PEPS14x**		
Teaching Scheme	**: 03 L + 02 T = 05**	**Credits**	**: 04**
Evaluation Scheme	**: 15 IE + 15 ME+70 ESE**	**Total Marks**	**: 100**
Duration of ESE	**: 3hrs.**		

(A) Electrical Power Quality

Unit 1:
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.

Unit 2:
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.

Unit 3:
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.

Unit 4:
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.

Unit 5:
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. ArindamGhosh "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

(B) Processor Application in Power System

Unit 1:

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.

Unit 2:

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

Unit 3:

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.

Unit 4:

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

Unit 5:

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

(C) Power System Optimization

Unit 1:

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

Unit 2:

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

Unit 3:

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.

Unit 4:

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

Unit 5:

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
Operations Research – An Introduction, Hamdi Taha, Pearson Education

(D) EHV Transmission

Unit 1:

Basic Aspects of A.C. Power Transmission: Power-Handling Capacity and Line Loss, Surface Voltage Gradient on Conductors, Electrostatic Field of EHV Lines. Measurement of Electrostatic Fields. Electromagnetic Interference.

Unit 2:

Traveling Waves and Standing Waves: Line Energization with Trapped - Charge Voltage. Reflection and Refraction of Traveling Waves. Transient Response of Systems with Series and Shunt Lumped Parameters. Principles of Traveling-Wave Protection Lightning & Lightning Protection, Insulation Coordination Based on Lightning

Unit 3:

Over Voltages in EHV Systems: Caused by Switching Operations, Origin of Over Voltages and their Types, Over Voltages Caused by Interruption of Inductive and Capacitive Currents, Ferro-Resonance Over Voltages, Calculation of Switching Surges, Power Frequency Voltage Control and Over Voltages, Power Circle Diagram.

Unit 4:

Reactive Power Flow and Voltage Stability in Power Systems: Steady - State Static Real Power and Reactive Power Stability, Transient Stability, Dynamic Stability. Basic Principles of System Voltage Control. Effect of Transformer Tap Changing in the Post- Disturbance Period, Effect of Generator Excitation Adjustment, Voltage Collapse in EHV Lines, Reactive Power Requirement for Control of Voltage in Long Lines. Voltage Stability

Unit 5:

Power Transfer at Voltage Stability Limit of EHV Lines: Magnitude of Receiving End Voltage at Voltage Stability Limit. Magnitude of Receiving End Voltage During Maximum Power Transfer. Magnitude of Maximum Power Angle at Voltage Stability Limit. Optimal Reactive Power at Voltage Stability Limit

Text Books:

1. A. Chakrabarti, D.P.Kothari, A.K. Mukhopdadhyay ,“Performance, operation & control of EHV

power transmission system " , wheeler publications
2. Rakosh Das Begamudre,"Extra high-voltage A.C. transmission Engineering" New Age International Pvt. Ltd.
3. S. Rao, "EHVAC & HVDC Transmission Engineering & Practice" , Khanna Publications

(E) Switchgear and Protection

Unit 1:
General philosophy of protection - Classification and Characteristic function of various protective relays-basic relay elements and relay terminology - Development of relaying scheme

Unit 2:
Digital Protection of power system apparatus – protection of generators – Transformer protection – magnetizing inrush current – Application and connection of transformer differential relays – transformer over current protection

Unit 3:
Bus bar protection - line protection - distance protection–long EHV line protection – Power line carrier protection

Unit 4:
Reactor protection – Protection of boosters - capacitors in an interconnected power system

Unit 5:
Digital signal processing – digital filtering in protection relays - numeric protection – testing Digital filtering in protection relays – digital data transmission – relay hardware – relay algorithms - Concepts of modern coordinated control system

Text Books:

1. Lewis Blackburn, J., 'Protective Relaying – Principles and Applications', Marcel Dekkar, INC, New York, 2006.
2. The Electricity Training Association, 'Power System Protection Vol1-4', The IEE, U.K., 2005.
3. C. Russeil Mason, 'The art and Science of Protective Relaying', GE Publishers, 1962.
4. A. T. Johns and S. K. Salman, 'Digital Protection for Power Systems', Peter Peregrinus Ltd., 1997.
5. Arun G Padkye and James S Thorp, 'Computer Relaying for Power Systems', John Wiley publications, 2nd Edition, 2009

Lab Practice I

Subject Code	**: PEPS15**		
Teaching Scheme	**: 02 PR**	**Credits**	**: 01**
Evaluation Scheme	**: 50 TW + 50 PEE**	**Total Marks**	**: 100**

Practical will be based on courses of Sem- I,

Seminar

Subject Code	**: PEPS16**		
Teaching Scheme	**: 02 PR**	**Credits**	**: 01**
Evaluation Scheme	**: 50 TW**	**Total Marks**	**: 50**

Students will have to deliver a seminar on any topic based on courses of sem-I

Semester II

Advanced Power Electronics

Subject Code	**: PEPS21**		
Teaching Scheme	**: 03 L + 02 T = 05**	**Credits**	**: 04**
Evaluation Scheme	**: 15 IE + 15 ME+70 ESE**	**Total Marks**	**: 100**
Duration of ESE	**: 3hrs.**		

Unit 1: 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

Unit 2: Input and output filter design, multi output operation of isolated converters

Unit 3: Design of transformers and inductors, modeling of the converters using state averaging techniques

Unit 4: Resonant inverters: DC link inverters, modified circuit topologies for DC link voltage clamping, voltage control-PWM techniques, quasi resonant inverters

Unit 5: 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

Advanced Power System Protection

Subject Code	**: PEPS22**		
Teaching Scheme	**: 03 L + 02 T = 05**	**Credits**	**: 04**
Evaluation Scheme	**: 15 IE + 15 ME+70 ESE**	**Total Marks**	**: 100**
Duration of ESE	**: 3hrs.**		

Unit 1:
Introduction: Evolution of Digital Relays from Electromechanical Relays, Performance and Operational Characteristics of Digital Protection.

Unit 2:
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.

Unit 3:
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.

Unit 4:
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.

Unit 5:
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.

Renewable Energy systems

Subject Code	**: PEPS23**		
Teaching Scheme	**: 03 L + 02 T = 05**	**Credits**	**: 04**
Evaluation Scheme	**: 15 IE + 15 ME+70 ESE**	**Total Marks**	**: 100**
Duration of ESE	**: 3hrs.**		

Unit 1:

Energy Scenario: Role of MNRE, 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, National renewable energy policy for various energy sources, Potential in India.

Unit 2:

Solar Energy: Solar radiation , factors affecting solar radiation, efficiency calculations, fill factor. Photo voltaic (PV) technology: Present status, - solar cells , cell technologies, characteristics of PV systems, equivalent circuit, array design , PV system, components, sizing and economics. Peak power operation. Standalone and grid interactive systems. I, II and IIIgeneration solar cells, solar panel rating, factors influencing the rating of solar panel.

Unit 3:

Wind Energy: Wind Energy: wind speed and power relation, power extracted from wind, TSR, wind speed predictions, system components, Types of Turbine, stall and pitch regulation. Choice of generators, turbine rating, electrical load matching, Variable speed operation, system design features, stand alone and grid connected operation. Schemes for wind electric generation: CSCF,VSCF,VSVF

Unit 4:

Other energy sources: Biomass–various resources, biomass energy conversion overview, 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. Biomass and biogas potential in India, advantages and disadvantages.

Unit 5:

Energy storage and hybrid system configurations: Energy storage: Battery–types, equivalent circuit, performance characteristics, battery design, charging and charge regulators.Battery management. Fuel Cell energy storage systems. Ultra Capacitors. SOC and DOD concept for various types of batteries, solar batteries type, hybrid system : Solar-diesel, solar-wind-hydro schemes, grid interactive inverters.

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. SolarPhotovoltaics 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

Elective II

Subject Code	**: PEPS24x**		
Teaching Scheme	**: 03 L + 02 T = 05**	**Credits**	**: 04**
Evaluation Scheme	**: 15 IE + 15 ME+70 ESE**	**Total Marks**	**: 100**
Duration of ESE	**: 3hrs.**		

(A) Computer Applications in Power Systems

Unit 1:

Introduction: Graph of a power system, incidence matrices, primitive network, formation of network matrices by singular transformation. Representation of power system for computerized analysis: 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.

Unit 3:
Short Circuit Studies: Symmetrical component, short circuit analysis of power systems using bus impedance matrix. Short circuit calculations for balanced and unbalanced faults.

Unit4:
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.

Unit 5:
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.

(B) Advanced Electrical Drives

Unit 1:
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 separately excited 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.

Unit 2:
DC drives with dc-dc converters: Principle of Motoring operation of separately excited and series motor 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

Unit 3:
Control of IM with solid state converters: Control of IM using VSI : Six step inverter, PWM inverter, braking and multi-quadrant control, VVVF control, Control of IM using CSI: Three-phase CSI, Braking, PWM in a thyristors, CS inverter, PWM with GTO based CSI, Variable frequency drives, Comparison of CSI and VSI based drives. Current controlled PWM inverters:

Unit 4:
AC voltage controllers: AC voltage controller circuits, four quadrant control and closed-loop operation; 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

Unit 5:
Synchronous motor drives: Wound field cylindrical rotor motor, equivalent circuits, operation with constant 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

(C) Power System Planning & Reliability

Unit 1:
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.

Unit 2:
System Planning : Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.

Unit 3:
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.

Unit 4:

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

Unit 5:

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

(D) High Voltage Engineering

Unit 1:

Conduction & Break Down in Gases: Ionization Process & Current Growth, Townsends Criterion for Break Down, Determination of Alpha & Gamma, Streamer Theory of Break Down in Gases, Paschen's Law, Breakdown in Non-Uniform Field & Corona Discharge. Conduction & Break Down in Pure Liquid & Commercial Liquid--cavitation mechanism, suspended particle mechanism etc.; Breakdown in Solid Dielectrics-intrinsic, electromechanical, thermal breakdown etc.

Unit 2:

Generation of High Voltage & Currents: Generation of High D. C. Voltages: voltage doubler, voltage multiplier, electrostatic machines etc.; Generation of High Alternating Voltages: cascade circuits, resonating circuits etc. Generation of transient voltages: Single stage and multistage

impulse generator circuits, tripping and synchronization of impulse generator; Generation of switching surge voltages; Generation of Impulse Currents

Unit 3:

Measurement of High Voltages & Currents: Measurement of High Direct Current Voltages, High Alternating Voltages & Impulse Voltages- use of potential dividers, gaps and other methods of measurement; Measurement of High Direct Currents, High Alternating Currents & High Impulse Currents

Unit 4:

Over Voltage Phenomenon & Insulation Coordination: Natural Causes for Over Voltages, Lightning Phenomenon, Over Voltages Due to Switching Surges, System Faults & Other Abnormal Conditions, Principles of Insulation Coordination on High Voltage & Extra High Voltage Power Systems,concept of statistical factor of safety, risk of failure

Unit 5:

High Voltage Testing of Power Apparatus: High voltage testing of bushings, transformers, cables etc. Non-destructive insulation test techniques: High voltage dielectric loss measurements, discharge measurements

Text Books:

1. M. S. Naidu , V. Kamaraju, "High Voltage Engineering" , Tata McGraw –Hill publications
2. E. kuffel, W.S. Zaengl, J. Kuffel, "High Voltage Engineering fundamentals", Butterworth – Heinemann publishers
3. D. kind, K. Feser, "High Voltage Test Techniques", Vieweg/ SBA publications
4. M. Khalifa, "High Voltage Engineering- Theory & Practices", Dekker publications

(E) Power System Design

Unit 1:

Power System Components: Location of Main Generating Stations and Substations, Interconnections, Load Dispatch Centers

Unit 2:

Design of Transmission Lines: Selection of Voltage, Conductor Size, Span, Number of Circuits, Conductor Configurations, Insulation Design, Mechanical Design of Transmission Line, Towers, Sag- Tension Calculations

Unit 3:

Design of EHV Transmission Line: Based Upon Steady State Limits and Transient Over Voltage, Design Factors Under Steady States, Design of 400kV, 1000mW Medium and Long Transmission Line Without and with Series Capacitance Compensation and Shunt Reactors at Both Ends, 750kVLong Transmission Line with Only Shunt Reactors. Extra High Voltage Cable Transmission, Design Basis of Cable Insulation, Search Performance of Cable
Systems, Laying of Power Cables

Unit 4:

Vigorous Solution of Long Transmission Line: Interpretation of Long Line Equations, Ferranti Effect, Tuned Power Lines, Equivalent Circuit of Long Line, Power Flow Thorough Transmission Line and Methods of Voltage Control

Unit 5:

Power System Earthing: Earth Resistance, Tolerable and Actual Step and Touch Voltages, Design of Earthing Grid, Concrete Encased Electrodes, Tower Footing Resistance, Impulse Behavior Earthing System

Text Books

1. M.V. Deshpande, "Electrical Power System Design", Tata McGraw Hill
2. B.R.Gupta, "Power System Analysis and Design", Wheeler Publishing co.
3. I.J.Nagrath& D. P. Kothari, "Power System Engineering", Tata McGraw Hill
4. Rakosh Das Begamudre, "Extra high-voltage A.C. transmission engineering", New Age International Pvt. Ltd.
5**.** S.S.Rao, "EHV AC & HVDC Transmission Engineering & Protection", Khanna Publishers

Lab Practice II

Subject Code	**: PEPS25**		
Teaching Scheme	**: 02 PR**	**Credits**	**: 01**
Evaluation Scheme	**: 50 TW + 50 PEE**	**Total Marks**	**: 100**

Practical will be based on courses of Sem- II,

Seminar

Subject Code	**: PEPS16**		
Teaching Scheme	**: 02 PR**	**Credits**	**: 01**
Evaluation Scheme	**: 50 TW**	**Total Marks**	**: 50**

Students will have to deliver a seminar on any topic based on courses of sem-II

DETAILED EVALUATION PROCEDURE

EXAMINATION	PROCEDURE OF EVALUATION
MSE (MID SEMESTER EXAMINATION) **(10-MARKS)**	The Mid Semester Examination marks shall be awarded by the concerned Subject Teacher on the basis of candidate" s performance in the written examination conducted by the Department. Usually, the MSE" s of two subjects shall be held on the same day. This will be ONE HOUR examination.
(IE) INTERNAL EVALUATION **(20-MARKS)**	The marks allotted for IA shall be awarded by the concerned Subject Teacher on the basis of Candidates performance in: Alertness/ response in the Class (05) Attendance (05) Assignments/ Tutorials (10)
(ESE) END SEMESTER EXAMINATION **(70-MARKS)**	The ESE shall be conducted by the University, as per schedule floated by it, as per its governing rules & regulations. This will be THREE HOURS written examination. The Theory paper of ESE shall comprise of EIGHT questions in all, out which the Candidate shall be required to answer ANY FIVE. All the Questions shall carry equal marks (14).
(TW) TERM WORK	The TERM WORK (TW) shall be there for the practical passing head and other passing Heads, for which theory evaluation is not there. The procedure of evaluation is already mentioned under the syllabus of respective head.
POE (PERFORMANCE & ORAL EXAMINATION)	The POE shall be there for all the passing heads where TW is there. The procedure of evaluation is already mentioned under the syllabus of respective head.