GOVT. COLLEGE OF ENGINEERING, AMRAVATI

CURRICULUM

M.Tech. (ELECTRICAL POWER SYSTEMS)

FULL TIME

Department of Electrical Engineering
2014-15
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Course</th>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory Hrs/week</td>
<td>Tutorial Hrs/week</td>
<td>Practical Hrs/week</td>
</tr>
<tr>
<td>EEP101</td>
<td>Power System Stability and Dynamics</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP107</td>
<td>Digital Protection for Power System</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP108</td>
<td>Computer Methods in Power System Analysis</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP109</td>
<td>Advanced Control Systems</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP104</td>
<td>Elective – I</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP105</td>
<td>Lab Practice - I</td>
<td>--</td>
<td>--</td>
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<tr>
<td>EEP106</td>
<td>Seminar- I</td>
<td>--</td>
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<tr>
<td></td>
<td>Total</td>
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<tr>
<td>EEP208</td>
<td>FACTS</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP209</td>
<td>Advanced Digital Signal Processing</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP203</td>
<td>High voltage Transmission</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP204</td>
<td>Elective – II</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>EEP205</td>
<td>Elective – III</td>
<td>3</td>
<td>1</td>
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<tr>
<td>EEP206</td>
<td>Lab Practice - II</td>
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<tr>
<td>EEP207</td>
<td>Seminar - II</td>
<td>--</td>
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<td>EEP301</td>
<td>Dissertation Phase - I</td>
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<tr>
<td>EEP401</td>
<td>Dissertation Phase - II</td>
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<td>---</td>
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</tr>
</tbody>
</table>

Duration of ESE for all courses is 2 Hrs. 30 Min.

TA: Teacher Assessment  CT: Class Tests  ESE: End Sem. Examination
### LIST OF ELECTIVES

<table>
<thead>
<tr>
<th>Elective - I - EEP104</th>
<th>Elective II - EEP204</th>
<th>Elective - III - EEP205</th>
</tr>
</thead>
<tbody>
<tr>
<td>F) AI TECHNIQUES IN POWER SYSTEMS</td>
<td>F) EMBEDDED SYSTEMS</td>
<td>F) DESIGN AND TESTING OF HIGH VOLTAGE APPARATUS</td>
</tr>
<tr>
<td>G) RENEWABLE POWER SYSTEMS</td>
<td>G) ADVANCED DRIVES</td>
<td>G) DIGITAL INSTRUMENTATION</td>
</tr>
<tr>
<td>H) POWER SYSTEM OPTIMIZATION</td>
<td>H) SMART GRID AND DISTRIBUTED GENERATION</td>
<td>H) POWER SYSTEM RESTRUCTURING AND Deregulation</td>
</tr>
<tr>
<td>I) ELECTRICAL MACHINES- MODELLING AND ANALYSIS</td>
<td>I) STATISTICAL SIGNAL PROCESSING</td>
<td>I) ROBOTICS AND AUTOMATION</td>
</tr>
<tr>
<td>J) POWER QUALITY</td>
<td>J) POWER SYSTEM RELIABILITY</td>
<td>J) ENERGY MANAGEMENT AND ENERGY AUDIT</td>
</tr>
</tbody>
</table>

**Note:**

i) The courses of old scheme shall be offered during academic year (2014-2015) including summer term for backlogger students

ii) In the academic year 2015-2016 and onwards, all students shall register for courses as per revised curriculum (New Scheme)
EEP101 POWER SYSTEM STABILITY AND DYNAMICS

Teaching Scheme : 03 L + 01 T  Total  04  Credit : 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE  Total Marks :100
Duration of ESE : 2 Hrs.30 min.


Large disturbance Stability: System of one machine connected against infinite bus, classical model, and equal area criteria technique and its applications, precalculated swing curve, Evaluation and simulation

Small disturbance Stability: Two-machine system with and without losses, techniques for S.S.S.limit, effect of inertia, saliency, saturation, governor action and SCR on SS power limit.

Excitation System: Effect of excitation system on generator power limit, transformation model of excitation system, dynamic stability, Routh’s criteria for dynamic stability, self excited electro-mechanical oscillations in Power System, power system stabilizer


Prime mover controllers: Control of Voltage, frequency, SCADA for stability, tie line power flow, emergency control techniques for stability. Application of energy functions for direct stability evaluation

References
5. http://www.nptel.iitm.ac.in/  
6. www.ocw.mit.edu
EEP107 DIGITAL PROTECTION FOR POWER SYSTEM

Teaching Scheme: 03 L + 01 T Total 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE Total Marks :100
Duration of ESE : 2 Hrs.30 min.


Basic elements of digital protection: Basic components of digital relay, signal conditioning subsystems, conversion subsystems, digital relay subsystem, digital relay as a unit.

Sinusoidal wave based algorithms: Sample and first derivative method, first and second derivative method, two sample technique.

Fourier Analysis and Walsh Function Based Techniques: Full cycle window, fractional cycle window and Fourier and discrete fourier transform based algorithms. Walsh function based algorithm.

Least Squares Based Methods: Integral LSQ, power series LSQ and multi-variable series LSQ techniques.

Differential Equation Based Techniques: Differential equation protection with selected limits, simultaneous differential equation technique.

Transmission Line Relaying: Sources of error, relaying as parameter estimation, symmetrical component distance relay, protection of series compensated transmission lines, digital line differential protection. Carrier current protection – phase comparison relaying, carrier aided distance protection, Frequency based relaying


Digital Protection of Machines and Buses: Generator protection, motor protection, digital bus protection.

References
7. www.ocw.mit.edu
8. http://www.nptel.iitm.ac.in/
EEP108 COMPUTER METHODS IN POWER SYSTEM ANALYSIS

Teaching Scheme : 03 L + 01 T   Total 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA + 60 ESE   Total Marks :100
Duration of ESE : 2 Hrs.30 min.

Introduction: Graph of a power system, incidence matrices, primitive network, formation of network matrices by singular and non singular 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, numerical solution of swing equation – Point-by-Point method, Euler’s method, Euler’s modified method and Runge-Kutta second order method.

Voltage Stability Analysis: Basic concepts, mathematical formulation – PV curves and QV curves, dynamic analysis, static analysis – V-Q sensitivity analysis and Q-V modal analysis.

References
2. Computer Techniques in Power System Analysis, M.A. Pai, TMH
EEP109 ADVANCED CONTROL SYSTEMS

Teaching Scheme : 03 L + 01 T  Total 04  Credit : 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE  Total Marks :100
Duration of ESE : 2 Hrs.30 min.

Sampled data systems : Sampling and reconstruction, Pulse response, Pulse transfer function, Block diagram analysis, $z$- domain equivalents to $s$- domain compensators, stability analysis, systems with dead time

Transform design of digital controls : Design specifications, Design on w- plane, Digital PID controller, Design on z – plane, Multivariable controllers

State space analysis of sampled data systems : Discrete time state equation, Similarity transformations, Cayley Hamilton theorem, Realization of pulse transfer function, state equations for sampled data systems, concepts of controllability and observability Lyapunov stability analysis

Digital control design using state space : Formulation of optimal control problem, Optimal state regulator, Eigen value assignment by state feedback, state observers.

References

5. Digital Control, Kannan Moudgalya, Wiley Publication
EEP104 ELECTIVE-I
F) AI TECHNIQUES IN POWER SYSTEMS

Teaching Scheme: 03 L + 01 T  Total  04  Credit : 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE  Total Marks :100
Duration of ESE  : 2 Hrs.30 min.


Application of ANN to Short-term Load Forecasting: An ANN approach to the Diagnosis of Transformer Faults, Real-Time Frequency and Harmonic Evaluation using ANN.


References

1. Intelligent System Applications in Power Engineering by Loi Lei Lai John Wiley Publication-2004
5.  http://www.nptel.iitm.ac.in/
6. www.ocw.mit.edu


References
2. Siegfried Heier, Rachel Waddington Grid Integration of Wind Energy Conversion Systems, Wiley publications
ELECTIVE-I

H) POWER SYSTEM OPTIMIZATION

Teaching Scheme: 03 L + 01 T Total 04 Credit: 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE Total Marks: 100
Duration of ESE: 2 Hrs.30 min.

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, Two-phase simplex method, Duality in LP, Transportation problem

Non-Linear Programming Problem: Unimodal 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, Recursive relationship

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 coordination of relays, optimal network planning

References
2. Power System Optimization, D. P. Kothari and J. S. Dhillon, Prentice Hall of India
EEP104 ELECTIVE-I
I) ELECTRICAL MACHINES MODELLING AND ANALYSIS

Teaching Scheme: 03 L + 01 T  Total 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE  Total Marks :100
Duration of ESE : 2 Hrs.30 min.


Reference-frame theory: Equations of transformation, Commonly used reference frames, Transformation between reference frames, Variables observed from several frames of reference, Park’s transformation.

Symmetrical Induction Machines: Voltage and torque equations in machine variables and in arbitrary reference-frame variables, Analysis of steady-state operation.

Synchronous Machines: Voltage and torque equations in machine variables, Stator voltage equations in arbitrary reference-frame variables, Torque equations in substitute variables, Analysis of steady-state operation.

References

Introduction, terms and definitions, general classes of power quality problems power quality terms.

Voltage sags and interruptions, sources of sag and interruptions, estimating voltage sag performance, fundamental principles of protection, solution at the end-user level motor –starting saga, Transient over voltages, sources of transient over voltages, principles of over voltage protection devices for over voltage protection utility, capacitor-switching transients, utility system, lightning protection, managing ferro-resonance switching transient problems with loads, computer tools for transients analysis

Fundamentals of harmonics, harmonic distortion, voltage versus current distortion, harmonics versus transients, harmonic indexes, harmonic sources from commercial loads, harmonic sources from industrial loads, locating harmonic sources, effects of harmonic distortion, inter-harmonics-harmonic distortion, evaluations principles for controlling harmonics, harmonic filter design: a case study - standards of harmonics

Long-duration voltage variations, principles of regulating the voltage devices for voltage regulation utility, voltage regulator, application capacitors for voltage regulation, end-users capacitors application regulating utility voltage with distributed resources flicker Power quality monitoring, monitoring considerations, historical perspective of power quality, measuring instruments, power quality measurement equipment, assessment of power quality measurement, data application of intelligent systems, power quality monitoring standards

References

3. Power Quality C.Sankaran CRC Press
Minimum two simulation / performance type experiments on each course in the current semester should be performed. Respective Course Coordinators shall submit all details of experiments based on concerned course to the Course Coordinator of this course at the beginning of semester.

Note:

ICA - Internal Continuous Assessment shall be based on the practical record and knowledge/skills acquired. The performance shall assess experiment wise by using continuous assessment formats, A and B.

ESE - The End Semester Exam for practical shall be based on performance in one of experiments and may be followed by sample questions.

Seminar on any technical subject other than above syllabus
Steady state and dynamics problems in AC systems, Flexible AC transmission systems (FACTS), principles of series shunt compensation, static var compensation (SVC), thyristor controlled series compensation (TCSC), static phase shifter (SPS), static condenser (STATCON), static synchronous series compensator (SSSC) and unified power flow controller (UPFC), modeling and analysis of FACTS controllers, control strategies to improve system stability.

References

5. http://www.nptel.iitm.ac.in/
6. www.ocw.mit.edu
Signals and Signal Processing: Characterization and classification of signals, Typical signal processing operations, Typical signal processing applications, Advantages of digital signal processing

Time Domain Representations of Signals and Systems: Discrete time signals Operations on sequences, Discrete time systems Linear time invariant discrete time systems, Characterization of LTI systems

Transform domain representation of signals and systems: The discrete time Fourier transform, The frequency response, The transfer function, Discrete Fourier series, Discrete Fourier transform, Computation of DFT, Linear convolution using DFT, The z-transform, The region of convergence of z-transform

Structures for discrete time systems: Block diagram and signal flow representation of constant coefficient, linear difference equation, Basic structures for IIR systems, Basic structures for FIR systems, Lattice structures, Effects of coefficient quantization, Effect of round off noise in digital filters, Zero-input limit cycles

Filter Design Techniques: Design of discrete time IIR filters from continuous time filters, Design of FIR filters by windowing, Optimum approximation of FIR filters, Linear phase filters

Sampling of continuous time signals: Periodic sampling, Frequency domain representation of sampling, Reconstruction of bandlimited signal from its samples, Discrete time processing of continuous time signals, Continuous time processing of discrete time signals, Changing the sampling rate using discrete time processing

References
3. Analog and Digital Signal Processing, Ashok Ambardar; Thomson Learning 2007
4. http://www.nptel.iitm.ac.in/
5. www.ocw.mit.edu
Extra High Voltage AC Transmission: Introduction to EHV-AC transmission, transmission line trends & preliminary aspects, standard transmission voltages-power handling capacities and line losses-mechanical aspects
Electrostatic field of EHV lines: electric shock & threshold currents, capacitance of long object, Effect of Electrostatic field on Human, Animal & Plants
Lightning: Lightning strokes, Mathematical model to represent lightning, Lightening stroke to tower and mid span, Insulation coordination based on lightning
Traveling waves in transmission lines: Circuits with distributed constants, Wave equations, Reflection and refraction of traveling waves, Traveling waves at different line terminations, Effect of short length of cables, Shape and attenuation and distortion of traveling waves, Selection of typical wave to represent over voltages, Lattice diagram
High Voltage DC Transmission: DC Power Transmission Technology: Introduction, comparison of AC & DC Transmission, application of DC transmission, Description of DC transmission systems, planning & modern trends
Analysis of HVDC Converters: 3-pulse, 6-pulse,12-pulse converters, converters station and terminal equipment, commutation process, rectifier & inverter operation, equivalent circuit for converters, simplified analysis of Graetz circuit Control of Converters
HVDC System Control: Firing angle control, Current and extinction angle control, starting and stopping of DC link, power control, higher level Controllers, Converter faults and protection: Introduction, Converter faults, protection against over current, over voltage in a converter station, surge arrestors. Smoothing reactor, Harmonics and filters
Multi Terminal DC Systems: Potential applications of MTDC systems, types of system, operation & control and protection of MTDC systems. Parallel operation of HVDC and HVAC

References
1. Extra High Voltage AC Transmission Engineering, Rakosh Das Begamudre, New Age International(P) Ltd. 2003
2. HVDC Transmission, K.R.Padiyar, Wiely Eastern Ltd; New Delhi,1999
Introduction to embedded systems, Background and History of Embedded Systems, definition and Classification, Programming languages for embedded systems: desirable characteristics of programming languages for embedded systems, low-level versus high-level languages, main language implementation issues: control, typing, exception handling, modularity and multi-threading. Major programming languages for embedded systems. Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits.

Processor and Memory Organization: Structural units in processor, Processor selection for an embedded system, Memory devices, Memory selection, Allocation for memory to program segments and blocks and memory map of a system, DMA, Interfacing processor. I/O Devices - Device I/O Types and Examples – Synchronous - Iso-synchronous and Asynchronous Communications from Serial Devices - Examples of Internal Serial-Communication Devices - UART and HDLC – Parallel Port Devices - Sophisticated interfacing features in Devices/Ports- Timer and Counting Device

Device Drivers and Interrupts Servicing Mechanism: Device driver, parallel port device driver in a system, serial port device driver in a system, device driver for internal programmable timing devices. Interrupt servicing (handling) Mechanism, Context and the period for context switching. Deadline and interrupt latency.

Real Time Operating Systems: RTOS Task scheduling models - Handling of task scheduling and latency and deadlines as performance metrics – Co-operative Round Robin Scheduling – Cyclic Scheduling with Time Slicing (Rate Monotonic Co-operative Scheduling) – Preemptive Scheduling Model strategy by a Scheduler – Critical Section Service by a Preemptive Scheduler – Fixed (Static)

Software Engineering Practice in the Embedded Systems: Software analysis design, implementation, testing, validation and debugging of embedded systems.

References

2. Embedded Software primer by David Simon Pearson Education-2005
4. http://www.nptel.iitm.ac.in/
5. www.ocw.mit.edu
Review of Electric Drives: Classification, Comparison of AC and DC drives, Basic elements, Torque equation, Multi-quadrant operation, Equivalent values of drive parameters, components of load torque, Stability consideration, closed loop control of drives, Thermal model of motor for Heating and Cooling, Classes of Duty.

DC Drives: Half controlled, full controlled and dual converter based separately excited dc motor drives and their analysis. Effect of source and load inductance. DC-DC converter (Chopper) fed dc series motor drives and its steady state analysis.


Special Topics: Measures of energy conservation in electrical drives, Introduction to the fundamental principles of torque controlled and sensor less drives, Vector controlled and Direct torque controlled induction motor drives.

References

11. http://www.nptel.iitm.ac.in/
12. www.ocw.mit.edu
Basics of Power Systems:
Load and Generation, Power Flow Analysis, Economic Dispatch and Unit Commitment Problems

Smart Grid:
Definition, Applications, Government and Industry, Standardization

Smart Grid Communications:
Two-way Digital Communications Paradigm, Network Architectures, IP-based Systems, Power Line Communications, Advanced Metering Infrastructure

Demand Response
Definition, Applications, and State-of-the Art, Pricing and Energy Consumption Scheduling, Controllable Load Models, Dynamics, and Challenges, Electric Vehicles and Vehicle-to-Grid Systems, Demand Side Ancillary Services

Wide Area Measurement:
Sensor Networks, Phasor Measurement Units, Communications Infrastructure, Fault Detection and Self-Healing Systems, Applications and Challenges

Security and Privacy:
Cyber Security Challenges in Smart Grid, Load Altering Attacks, False Data Injection Attacks, Defense Mechanisms, Privacy Challenges

Economics and Market Operations
Energy and Reserve Markets, Market Power, Generation Firms, Locational Marginal Prices, Financial Transmission Rights

References
SMART GRID: Technology and Applications By Janaka Ekanayake, Kithsiri Liyanage, Akihiko Yokoyama, and Nick Jenkins, Wiley Publisher, 2012

The students will also need to read several recent papers in the field of smart grid, e.g., in the IEEE Transactions on Smart Grid, the IEEE Innovative Smart Grid Technologies Conference, and the IEEE Conference on Smart Grid Communications.
EEP204 ELECTIVE-II

I) STATISTICAL SIGNAL PROCESSING

Teaching Scheme : 03 L + 01 T Total 04

Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE Total Marks :100

Duration of ESE : 2 Hrs.30 min.

**Probability:** Definition of set, set operations, probability introduction using sets and relative frequency, joint and conditional probability, total probability, Bayes Theorem, independent events, combined experiments, Bernoulli trials.

**The Random Variable:** The random variable concept, the definition of random variable, conditions for a function to be a random variable, discrete and continuous random variable, mixed random variable, distribution function, density function, properties of density function, the Gaussian random variable, other distribution and density examples, binomial, Poisson, exponential, Rayleigh, conditional distribution and density functions.

**Multiple Random Variables:** vector random variables, joint distributions and its properties, joint density and its properties, conditional distributions and density, statistical independence, central limit theorem.

**Operations On Random Variables:** Expectations, moments, functions that give moments, transformation of random variables, computer generation of one random variable, expected value of function of a random variable, jointly Gaussian random variable, sampling and some limit theorems.

**Random Processes:** Concept of random process, stationarity and independence, correlation functions, measurement of correlation functions, Gaussian random process, Poisson random process, power spectral density, relation between power spectral density and autocorrelation function.

**Linear Systems With Random Inputs:** Linear system response to random signals, system evaluation using random noise, spectral characteristics of system response, noise bandwidth, bandpass band limited and narrow/band processes, sampling of processes, discrete time systems, modeling of noise sources, incremental modeling of noisy networks, systems that maximize signal to noise ratio, systems that minimize mean squared error, some practical applications.

**Optimum Linear Systems:**
Systems that maximize signal-noise ratio, systems that minimize mean squared error, Weiner filters, optimization by parameter selection

**References**
1. Probability, Random variables and random signal principles 4/e, Peyton Z. Peebles TMH, 2001
3. [http://www.nptel.iitm.ac.in/](http://www.nptel.iitm.ac.in/)
4. [www.ocw.mit.edu](http://www.ocw.mit.edu)
EEP204 ELECTIVE-II

J) POWER SYSTEM RELIABILITY

Teaching Scheme : 03 L + 01 T  Total 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE  Total Marks :100
Duration of ESE : 2 Hrs.30 min.

Probability and Reliability: Review of probability concepts, probability distributions, applications of binomial distribution to engineering problems, probability distribution in reliability evaluation, reliability indices, network modeling and evaluation of simple and complex networks, system reliability evaluation using probability distributions, frequency and load duration techniques, key indices of power system reliability and their calculations.

Generation System Reliability Evaluation: Concept of loss of load probability (LOLP), Energy demand, E(DNS), Evaluation of these indices for isolated systems, generation system, reliability analysis using the frequency and duration techniques.

Transmission System Reliability Evaluation: Evaluation of LOLP and E(DNS), indices for an isolated transmission system, interconnected system reliability, bulk power system reliability.

Distribution System Reliability Evaluation: Reliability analysis of radial systems with perfect and imperfect switching.

References
1. Power System Reliability Calculatio , Billinton R TMH,2001
3. http://www.nptel.iitm.ac.in/
4. www.ocw.mit.edu
EEP205 ELECTIVE-III

F) DESIGN AND TESTING OF HIGH VOLTAGE APPARATUS

Teaching Scheme : 03 L + 01 T    Total 04    Credit : 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA + 60 ESE    Total Marks :100
Duration of ESE : 2 Hrs.30 min.

Insulation Coordination for AC Transmission and Distribution System
Classification of dielectric stress, voltage time characteristics, factors affecting the switching over voltages, Methods of controlling the switching surges, factors affecting lightning over voltages entering the substation, methods of controlling the lightning over voltages. Lightning Phenomenon, Physics of Lightning, Lightning termination at ground, Risk factors and protection

Applications of gaseous insulants
Atmospheric air clearance, Switchgear, GIS and system modelling

High Voltage Cables
The components of electric power cables, Design features, manufacturing process and materials, Testing

Gas filled interrupters
Principle of current interrupters in HV Systems, Arc control and extinction, other forms of interrupters

Switchgear design, development and systems
SF₆ Live and dead-tank circuit-breakers, closing resistors/metal-oxide arrestors, Disconnector switching, Ferroresonance, System monitoring

High Voltage Bushing
Types of bushings, Bushing design, bushing applications, Testing

HV Transformer requirements, specifications and testings
User requirements, specifications and standards, Testings

Partial Discharge measuring techniques
Physical background of Partial discharge, calibration of partial discharge measurement systems, partial discharge measurements on HV Transformers, HV Cables, and HV GIS

References
Introduction to Computer aided instrumentation, PC architecture and general structure of PC based instrumentation

Buses and Standards: BUS types, the I/O BUS, ISA bus, EISA Bus, PCI bus, GPIB, RS-232

Interfacing Using C/ VB: C/VB as an interfacing language, Small routines for interfacing, Graphics designing through C/VB, File generation for data storage, Data acquisition through C/VB, Real time interfacing and display, Software compensation techniques

Interfacing Cards for Process Control: Introduction, Block diagram description, Installation, Application areas of Digital input-output card PCL – 225, Opto Input-Output card

High performance analog Data acquisition card with DIO and Timer/Counter, Application Area: Transient Analysis, Event triggering, Industrial measurements, Process control

Port Interfacing Techniques: introduction, working as input/output port, programming of Parallel Port, Serial Port, USB Port

Case Study: Power plant controller, Cement plant control, Sugar plant control, Textile plant control

References
2. See also accompanying Laboratory Manual by Same title: ISBN 0 –13 – 339797-1 120
4. Measurement and Instrumentation by AK Sawhney, Dhanpat Rai and Sons, New Delhi
EEP205 ELECTIVE-III
H) POWER SYSTEM RESTRUCTURING AND DEREGULATION
Teaching Scheme : 03 L + 01 T Total 04 Credit : 04
Marking Scheme: 15 CT1 + 15 CT2 +10 TA+ 60 ESE Total Marks :100
Duration of ESE : 2 Hrs.30 min.

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: PoolCo 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.

International Scenario

References

1. Electric Utility Planning and regulation – Edward Kahn , University of California- 2005
4. http://www.nptel.iitm.ac.in/
5. www.ocw.mit.edu
EEP205 ELECTIVE-III
I) ROBOTICS AND AUTOMATION

Teaching Scheme: 03 L + 01 T Total 04
Marking Scheme: 15 CT1 + 15 CT2 + 10 TA + 60 ESE Total Marks: 100
Duration of ESE: 2 Hrs. 30 min.


Manipulator Kinematics and Mechanics of Robot Motion: Link coordinate frames, Denavit- Hartenberg convention, Joint and end-effectors, Cartesian space, Forward kinematics transformations of position, Inverse kinematics of position, Translational and rotational velocities, Velocity Transformations. Manipulator Jacobian. Forward and inverse kinematics of velocity, Singularities of robot motion, Static Forces, Transformations of velocities and static forces, Joint and End Effectors force/torque transformations.

Manipulator Dynamics: Trajectory Planning, Control. Lagrangian formulation, Model properties, Newton-Euler equations of motion, Joint-based motion planning, Cartesian-based path planning. Independent joint control, Feed-forward control, Inverse dynamics control, Robot controller architectures, Implementation problems.


References
3. http://www.nptel.iitm.ac.in/
4. www.ocw.mit.edu
**EEP205 ELECTIVE-III**

**J) ENERGY MANAGEMENT AND ENERGY AUDIT**

**Teaching Scheme:** 03 L + 01 T  Total 04  
**Credit :** 04  
**Marking Scheme:** 15 CT1 + 15 CT2 +10 TA+ 60 ESE  
**Total Marks :** 100  
**Duration of ESE :** 2 Hrs.30 min.

Energy Scenario: Primary energy resources, Commercial and Non-commercial energy, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment.

Energy management : Definition, significance and objectives of energy management, principle of energy management , sectors of supply side management , Energy and economy, electricity tariff, load management and maximum demand control, power factor improvement, selection and location of capacitors ,optimizing the input energy requirements, fuel and energy substitution

Energy strategies and energy planning: Energy Action Planning: Key elements, force field analysis, Energy policy purpose, Energy planning flow for supply side, essential data for supply side energy planning, roles and responsibilities of energy manager,

Energy Audit: Definition, need of energy audit, types of energy audit, intermediate and comprehensive energy audit, end use of energy consumption profile, procedure of energy auditing, site testing and measurement. Energy security, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, energy audit instruments, Energy Conservation Act-2001

Energy Conservation and Recycling: Energy conservation and its importance, Listing of energy conservation opportunities (ECOs ),Electrical ECOs, ECOs in process industry, small industries building and shopping complexes , waste management , Recycling of discarded materials and energy recycling

Energy Monitoring and Targeting: Defining monitoring and targeting, elements of monitoring and targeting, data and information-analysis, On line energy monitoring: Various aspects and techniques of on line energy monitoring, Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams. Financial analysis techniques-simple pay back period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis, financing options, energy performance contracts .

References
2. Introduction to energy technologies – V.A.Venikov ,E.V.Putiatin , Mir, Moskow -2006
EEP206 LAB-II

Teaching Scheme: 08 P + 00 Total 08
Marking Scheme: 50 Internal + 50 External
Credit: 04
Total Marks: 100

Minimum two simulation / performance type experiments on each course in the current semester should be performed. Respective Course Coordinators shall submit all details of experiments based on concerned course to the Course Coordinator of this course at the beginning of semester.

Note:
ICA - Internal Continuous Assessment shall be based on the practical record and knowledge /skills acquired. The performance shall assess experiment wise by using continuous assessment formats, A and B.

ESE - The End Semester Exam for practical shall be based on performance in one of experiments and may be followed by sample questions.

EEP207 SEMINAR II

Teaching Scheme: 02 P + 00 Total 02
Marking Scheme: 25 Internal
Credit: 01
Total Marks: 25

Seminar on any technical subject other than above syllabus
SEMESTER III

EEP301 DISSERTATION PHASE I

Teaching Scheme : 08 P + 00    Total 08
Evaluation Scheme : 100 Internal    Total Marks: 100
Credit: 10

Dissertation topic selection and seminar on scope & plan of the work
Student has to submit the report and deliver the seminar based on state of the art, literature survey, problem definition and preliminary work. It is to be evaluated & approved internally 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 two weeks before the end of semester.

SEMESTER IV

EEP401 DISSERTATION PHASE II

Teaching Scheme : 08 P + 00    Total 08
Evaluation Scheme : 100 Internal +200 External    Total Marks :300
Credit : 30

Final dissertation and final seminar on complete work

Dissertation (Phase-II): Internal assessment of dissertation (complete work) is to be carried out by the guide for 100 Marks. External assessment of Dissertation (complete work) is to be carried out by panel of examiner consisting of internal (guide) and external examiner for 200 marks. Candidate shall present the entire work on Dissertation, followed by viva-voce. Please see Appendix-C of Rules & Regulation for Further information.