Structure and syllabus

Of

M. Tech.(Electrical Power Systems)

With effect from July 2017

Program Educational Objectives:

1. To prepare graduates meet the challenges of modern society through viable engineering solutions.
2. To prepare graduates to develop economically viable cutting edge technology for local industry. Need.
3. To prepare graduates to inspire next generation graduates as successful engineer/ entrepreneur, scientist and researcher.

Program Outcomes:

1. Ability to apply knowledge of science, mathematics, and engineering principles for solving problems.
2. Ability to identify, formulate and solve electrical power system problems
3. Ability to understand and use different software tools in the domain of Power electronics, power system and control system simulations.
4. Ability to design and conduct experiments and analyze and interpret data.
5. Ability to coherently work in a multidisciplinary team.
6. Demonstrate sensitivity towards professional and ethical responsibility.
7. Ability to communicate effectively in writing as well as through public speaking.
8. Demonstrate ability to appreciate and engage in lifelong learning.
9. Demonstrated knowledge of contemporary issues.
10. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
11. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

Proposed Teaching & Examination schemes for M. Tech. (Electrical Power Systems) W.E.F. July 2017.

Semester I

Subject Code	Subject	Teaching scheme			Credits	Examination scheme				
						Theory		CA	PR/ OR	Total
		L	P	T		TH	Test			
MTEPS101	Power System Modeling	03	0	1	04	60	20	20	--	100
MTEPS102	Renewable Energy Systems	03	0	1	04	60	20	20	--	100
MTEPS103	Advanced Power Electronics	03	0	1	04	60	20	20	--	100
MTEPS104	Elective-I	03	0	0	03	60	20	20	--	100
MTEPS105	Elective-II	03	0	0	03	60	20	20	-	100
MTBS106	Communication Skill	02	-	-	02	-	-	25	25	50
MTEPS107	Power system Lab-I	-	3	-	02	-	-	25	25	50
	Total	17	3	03	22	300	100	150	50	600

Elective-1 MTEPS104

1) **High Voltage Power Transmission.**
2) **Advanced Topics in Power System.**
3) **Electrical Transients in Power System**

Elective-II. MTEPS105

1) **Power System Planning and Reliability.**
2) **Power Quality Assessment and Mitigation.**
3) **Advance Control System.**

Semester-II

Subject Code	Subject	Teaching scheme			Credits	Examination scheme				
						Theory		CA	PR/ OR	Total
		L	P	T		TH	Test			
MTEPS201	Power System Dynamics and Control	03	0	1	04	60	20	20	--	100
MTEPS202	Advance Power System Protection	03	0	1	04	60	20	20	--	100
MTEPS203	Elective-III (Departmental)	03	0	0	03	60	20	20	--	100
MTEPS204	Elective-IV (Departmental)	03	0	0	03	60	20	20	--	100
MTEPS205	Elective-V(Open)	03	0	0	03	60	20	20	-	100
MTEPS206	Seminar-I	-	4	-	02	-	-	50	50	100
MTEPS207	Power System Lab-II/ Mini Project	-	4	0	02	-	-	50	50	100
	Total	15	8	02	21	300	100	200	100	700

Elective-III. MTEPS203

1) **Power Sector Economics Restructuring & Regulation**
2) **Smart Grid Design and Analysis**
3) **Distributed generation and micro grid.**

Elective-IV. MTEPS204

1) **Application of Power Electronics to Power System.**
2) **Modelling and Simulation of Power Electronics System.**
3) **A I Techniques in Power System**

Elective- V. MTEPS205

1) **Modern Optimisation Techniques in Power System.**
2) **Finance Management.**
3) **Energy Management and Auditing.**

Third Semester											
1	MTME301	Project Management and Intellectual Property Rights (Self Study)*	--	--	--	02	--	-- --	50	50	**100**
2	MTEPS302	Project Stage -I	---	--	--	14			50	50	**100**
		Total for Semester III	**--**	**--**	**--**	**16**	**--**	**--**	**100**	**100**	**200**
Fourth Semester											
1	MTEPS401	Project Stage-II	-	-	-	28	-	-	100	100	**200**
		Total for Semester IV	**-**	**-**	**-**	**28**	**-**	**-**	**100**	**100**	**200**
GRAND TOTAL											**1700**

*Evaluation at the end of semester

MTEPS101: POWER SYSTEM MODELING

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS101	**Power System Modeling**	**core**	**3-0-1**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Pre-Requisites: power system analysis, power electronics

Course Objective:

To describe characteristics and appropriate mathematical models for representations of power system components such as synchronous machine, transmission line, transformer, induction motor, excitation systems and non-electrical components in power system dynamic studies. Review of steady state and transient performance characteristic of synchronous machine.

Course Outcomes:

CO1	Develop power system components modeling and analyze their performance
CO2	Develop modeling of synchronous machine and analyze its performance
CO3	Perform steady state and dynamic analysis on simulation models
CO4	Understand configuration and functioning of synchronous machine excitation system.
CO5	Develop excitation system components modeling and analyze their performance.
CO6	Understand and transmission line, load and reactive power compensator modeling.

Course Content

UNIT-1: Modeling of Power System Components: [8 Hours]

The need for modeling of power system, different areas of power system analysis. Models of non-electrical components like boiler, steam & hydro-turbine & governor system. Transformer modeling such as auto-transformer, tap-changing & phase shifting transformer.

UNIT-2: Synchronous machine modeling [8 Hours]

Model required for steady-state analysis. The development of model required for dynamic studies. The current & flux linkage models using Park's transformation leading to simulation as linear model.

UNIT-3: Analysis of synchronous machine modeling[6 Hours]

Synchronous machine connected to an infinite bus, its simulation for steady-state condition.

UNIT-4 Excitation systems [7 Hours]

Simplified view of excitation control. Excitation configuration, primitive systems, Definitions of voltage response ratio & exciter voltage ratings.

UNIT-5 Excitation system modeling[7 Hours]

Excitation control systems using dc generator exciter, alternator-rectifier, alternator SCR, and voltage regulators such as electro-mechanical and solid state. Modeling of excitation systems.

UNIT-6-Transmission line, SVC and load modeling: [6 Hours]

Transmission line modeling, Modeling of static V AR compensators, load modeling.

Reference books:

1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993.
2. R.Ramunujam," Power System Dynamics Analysis and Simulation, PHI Learning Private Limited, New Delhi, 2009.
3. Electric Power Systems: B.M. Weddy and B.J. Cory, John Wiely and Sons, Fourth adition (2002).
4. Power System Analysis and Design :J. Duncan Glover, MulukutlaS. Sarma, Thomson Brooks/cole/ Third Edition (2003)

MTEPS102: RENEWABLE ENERGY SYSTEM

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS102	**RENEWABLE ENERGY SYSTEMS**	**core**	**3-0-1**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Pre-Requisites: Power Plant engineering, Power system-I

Course Objectives:

- To introduce the new paradigm of power generation in the form of renewable energy and the various means used for power processing and optimization.
- To relate and study the various energy storage technology and their significance in the context of renewable energy based applications.

Course Outcomes:

CO1	Understand current energy scenario and their impact on environment(K1 A1)
CO2	Understand the process of power generation by renewable energy sources(K1 A1)
CO3	Understand configuration of various renewable energy systems(K1 A1)
CO4	Understand various forms of energy storage and their importance (K1 A1)
CO5	Analyze the performance of grid connected system.(K2 A2)
CO6	Understand the various standards and quality issues for grid integration.(

MTEPS102: RENEWABLE ENERGYSYSTEMS

Course contents:

UNIT-1: Energy Scenario [7 Hours]

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

UNIT-2: Solar Energy [7 Hours]

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.

UNIT 3:-Wind Energy [7Hours]

Wind Energy: wind speed and power relation, power extracted from wind, wind distribution and wind speed predictions. Wind power systems: system components, suitability of generators, turbine rating, electrical load matching, Variable speed operation, maximum power operation, control systems, system design features, stand alone and grid connectivity, environmental impacts of wind farms.

UNIT-4: Other Energy Sources [7Hours]

Biomass - various resources, energy contents, technological advancements, conversion of biomass in other form of energy - solid, liquid and gases. Gasifiers, Biomass fired boilers, Co firing, Municipal solid waste systems, Problems in harnessing. Hydro energy - feasibility of small, mini and micro hydel plants scheme layout economics. Tidal and wave energy - schemes, feasibility and viability. Geothermal and Ocean thermal energy conversion (OTEC) systems - schemes, feasibility and viability. Fuel Cell Technology

UNIT-5: Energy storage and hybrid system configurations [7Hours]

Energy storage: Battery' - types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management. Fly wheel- energy relations, components, benefits over battery. Other energy storage systems.

Stand alone systems, Hybrid systems - hybrid with diesel, with fuel cell, solar-wind, wind - hydro systems, mode controller, load sharing, system sizing. Hybrid system economics.

UNIT-6 Grid Integration [7Hours]

Grid connected system and their electrical performance: Interface requirements, synchronization with grid, inrush, stable operation, load transient, safety. Operating limits of voltage, frequency, stability margin, energy storage, and IQad scheduling. Quality of power- harmonic distortion, voltage transients and sags, voltage flickers. Dynamic reactive power support. Systems stiffness.

Effect of Utility restructuring.

References:

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

MTEPS103. ADVANCED POWER ELECTRONICS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS103	**ADVANCED POWER ELECTRONICS**	**core**	**3-0-1**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Pre-Requisites: Power Electronics, Circuit theory.

Course Objectives:

To understand configuration and characteristics of different power semiconductor devices used in power system operation and control. To analyses principle of operation of various power converter used in power system operation. To understand various advance power conversion techniques using power semiconductor devices.To explore the ability of advance power conversion techniques in harnessing renewable energy sources.

Course Outcomes:

Upon successful completion of this course the students will be able to:

CO1	Understand the behavior of power semiconductor devices operated as power switches.
CO2	analyze operation of various power converters
CO3	Understand advance power conversion techniques
CO4	Apply power conversion technology for exploring RES
CO5	Ability to design and test power electronic circuits in the laboratory

MEE1103. ADVANCED POWER ELECTRONICS

Course content:

UNIT-I Overview of Switching Power Devices: [8 Hours]

Solid State Power Semi-conducting Devices: Review of the thyristors, traic, GTO, transistor MOSFET and other modem power devices (IGBT, SIT, SITCH, MCT), characteristics ratings, commutation methods, protection and requirement of firing circuits.

UNIT-II Phase Controlled Rectifiers: [8 Hours]

Principle of phase controlled converter operation- single phase full converter and semi converters- dual converters- three phase full and semi converters- reactive power- power factor improvements – extinction angle control- symmetrical angle control- PWM control- SPWM control.

UNIT-III DC-DC Converters: [9 Hours]

Study of Class – A- B- C- and D choppers- non-isolated DC-DC converters: buck- boost- buck-boost converters under continuous and discontinuous conduction operation. Isolated DC-DC converters: forward- fly-back- push-pull- half-bridge- and full-bridge converters. Relationship between I/P and O/P voltages- expression for filter inductor and capacitors.

UNIT-IV Inverters: [9 Hours]

Single-phase and three-phase inverters- 120^0 and 180^0 modes of operation- PWM techniques: single- multiple- and sinusoidal PWM techniques- selective harmonic elimination- space vector modulation- current source inverter- multi-level inverters- techniques for reduction of harmonics.

UNIT-V Advance Techniques [5 Hours]

Advanced power conversion techniques viz resonant power conversion, multilevel converters etc.

UNIT-VI Convertor for Non-Conventional Energy Sources [5 Hours]

Power Electronics Controller for Wind Energy Electric Conversion Systems, Photo Voltaic Arrays, energy saving in AC and DC Drives.

Reference:

1. Power Electronics-circuits, Devices & Applications**,** M.H. Rashid **:** 3rd ed., PHI, 2005.

2. Power Electronics: Converters, Applications**,** Ned Mohan, T.M. Undeland, William P.Robbins**:** 3rd ed., John Wiley & Sons, 2009

MTEPS104-1: HIGH VOLTAGE POWER TRANSMISSION

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS104-1	**HIGH VOLTAGE POWER TRANSMISSION**	**Elective-I**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Electromagnetic theory, Power electronics, Power system operation and protection.

Course Objective

- To understand basic philosophy of EHV AC transmission.
- To understand the concept of voltage gradient and effect of electrostatic field.
- To understand the electromagnetic interference, AN, RI.
- To understand basic concepts of design of EHV AC transmission system.

Course Outcome

Upon successful completion of this coursestudents will be able to:

CO1	Understand the engineering aspectsof EHV AC transmission system.
CO2	Understand and analyze various transients in transmission line
CO3	Design transient protection for power system
CO4	Understandmaintenance procedure, tools and safety precautions.
CO5	Understandthe voltage control principles.
CO6	Understand different configuration, design procedure, protection requirements of HVDC line.

MTEPS104-1: HIGH VOLTAGE POWER TRANSMISSION

Course contents:

UNIT-I: Engineering Aspects of EHV AC Transmission System.[7 Hours]

Principles, configuration, special features of high voltage AC lines, power transfer ability, reactive power compensation, audible noise, corona bundle conductors, electric field, right of way, clearances in a tower, phase to phase, phase to ground, phase to tower, factors to be considered, location of ground wire, angle of protection, clearances, tower configuration. Principles of radio interference, origin of radio interference, method of propagation, factors to

be considered in line design.

UNIT-II: Power System Transients [7 Hours]

Introduction, circuit closing transients, sudden symmetrical short circuit of alternator, recovery transients due to removal of short circuit, traveling waves on transmission lines, wave equation, surge impedance and wave velocity, specifications of traveling waves, reflection and refraction of waves, typical cases of line terminations , equivalent circuit for traveling wave studies, forked lines, reactive termination, successive reflections, Bewley lattice diagram, attenuation and distortion, arcing grounds, capacitance switching, current chopping, lightning phenomenon, over voltages due to lightning, line design based on direct strokes, protection of systems against surges, statistical aspects of insulation coordination.

UNIT-III: Other Issues [7 Hours]

Biological effects of electric field, safe values of electric field, requirements of transmission line, live line maintenance, basic principle, special tools and procedure, methods of voltage control, tap changing, shunt compensation, shunt rectors and shunt capacitors.

UNIT-IV: General Background [7 Hours]

EHV AC versus HVDC Transmission, power flow through HVDC link, equation for HVDC power flow, effect of delay angle and angle of advance, bridge connections, waveform of six pulse and twelve pulse bridge converter, commutation, phase control, angle of extinction, control of DC voltage, connections of three phase six pulse and twelve pulse converter bridges, voltage and current waveforms.

UNIT-V: HVDC Transmission [7 Hours]

Bipolar HVDC terminal, converter transformer connections, switching arrangements in DC yard for earth return to metallic return, HVDC switching system, switching arrangements in a bipolar HVDC terminal, sequence of switching operations, HVDC circuit breakers, DC current interruption, commutation principle, probable types and applications of HVDC circuit breakers, multi-terminal HVDC systems, parallel tapping, reversal of power, configurations and types of multi-terminal HVDC systems, commercial multi terminal systems.

UNIT-VI: Protection of HVDC [7 Hours]

Faults and abnormal condition in bipolar, two terminal HVDC system, pole-wise segregation, protective zones, clearing of DC line faults and reenergizing, protection of converters, transformer, converter valves, DC yards, integration of protection 'and controls, hierarchical levels of control, block diagram, schematic diagram, current control, power control, DC voltagecontrol, commutation channel, master control, station control, lead station, trail station, pole control, equidistant firing control, synchronous HVDC link, asynchronous HVDC Link.

References:

1. An Introduction to High Voltage Engineering by Subir Ray, Prentice Hall of India

Private Limited, New Delhi - 110 001.

2. Direct Current Transmission Vol-I, Kimbark E. W , Wiley Interscience

3. HVDC Transmission- Adamson C. Hingorani N. G.

4. EHV AC Transmission Rakosh Das Begamudre, New Age Publishers

5. HVAC and HVDC Transmission, Engineering and practice: S. Rao, Khanna Publisher, Delhi.

6. Electric Power Systems: B.M. Weddy and B.J. Cory, John Wiely and Sons, Fourth edition

7. Power System Analysis and Design : J. Duncan Glover, Mulukutla S. Sarma,Thomson Brooks/cole/ Third Edition (2003)

8. Power System Analysis and Design, B.R. Gupta, S. Chand and Company (2004)

MTEPS104-2. ADVANCE TOPICS IN POWER SYSTEM

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS104-2	**ADVANCE TOPICS IN POWER SYSTEM**	**Elective-I**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power system operation and analysis

Course Objectives:

This course objectives to study power system stability and reliability. To overcome the stability problem for complex and large capacity units. Classification of stability on the basis of nature of perturbation and evaluation time. In this course we will try to understand how to analyze the stability of a power system, how to improve the stability and finally how to prevent system becoming unstable.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand facts, concepts and classification of stability on the basis of perturbation and economical aspect of energy exchange.
CO2	Analyze the characteristics of synchronous alternator under small and large disturbances.
CO3	Understand the apply knowledge of electrical subjects for solving stability problem and use method for enhancing stability
CO4	Understand and analyze the voltage stability problems and methods of improving voltage stability.
CO5	Understand and analyze the contingency issues in lines and apply the different

	techniques to improve it.
CO6	Understand and apply the state estimation technique for system security and load forecasting.

MTEPS104-2. ADVANCE TOPICS IN POWER SYSTEM

Course contents:

UNIT-I: [7 hours]

Generation Control Loops, AVR Loop, Performance and Response, Automatic Generation Control of Single Area and Multi Area Systems, Static and Dynamic Response of AGC Loops, Economic Dispatch and AGC.

UNIT-II: [7 hours]

Transient Stability Problem, Modeling Of Synchronous Machine, Loads, Network, Excitation and Systems, Turbine And Governing Systems, Trapezoidal Rule Of Numerical Integration Technique For Transient Stability Analysis, Data For Transient Stability Studies, Transient Stability Enhancement Methods

UNIT-III: [7 hours]

Low Frequency Oscillations, Power System Model For Low Frequency Oscillation Studies, Improvement Of System Damping With Supplementary Excitation Control, Introduction To Sub Synchronous Resonance and Countermeasures.

UNIT-IV: [7 Hours]

Voltage Stability Problem, Real And Reactive Power Flow In Long Transmission Lines, Effect Of ULTC And Load Characteristics On Voltage Stability, Voltage Stability Limit, Voltage Stability Assessment Using PV Curves, Voltage Collapse Proximity Indices, Voltage Stability Improvement Methods.

Unit-V: [7 Hours]

Contingency analysis ZBUS Method in Contingency Analysis, Adding and Removing Multiple Lines, Piecewise Solution of Interconnected Systems, Analysis of Single Contingencies, Analysis of Multiple Contingencies, Contingency Analysis of DC Model, System Reduction for Contingency and Fault Studies.

Unit-VI: [7 Hours]

Introduction to power system security. System state classification, Load Forecasting & State Estimation: Estimation of average, periodic, stochastic components of load, basic idea of state estimation of power system. State estimation in power systems Security analysis.

Reference books:

1. Electric Energy System Theory: An Introduction.O.I. Elgard, .II Edition, McGraw Hill, New York, 1982.
2. Power Generation, Operation And Control., A.J. Wood, B.F. Wollenberg, .John Wiley And Sons, New York, 1984, 2nd Edition: 1996.
3. Computer Modeling Of Electrical Power Systems.,J. Arrilaga, C.P. Arnold, B.J. Harker, Wiley, New York, 1983.
4. Power System Engineering, I.J. Nagrath, O.P. Kothari, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
5. Electric Power System Dynamics,Yao-Nan-Yu,
6. Power System Stability andControl.P. Kundur McGraw Hill, New York, 1994.

7 Power System Dynamics, Stability and Control, K.R. Padiyar Interline Publishing (P) Ltd., Bangalore, 1999.
8. Voltage Stability of Electric Power Systems.C. Van Custem, T. Vournas, Rlever Academic Press (U.K.), 1999.
9. Power System Analysis andDesign.B.R. Gupta, III Edition, A.H. Wheeler & Co. Ltd., New Delhi, 1998.
10. Reactive Power Control in Electric Power Systems.T.J.E. Miller John Wiley and Sons, New York, 1982.

MTEPS104-3 ELECTRICAL TRANSIENTS IN POWER SYSTEM

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS104-3	**ELECTRICAL TRANSIENTS IN POWER SYSTEM**	**Elective-I**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Electromagnetic wave theory, Power system operation and analysis

Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand basic concepts of travelling wave
CO2	Understand and analyze the electrical transients and effects on transmission line
CO3	Evaluate system parameters and model the overhead lines and underground cables systems using advance digital computing tools.
CO4	Apply advance digital computing tools in evaluation of system parameters.

MTEPS104-3 ELECTRICAL TRANSIENTS IN POWER SYSTEM

Course contents:

UNIT-I Review Of Travelling Wave Phenomena [8Hours]

Lumped and Distributed Parameters – Wave Equation – Reflection, Refraction, Behavior of Travelling waves at the line terminations – Lattice Diagrams – Attenuation and Distortion.

UNIT-II Lightning, Switching and Temporary Overvoltage [9 Hours]

Lightning over-voltages: interaction between lightning and power system- ground wire voltage and voltage across insulator; switching overvoltage: Short line or kilometric fault, energizing transients-closing and re-closing of lines, methods of control; temporary over-voltages: line dropping, load rejection; voltage induced by fault; very fast transient overvoltage (VFTO).

UNIT-III Parameters and Modelling of Overhead Lines [9 Hours]

Review of line parameters for simple configurations: series resistance, inductance and shunt capacitance; bundle conductors: equivalent GMR and equivalent radius; modal propagation in transmission lines: modes on multiphase transposed transmission lines, α-β-0 transformation and symmetrical components transformation, modal impedances; analysis of modes on untransposed lines; effect of ground return and skin effect; transposition schemes.

UNIT IV - Parameters of Underground Cables [8 Hours]

Distinguishing features of underground cables: technical features, electrical parameters, overhead lines versus underground cables; cable types; series impedance and shunt admittance of single-core self-contained cables, impedance and admittance matrices for three phase system formed by three single-core self-contained cables; approximate formulas for cable parameters.

UNIT-V Computation of Power System Transients - EMTP [8 Hours]

Digital computation of line parameters: why line parameter evaluation programs? salient features of tine; constructional features of that affect transmission line parameters; elimination of ground wires bundling of conductors; principle of digital computation of transients: features and capabilities of EMTP; steady state and time step solution modules: basic solution methods.

References:

1., Electrical Transients in Power System,Allan Greenwood Wiley & Sons Inc. New York, 1991.

2. Extra High Voltage AC Transmission Engineering,Rakosh Das Begamudre, (Second edition) Newage International (P) Ltd., New Delhi, 1990.

3. High Voltage Engineering, Naidu M S and Kamaraju V, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

4.EMTP Theory Book, Hermann W. Dommel, second Edition, Microtran Power System Analysis
corporation, Vancouver, British Columbia, Canada, May 1992, Last Update: April 1999.

5. EMTP Literature from www.microtran.com.

MTEPS105-1: POWER SYSTEM PLANNING AND RELIABILITY

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS105-1	**POWER SYSTEM PLANNING AND RELIABILITY**	**Elective-II**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power system operation and control

Couse objectives:-

- To use reliability theory as a tool for decision support for design, operation and planning of electric power system.
- To familiarize the students with various aspects of probability theory
- To acquaint the students with reliability and its concepts
- To introduce the students to methods of estimating the system reliability of simple and complex systems
- To understand the various aspects of Maintainability, Availability and FMEA procedure

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand load forecasting and planning techniques in power system
CO2	Understand concepts of reliability to design secure and reliable networks.
CO3	Carry out planning and reliability for generation, transmission, and distribution system

MTEPS105-1: POWER SYSTEM PLANNING AND RELIABILITY

Course contents:

UNIT-I Load Forecasting [7 Hours]

Introduction, Factors affecting Load Forecasting, 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 Forecasting, Weather Forecasting, Annual Forecasting, Monthly Forecasting, Total Forecasting.

UNIT-II System Planning [7 Hours]

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

UNIT-III Reliability [7 Hours]

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-IV Generation Planning and Reliability [7 Hours]

Objectives & Factors affecting Generation Planning, Generation Sources, 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-V Transmission Planning and Reliability [7 Hours]

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

UNIT-VI Distribution Planning and Reliability [7 Hours]

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.

References:

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

MTEPS105-2: POWER QUALITY ASSESSMENT AND MITIGATION

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS105-2	**POWER QUALITY ASSESSMENT AND MITIGATION**	**Elective-II**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Electromagnetic theory (desirable)

Course Objectives:-

- To know various power quality issues, it causes and effects
- To understand effects of harmonics due to non-linear load
- To learn mitigation methods for harmonics

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand the different power quality issues and standards

CO2	Understand the power monitoring importance and monitoring procedure to access the power quality
CO3	Apply the mitigation techniques to reduce the adverse effects of power quality on system and equipment

MTEPS105-2: POWER QUALITY ASSESSMENT AND MITIGATION

Course contents:

UNIT-I Introduction [7 Hours]

Importance of power quality, terms and definitions of power quality as per IEEE std. 1159 such as transients, short and long duration voltage variations, interruptions, short and long voltagefluctuations, imbalance, flickers and transients. Symptoms of poor power quality. Definitions and terminology of grounding. Purpose of groundings. Good grounding practices and problems due to poor grounding.

UNIT-II Flickers & transient voltage [7 Hours]

RMS voltage variations in power system and voltage regulation per unit system, complex power. Principles of voltage regulation. Basic power flow and voltage drop. Various devices used for voltage regulation and impact of reactive power management. Various causes of voltage flicker and their effects. Short term and long term flickers. Various means to reduce flickers. Transient over voltages, sources, impulsive transients, switching transients, Effect of surge impedance and line termination, control of transient voltages

UNIT-III Voltage sag and interruptions [7 Hours]

Definitions of voltage sag and interruptions. Voltage sags versus interruptions. Economic impact of voltage sag. Major causes and consequences of voltage sags. Voltage sag characteristics. Voltage sag assessment. Influence of fault location and fault level on voltage sag. Areas of vulnerability. Assessment of equipment sensitivity to voltage sags. Voltage sag requirements for computer equipment, CBEMA, ITIC, SEMI F 42 curves. Representation of the results of voltage sags analysis. Voltage sag indices. Mitigation measures for voltage sags, such as UPS, DVR, SMEs, CVT etc., utility solutions and end user solutions

UNIT-IV Waveform Distortion [7 Hours]

Definition of harmonics, interharmonics, subharmonics. Causes and effect of harmonics. Voltage versus current distortion. Overview of Fourier analysis. Harmonic indices. A.C. quantities under non-sinusoidal conditions. Triplen harmonics, characteristics and non-characteristics harmonics. Harmonics series and parallel resonances. Consequences of harmonic resonance. K-rated transformer. Principles for controlling harmonics. Reducing harmonic currents in loads. Harmonic study procedure. Computer tools for harmonic analysis. Locating sources of harmonics. Harmonic filtering, passive and active filters. Modifying the system frequency response. IEEE Harmonic standard 519-1992

UNIT-V Power Quality Monitoring [7 Hours]

Need of power quality monitoring and approaches followed in power quality monitoring. Power quality monitoring objectives and requirements. Initial site survey. Power quality Instrumentation. Selection of power quality monitors, selection of monitoring location and period. System wide and discrete power quality monitoring. Setting thresholds on monitors, d data collection and analysis. Selection of transducers. Harmonic monitoring, transient monitoring, event recording and flicker monitoring.

UNIT-VI Power Quality Assessment and Mitigation[7 Hours]

Power Quality assessment, Power quality indices and standards for assessment disturbances, waveform distortion, voltage and current unbalances. Power assessment under waveform distortion conditions. Power quality state estimation, State variable model, observity analysis, capabilities of harmonic state estimation. Test systems. Mitigation techniques at different environments

References:

1. Understanding power quality problems, voltage sag and interruptions - M. H. J. Bollen IEEE press, 2000, series on power engineering.
2. Electrical power system quality - Pogei G. Dugan, Mark F. McGranghan, Surya santoso, H. Wayne Beaty, second edition, McGraw Hill Pub.
3. Power system quality assessment - J. Arrillaga, M.R. Watson, S. Ghan, John Wiley and sons.

MTEPS105-3 ADVANCED CONTROL SYSTEM

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS105-3	**ADVANCED CONTROL SYSTEM**	**Elective-V**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Course Objectives:

- To make students understand the concept of nonlinear control, Adaptive Control and Sliding mode control.

- To study the behavior of nonlinear systems using various techniques.

Course outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand various control system design techniques.
CO2	Evaluate performance analysis of non linear system using various techniques.

MTEPS105-3 ADVANCED CONTROL SYSTEM

Course Contents:

UNIT-I:
Control system design by root locus method-lead, lag and lead lag compensation. PI, PD and PID controllers design procedures and examples. Control system design by frequency response approach- lead, lag and lead lag compensation. PI,PD and PID controllers design procedures and examples. [8hrs]

UNIT- II: EIGEN VALUE AND EIGENVECTOR SENSITIVITIES IN LINEAR SYSTEM THEORY
Continuous time systems: Introduction, first-order Eigen value sensitivities, first order eigenvector sensitivities, second-order Eigen value sensitivities, first order eigenvector sensitivities, second order Eigenvector sensitivities.
[7hrs]

UNIT- III: MODE-CONTROLLABILITY MATRIX:
Distinct Eigen-values, confluent Eigen-values associated with single Jordan block, confluent Eigen-values associated with number of distinct Jordan blocks, confluent Eigen-values associated with a number of non-distinct Jordan block. Mode –Controllability structure of multivariable linear systems: Introduction, Distinct Eigen-values, confluent Eigen-values associated with single Jordan block, confluent Eigen-values associated with a number of non-distinct Jordan blocs.
[8hrs]

UNIT- IV: OBSERVABILITY MATRICES:
Distinct Eigen-values, confluent Eigen-values, mode observability structure of multivariable linear systems: Introduction, Distinct Eigen-values, confluent Eigenvalues. Nonlinear systems: Common physical nonlinearities: the phase plane method – basic concept, singular points, construction of phase trajectories – Isocline and delta methods, Describing function – basic concept – derivation of describing functions – stability analysis by describing function method.
[9hrs]

UNIT- V: LYAPUNOV STABILITY ANALYSIS:

Second method of Lyapunov, stability in the sense of Lyapunov, construction of Lyapunov functions – Krasovskii's and variable gradient methods, Lyapunov stability analysis of linear time varying systems. [10 hrs]

TEXT BOOKS:

1. Advanced Control Systems B. N. Sarkar, PHI Learning Private Limited.
2. Advanced Control Theory, Somanath Majhi, Cengage Learning.
3. Control System Engineering – I J Nagarath, M. Gopal – New Age International – 3rdedition.
4. Control Systems – N K Sinha – New Age International – 3rd edition.

MTBS106: COMMUNICATION SKILLS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTBS106	**COMMUNICATION SKILLS**	**compulsory**	**2-0-0**	**28**

Evaluation scheme:

PR/OR	Test	Continuous Assessment	Total	Credits
25	0	25	50	2

Pre-Requisites: Basic English language understanding

Course Objectives:

Develop the verbal and written English communication skill among the students

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Students are found to be confident while using English
CO2	Engage in analysis of speeches or discourses and several articles
CO3	Identify and control anxiety while delivering speech
CO4	Write appropriate communications(Academic/Business)
CO5	Prepared to take the examinations like GRE/TOFEL/IELTS
CO6	Identify and control the tone while speaking
CO7	Develop the ability to plan and deliver the well-argued presentations

MTBS106: COMMUNICATION SKILLS

Course Contents:

UNIT-I:Communication and Communication Processes [4 Hours]Introduction to Communication, Forms and functions of Communication, Barriers to Communication and overcoming them, Verbal and Non-verbal Communication, Ways of Effective Communication.

UNIT-II: Oral Communication [6 Hours]

Use of Language in Spoken Communication, Features of Good Communication, Principles and Practice of Group Discussion, Public Speaking (Addressing Small Groups and Making Presentation), Interview Techniques, Appropriate Use of Non-verbal Communication, Presentation Skills, Telephonic Etiquettes, Extempore, Elocution, Describing Experiences and Events.

UNIT-III: Study of Sounds in English [4Hours]

Introduction to phonetics, Study of Speech Organs, Study of Phonemic Script, Articulation of Different Sounds in English, Stress Mark.

UNIT-IV: English Grammar [4 Hours]Grammar: Forms of Tenses, Articles, Prepositions, Use of Auxiliaries and Modal Auxiliaries, Synonyms and Antonyms, Common Errors, Sentence Formation and Sentence Structures, Use of Appropriate Diction.

UNIT-V:Writing Skills [6 Hours]Features of Good Language, Difference between Technical Style and Literary Style, Writing Emails, Formal and Informal English, Business Writing, Advertisements, Essay Writing, (Technical, Social, and Cultural Topics), Technical Reports: Report Writing: Format, Structure and Types, Writing Memorandum, Circulars, Notices, Agenda and Minutes, Technical Manuals, Brochures

Letter Writing: Types, Parts, Layouts, Letters and Applications, Use of Different Expressions and Style, Writing Job Application Letter and Resume.

UNIT-VI: Reading Skills & Listening Skills [4 Hours]Reading: Introduction to Reading, Barriers to Reading, Types of Reading: Skimming, Scanning, Fast Reading, Strategies for Reading, Comprehension.

Listening : Importance of Listening, Types of Listening, Barriers to Listening.

REFERENCES:

1. *Communications Skills for Engineers*, Mohd. Ashraf Rizvi, Tata McGraw Hill
2. *Communication Skills*, Sanjay Kumar, Pushp Lata Oxford University Press, 2016
3. *Communication Skills*, Meenakshi Raman, Sangeeta Sharma,Oxford University Press, 2017
4. Michael Gamble, *Communication Works*, Teri Kwal Gamble, Tata McGraw Hill Education, 2010

MTEPS107P.G. LABORATORY –I

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS107	**P.G–I**	**compulsory**	**0-3-0**	**42**

Evaluation scheme:

PR/OR	Test	Continuous Assessment	Total	Credits
25	0	25	50	2

Objective: To develop the analytical and practical skills in the students.

Course Outcomes:

Upon successful completion of this LAB-I the student will be able to:

CO1	Apply the knowledge to design the practical circuits for applications.
CO2	Model and simulate different electrical and electronics systems
CO3	Simulate and test the circuit performance for comparative study.

The power system lab -1 will be comprising of **at least TWO** experiments from each of the subjects MTEPS101 to MTEPS105 such as representation of Power System Elements like Synchronous machines, transformers, transmission lines, loads, power system load flow, short circuit studies and power system stability studies using MATLAB-SIMULINK, PSCAD, CAPS software. Study of power semiconductor devices, study AC to DC, DC to DC converter circuits etc using software, design as well as by building up the circuits in laboratories. Renewable energy systems.

SEMESTER II

MTEPS201 POWER SYSTEM DYNAMICS AND CONTROL

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS201	**POWER SYSTEM DYNAMICS AND CONTROL**	**Compulsory**	**3-0-1**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Pre-Requisites: Power system operation and control

Course Objective

To review fundamental aspects of dynamic systems and to illustrate the nature of small signal and transient stability problems, identifying factors influencing them. To present analytical techniques useful in the study of small signal and transient stability.

Course Outcome

Upon successful completion of this course the student will be able to:

CO1	Understand various models of Synchronous machine
CO2	Analyze SMIB performance for various conditions
CO3	Understand philosophy of power system stabilizer and their applications
CO4	Evaluate small signal stability analysis with and with out controller
CO5	Apply various small signal stability enhancement techniques.

UNIT-I: Dynamics of Synchronous Generator Connected To Infinite Bus [7 Hours]

Review of Classical Methods System model, states of operation and system security, steady state stability, transient stability, simple representation of excitation control. System model, synchronous machine model, calculation of Initial conditions, system simulation, other machine models, inclusion of SVC model.

UNIT-II: Analysis Of Single And Multi-Machine System[7 Hours]

Small signal analysis, applications of Routh-Hurwitz criterion, analysis of synchronizing and damping torque, state equation for small signal model

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 III: Power System Stabilizers [5 Hours]

Basic concepts of control signals in PSS, structure and tuning, field implementation and operating experiences, example of PSS design and application, future trends.

UNIT-IV: Signal Stability Analysis without Controllers [9 Hours]

Classification of Stability, Basic Concepts and Definitions: Rotor angle stability, The Stability Phenomena. Fundamental Concepts of Stability of Dynamic Systems: Statespace representation,

stability of dynamic system, Linearization, Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, Eigen value and stability, mode shape and participation factor. Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example, Effects of Field Circuit Dynamics: synchronous machine, network and linearized system equations, block diagram representation with K-constants; expression for K-constants (no derivation), effect of field flux variation on system stability: analysis with numerical example.

UNIT-V:Small-Signal Stability Analysis with Controllers[8 Hours]

Effects Of Excitation System: Equations with definitions of appropriate K-constants and simple thyristor excitation system and AVR, block diagram with the excitation system, analysis of effect of AVR on synchronizing and damping components using a numerical example, Power System Stabilizer: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example, Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical example. Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates, illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example. Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stabilizers.

UNIT-VI:Enhancement of Small Signal Stability[6 Hours]

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

References:

1.Power System Dynamics and Stability, P. W. Sauer and M. A. Pai,, Stipes Publishing Co, 2007

2. Dynamic Models for Steam and Hydro Turbines in Power System Studies,IEEE Committee Report, IEEE Trans., Vol.PAS-92, pp 1904-1915, November/December, 1973. on Turbine-Governor Model.

3. Power System Control and Stability, P.M Anderson and A.A Fouad, Iowa State University Press, Ames, Iowa, 1978.

4. Power System Dynamics Analysis and Simulation, R.Ramunujam,PHI Learning Private Limited, New Delhi, 2009

5. Power System Stability and Control, P. Kundur,McGraw-Hill, 1993.

MTEPS202 ADVANCED POWER SYSTEM PROTECTION

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS202	**ADVANCED POWER SYSTEM PROTECTION**	**Compulsory**	**3-0-1**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	4

Pre-Requisites: Switchgear and protection

Course Objectives:-

- To understand various Optimization Techniques applicable in Power System and Optimal Power flow solution methods.
- To understand the concept of power System Security.
- To apply state estimation in power system.

Course Outcomes:-

Upon successful completion of this course the student will be able to:

CO1	Understand philosophy of various relays used in power system protection.
CO2	Understand basic principle of digital relaying

MTEPS202 ADVANCED POWER SYSTEM PROTECTION

Course content:

UNIT-I: Static Relays [9 Hours]

Advantages of static relays-Basic construction of static relays-Level detectors-Replica impedance –Mixing circuits-General equation for two input phase and amplitude comparators-Duality between amplitude and phase comparators. AMPLITUDE COMPARATORS: Circulating current type and opposed voltage type- rectifier bridge comparators, Direct and Instantaneous comparators.

UNIT-II: Phase Comparators [8 Hours]

Coincidence circuit type- block spike phase comparator, techniques to measure the period of coincidence-Integrating type-Rectifier and Vector product type- Phase comparators. STATIC OVER CURRENT RELAYS: Instantaneous over-current relay-Time over-current relaysbasic principles –definite time and Inverse definite time over-current relays.

UNIT-III: Static Differential Relays [9 Hours]

Analysis of Static Differential Relays –Static Relay schemes –Duo bias transformer differential protection –Harmonic restraint relay. STATIC DISTANCE RELAYS: Static impedance-

reactance–MHO and angle impedance relaysampling comparator –realization of reactance and MHO relay using sampling comparator.

UNIT-IV: Multi-Input Comparators[8 Hours]

Conic section characteristics-Three input amplitude comparator –Hybrid comparator-switched distance schemes –Poly phase distance schemes- phase fault scheme –three phase scheme – combined and ground fault scheme. POWER SWINGS: Effect of power swings on the performance of distance relays –Power swing analysis-Principle of out of step tripping and blocking relays-effect of line and length and source impedance on distance relays.

UNIT-V: Microprocessor Based Protective Relays [8 Hours]

(Block diagram and flowchart approach only)-Over current relays–impedance relays-directional relay-reactance relay .Generalized mathematical expressions for distance relays-measurement of resistance and reactance –MHO and offset MHO relays-Realization of MHO characteristics-Realization of offset MHO characteristics -Basic principle of Digital computer relaying.

TEXT BOOK:

1. Power system protection and Switch gear ,Badri Ram and D.N.Vishwakarma, "TMH publication New Delhi 1995.

REFERENCES:

1 Static relays, T.S.Madhava Rao, TMH publication, second edition 1989.

2. Protection and Switchgear, Bhavesh Bhalja, R. P. Maheshwari, Nilesh G. Chothani, Oxford University Press.

3. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.

MTEPS203-1 POWER SECTOR ECONOMICS, REGULATION & RESTRUCTURING

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS203-1	**POWER SECTOR ECONOMICS, REGULATION & RESTRUCTURING**	**Elective-III**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power plant engineering, power systems

Course Objectives:-To understand national policy in power system restructuring

Course Outcomes:-

Upon successful completion of this course the student will be able to:

CO1	Understand power sector scenario in India
CO2	Understand the national policy, economics and regulation.
CO3	Understand the power sector restructuring and market reforms.
CO4	Understand the transmission planning and pricing techniques.

UNIT-I: Power Sector in India [7 Hours]

Introduction to various institutions in an Indian Power sector such as CEA, Planning Commissions, PGCIL, PFC, Ministry of Power, state and central governments, REC, utilities and their roles. Critical issues challenges before the Indian power sector, Salient features of Electricity act 2003, various national policies and guidelines under this act.

UNIT-II: Power sector economics and regulation [7 Hours]

Typical cost components and cost structure of the power sector, Different methods of comparing investment options, Concept of life cycle cost , annual rate of return , methods of calculations of Internal Rate of Return (IRR) and Net Present Value (NPV) of project, Short term and long term marginal costs, Different financing options for the power sector. Different stakeholders in the power sector, Role of regulation and evolution of regulatory commission in India, types and methods of economic regulation, regulatory process in India.

UNIT-III: Power Tariff [7 Hours]

Different tariff principles (marginal cost, cost to serve, average cost), Consumer tariff structures and considerations, different consumer categories, telescopic tariff, fixed and variable charges, time of day, interruptible tariff, different tariff based penalties and incentives etc., Subsidy and cross subsidy, life line tariff, Comparison of different tariff structures for different load patterns etc.

UNIT-IV: Power sector restructuring and market reform [7 Hours]

Different industry structures and ownership models Competition in the electricity sector-conditions, barriers, different types, benefits and challenges etc. Different market and trading models arrangements, key market entities- ISO, Genco, Transco, Disco, Retailco, Power market types, Energy market, ancillary service market, transmission market, Forward and real time markets, market power.

UNIT-V: Electricity Markets Pricing and Non-price issues [7 Hours]

Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs. Dynamic, spot pricing and real time pricing, Dispatch based pricing, Power flows and prices, Optimal power flow Spot prices for real and reactive power. Unconstrained real spot prices, constrains and real spot prices. Non price issues in electricity restructuring (quality of supply and service,

environmental and social considerations) Global experience with electricity reforms in different countries.

UNIT-VI: Transmission Planning and pricing [7 Hours]

Transmission planning, Different methods of transmission pricing, Different transmission services, Congestion issues and management, Transmission cost allocation methods, Locational marginal price, firm transmission right.

Transmission ownership and control, Transco and ISO, Transmission pricing Model in India, Availability based tariff, role of load dispatch centers (LDCs) Salient features of Electricity act 2003, Price based Unit commitment, concept of arbitrage in Electricity markets, game theory methods in Power System, and security constrained unit commitment. Ancillary services for restructuring, forward ancillary service auction

References

1. Regulation in infrastructure SeNices: Progress and the way forward - TERI, 2001
2. Paper "The real challenges in Power sector Restructuring: Instilling Public Control Through TApn, Prayas Energy Group, Energy for Sustainable Development, September 2001, www.DravaSDune.org
3. Privatization or Democratization The Key to the Crises in the ElectricitySector - The Case of Maharashtra 2002, www.prayaspune.org
4. Maharashtra Electricity Regulatory Commission Regulations and Orders – www.mercindia.com
5. Various publications, reports and presentations by Prayas, Energy Group, Pune
6. Central Electricity Regulatory Commission, Regulations and Orders - www.cercind.ora
7. Electricity Act 2003 and National Policies - www.Dowermin.nic.in
8. Sally Hunt, "Making Competition Work in Electricityn, 2002, John Wiley Inc
9. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy
10. Market Operations in Electric Power Systems Forecasting, Scheduling and Risk Management

MTEPS203-2 SMART GRID DESIGN AND ANALYSIS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS203-2	**SMART GRID DESIGN AND ANALYSIS**	**Elective-III**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power plant engineering , Power system operation and control

Course Objectives:-

To understand various aspects of smart grid design to meet the needs of a utility viz Meeting a utility's objectives, Helping to adopt new technologies into the grid, Creating a framework for knowledgeable power engineers to operate the grid more effectively and to address the issues and challenges that remain to be solved.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	The various aspects of the smart grid.
CO2	Understand grid architecture design.
CO3	Understand various performance analysis tools for smart grid design.
CO4	Evaluate stability analysis for smart grid
CO5	Understand the integration of RES with smart grid and energy storage

MTEPS203-2 SMART GRID DESIGN AND ANALYSIS

Course contents:

UNIT-I: Introduction to Smart Grid [7 Hours]

What is Smart Grid? Working definitions of Smart Grid and Associated Concepts – Smart Grid Functions – Comparison of Traditional Power Grid and Smart Grid – New Technologies for Smart Grid – Advantages – Indian Smart Grid – Key Challenges for Smart Grid.

UNIT-II: Smart Grid Architectural Designs [7 Hours]

Smart grid – power system enhancement – communication and standards - General View of the Smart Grid Market Drivers - Stakeholder Roles and Function - Measures - Representative Architecture - Functions of Smart Grid Components-Wholesale energy market in smart grid-smart vehicles in smart grid.

UNIT-III: Smart Grid Communications and Measurement Technology [7 Hours]

Communication and Measurement - Monitoring, Phasor Measurement Unit (PMU), Smart Meters, Wide area monitoring systems (WAMS)- Advanced metering infrastructure- GIS and Google Mapping Tools.

UNIT-IV: Performance Analysis Tools For Smart Grid Design [7 Hours]

Introduction to Load Flow Studies - Challenges to Load Flow in Smart Grid and Weaknesses of the Present Load Fl ow Methods - Load Flow State of the Art: Classical, Extended Formulations, and Algorithms –Load flow for smart grid design-Contingencies studies for smart grid.

UNIT-V: Stability Analysis Tools For Smart Grid [7 Hours]

Voltage Stability Analysis Tools-Voltage Stability Assessment Techniques-oltage Stability Indexing-Application and Implementation Plan of Voltage Stability in smart grid-Angle stability

assessment in smart grid-Approach of smart grid to State Estimation-Energy management in smart grid.

UNIT- VI: Renewable Energy and Storage [7 Hours]

Renewable Energy Resources-Sustainable Energy Options for the Smart Grid-Penetration and Variability Issues Associated with Sustainable Energy Technology-Demand Response Issues-Electric Vehicles and Plug-in Hybrids-PHEV Technology-Environmental Implications-Storage Technologies-Grid integration issues of renewable energy sources.

References:-

1) Smart Grid: Fundamentals of design and analysis, James Momoh John Wiley & sons Inc, IEEE press 2012.
2) Smart Grid: Technology and Applications,Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, John Wiley & sons inc, 2012.
3) Smart Grid: Integrating Renewable, Distributed & Efficient Energy,Fereidoon P. Sioshansi, Academic Press, 2012.
4) The smart grid: Enabling energy efficiency and demand response,Clark W.Gellings, Fairmont Press Inc, 2009.

MTEPS203-3 DISTRIBUTED GENERATION AND MICROGRID

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS203-3	**DISTRIBUTED GENERATION AND MICROGRID**	**Elective-III**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power plant engineering , Power system operation and control

Course Objectives:- To understand various aspects of micrgrid design to meet the needs of a utility viz Meeting a utility's objectives, Helping to adopt new technologies into the grid, Creating a framework for knowledgeable power engineers to operate the grid more effectively and to address the issues and challenges that remain to be solved

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand exploration of renewable energy sources
CO2	Understand philosophy of distributed generation
CO3	Understand various issues of DG with grid integration
CO4	Understand the concept of micro grid and various power quality issues.

MTEPS203-3 DISTRIBUTED GENERATION AND MICROGRID

Course content:

UNIT I – INTRODUCTION (9 hours)

Conventional power generation: advantages and disadvantages, Energy crises, Non-conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT II – DISTRIBUTED GENERATIONS (DG) (9 hours)

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT III – IMPACT OF GRID INTEGRATION (9 hours)

Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT IV- MICROGRIDS (10 hours)

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, communication infrastructure, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

UNIT V- POWER QUALITY ISSUES IN MICROGRIDS (5 hours)

Power quality issues in microgrids- Modelling and Stability analysis of Microgrid, regulatory standards, Microgrid economics, Introduction to smart microgrids.

REFERENCES:

1. Voltage Source Converters in Power Systems: Modeling, Control and Applications,AmirnaserYezdani, and Reza Iravani, IEEE John Wiley Publications,2009.
2. Power Switching Converters: Medium and High Power, Dorin Neacsu, CRC Press, Taylor & Francis, 2006.
3. Solar Photo Voltaics, Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi,2009.
4. Wind Energy Explained, theory design and applications,J.F. Manwell, J.G. McGowan Wiley publication,2002.
5. Biomass Regenerable Energy,D. D. Hall and R. P. Grover, John Wiley, New York, 1987.
6Renewable Energy Resources, John Twidell and Tony Weir, Tyalor and Francis Publications, 2005.

MTEPS204-1APPLICATION OF POWER ELECTRONICS TO POWER SYSTEMS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS204-1	**APPLICATION OF POWER ELECTRONICS TO POWER SYSTEMS**	**Elective-IV**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power electronics, Power system operation and control

Course Objectives:-

- To know the basic principle of conventional active and reactive power flow control in power systems and problems associated with long distance power transmission.
- To make students aware how power electronics devices can be used to find solution to the problems in long distance power transmission.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand the concept of FACTs
CO2	Select and implement proper compensator to solve the problems occurring power transmission
CO3	Model and analyze the FACT controllers
CO4	Understand and apply the active filtering techniques in mitigation of harmonic distortion.

MTEPS204-1APPLICATION OF POWER ELECTRONICS TO POWER SYSTEMS

Course contents:

Unit 1

Review of semiconductor devices, Steady state and dynamic problems in AC systems, Power flow [5 hrs]

Unit 2

Flexible AC transmission systems (FACTS): Basic realities & roles, Types of facts controller, Principles of series and shunt compensation. [6 hrs]

Unit 3

Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC). [9 hrs]

Unit 4

Modelling and Analysis of FACTS controllers. Control strategies to improve system stability. Power Quality problems in distribution systems. [8 hrs]

Unit 5

Harmonics, harmonics creating loads, modelling, Series and parallel resonances, harmonic power flow, Mitigation of harmonics, filters, passive filters. [7 hrs]

Unit 6

Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker. Mitigation of power quality problems using power electronic conditioners. IEEE standards. [7 hrs]

References:

1. Understanding of FACTs.,Hingorani, N. G.; IEEE Press 1996.

2. Power Quality.; Heydt G.T.; Stars in a Circle Pblications , Indiana, 1991.

3. Static Reactive Power Compensation.; Miller T.J.E.; John Wiley & Sons, New York, 1982

4. Flexible AC Transmission System. (FACTs).;Yong Hua Song.; IEE 1999.

5. Recent Publications on IEEE Journals.

MTEPS204-2 MODELING & SIMULATION OF POWER ELECTRONIC SYSTEMS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS204-2	**MODELING & SIMULATION OF POWER ELECTRONIC SYSTEMS**	**Elective-IV**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power electronics, Power system, electrical machines design

Course Objectives:-

1. To know the challenges, process, solution techniques for simulation
2. **To make the students familiar to use state space techniques and SIMULINK tool to simulate power electronics converters, electrical drives.**
3. **To model and design power electronics switching converters using state space averaging technique.**
4. **To model and simulate impedance and converter based converters.**

Upon successful completion of this course the student will be able to:

CO1	Understand and apply computer simulation process, challenges and techniques modeling and simulation of power electronics converters.
CO2	Apply the state space modeling techniques for simulation of power electronics converters
CO3	Use the SIMULINK tool for simulation of various power electronics converters
CO4	Model and simulate the electrical drives and analyze the performance
CO5	Apply state space averaging technique to model power electronics converters
CO6	Model and simulate the FACT controllers.

MTEPS204-2 MODELING & SIMULATION OF POWER ELECTRONIC SYSTEMS

Course contents:

Unit.1. Introduction: [4]

Challenges in computer simulation - Simulation process - mechanics of simulation - Solution techniques for time domain analysis - Equation solvers - circuit-oriented simulators

Unit-2. Simulation of Power Electronic Converters: [8]

State-space representation of power electronic converters (with buck converter as a representative example) - Trapezoidal integration - M & N method for simulating power electronic converters (with buck converter as a representative example) - Introduction to MATLAB and Simulink - Simulation of rectifiers - choppers and inverter circuits along with PWM techniques

Unit.3. Simulation of Electric Drives: [9]

Modeling of power electronic converters with transportation delay - Concept of control gain - linearization of rectifiers with inverse cosine control - State space model of 3-Ph IM - Principle of Vector control - Modeling and simulation of Vector controlled 3-Ph IM with a 3-level inverter drive

Unit.4. Modeling - Simulation of Switching Converters with State Space Averaging: [8]

State Space Averaging Technique– Modeling AND linearization of converter transfer functions - Simulation and Design of power electronic converters using State-space averaged models

Unit. 5. Modeling and simulation of impedance based compensators [8]

Modeling and analysis of series and shunt static Var Compensators:

Unit. 6. Modeling and simulation of converter based compensators.[9]

Modeling and Analysis of STATCOM, SSSC, UPFC.

References:

1.**:** *Simulation of Power Electronic Converters***,** M. B. Patil - V. Ramnarayanan, V. T. Ranganathan ,1st ed., Narosa Publishers, 2010

2. Power Electronics: Converters, Design and control, Ned Mohan, Undeland and Robbins**, -** 2nd ed., John Wiley

MTEPS204-3: AI APPLICATIONS TO POWER SYSTEMS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS204-3	**AI APPLICATIONS TO POWER SYSTEMS**	**Elective-IV**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power system operation and control

Course Objectives:- To understand and apply AI techniques in solving power system problems.

Upon successful completion of this course the student will be able to:

CO1	Understand concept of AI techniques
CO2	Understand various ANN configuration
CO3	Understand and design expert system
CO4	Apply ASI techniques for power system problems.

MTEPS204-3: AI APPLICATIONS TO POWER SYSTEMS

Course contents:

Unit-1.Introduction to AI:

Definition, Applications, Components of an AI program; production system. Problem Characteristics. Overview of searching techniques. Knowledge representation: Knowledge representation issues; and overview. Representing knowledge using rules; procedural versus declarative knowledge. Logic programming, forward versus backward reasoning, matching. Control knowledge. [7hrs]

Unit.2.Statistical Reasoning:

Probability and Daye's theorem. Certainty factor and rule based systems. Baysian Networks, Dampster Shafer theorem. Semantic nets and frames, Scripts. Examples of knowledge based systems. [7 hrs]

Unit.3.Pattern Recognition:

Introduction, automatic pattern recognition scheme. Design Concepts, Methodologies, Concepts of Classifier, concept of feature selection. Feature selection based on means and covariances. Statistical classifier design algorithms; increment-correction and LMSE algorithms. Applications.

[7hrs]

Unit4. Artificial Neural Networks:

Biological Neuron, Neural Net, use of neural 'nets, applications, Perception, idea of single layer and multilayer neural nets, back propagation, Hopfield nets, supervised and unsupervised learning.

[8hrs]

Unit.5.Expert Systems:

Introduction. Study of some popular expert systems, Expert System building tools and Shells, Design of Expert Systems.[6 hrs]

Unit.6. Applications of AI Techniques:

Load forecasting – Load flow studies – Economic load dispatch – Load frequency control – Single area system and two area system – Small Signal Stability (Dynamic stability) Reactive power control [6hrs]

REFERENCE BOOKS

1. Neural Networks, Fuzzy Logic & Genetic Algorithms,S.Rajasekaran and G.A.V.Pai,- PHI, New Delhi, 2003.
2. Computing Theory & Practice, P.D.Wasserman,Van Nostrand Reinhold, Neural- New York,1989.
3. Neural Network & Fuzzy System, Bart Kosko, Prentice Hall, 1992.
4. Fuzzy sets,Uncertainty and Information,G.J.Klir and T.A.Folger, PHI, Pvt.Ltd,1994.
5. Genetic Algorithms,D.E.Goldberg, Addison Wesley 1999.

MTEPS205-1 MODERN OPTIMIZATION TECHNIQUES IN POWER SYSTEMS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS205-1	**MODERN OPTIMIZATION TECHNIQUES IN POWER SYSTEMS**	**Elective-V**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power system operation and control

Course Objectives:-

- Formulate a real-world problem as a mathematical programming model.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

Course outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand the theoretical workings of the simplex method for linear programming and perform iterations of it by hand.
CO2	Perform sensitivity analysis to determine the direction and magnitude of change of a model‘s optimal solution as the data change.
CO3	Solve specialized linear programming problems like the transportation and assignmen problems.
CO4	Solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
CO5	Understand the applications of, basic methods for, and challenges in intege programming
CO6	Model a dynamic system as a queuing model and compute important performance measures

MTEPS205-1 MODERN OPTIMIZATION TECHNIQUES IN POWER SYSTEMS

Course contents:

UNIT I - FUNDAMENTALS OF OPTIMIZATION (8 hrs)

Definition-Classification of optimization problems-Unconstrained and Constrained optimization-Optimality conditions-Classical Optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming)-Intelligent Search methods (Optimization neural network, Evolutionary algorithms, Tabu search, Particle swarm optimization, Application of fuzzy set theory).

UNIT II - EVOLUTIONARY COMPUTATION TECHNIQUES (8 hrs)

Evolution in nature-Fundamentals of Evolutionary algorithms-Working Principles of Genetic Algorithm- Evolutionary Strategy and Evolutionary Programming-Genetic Operators-Selection, Crossover and Mutation-Issues in GA implementation- GA based Economic Dispatch solution-Fuzzy Economic Dispatch including losses- Tabu search algorithm for unit commitment problem-GA for unit commitment-GA based Optimal power flow- GA based state estimation.

UNIT III - PARTICLE SWARM OPTIMIZATION (10hrs)

Fundamental principle-Velocity Updating-Advanced operators-Parameter selection- Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO) -Binary, discrete and combinatorial PSO-Implementation issues-Convergence issues- PSO based OPF problem and unit commitment-PSO for reactive power and voltage control-PSO for power system reliability and security.

UNIT IV - ADVANCED OPTIMIZA TION METHODS (7 hrs)

Simulated annealing algorithm-Tabu search algorithm-SA and TS for unit commitment-Ant colony optimization- Bacteria Foraging optimization.

UNIT V - MULTI OBJECTIVE OPTIMIZATION (10 hrs)

Concept of pareto optimality-Conventional approaches for MOOP-Multi objective GA-Fitness assignment-Sharing function-Economic Emission dispatch using MOGA-Multiobjective PSO (Dynamic neighbourhood PSO, Vector evaluated PSO) –Multiobjective OPF problem.

REFERENCES:

1. D.P.Kothari and J.S.Dhillon, "Power System Optimization", 2ndEdition, PHI learning private limited, 2010.
2. Kalyanmoy Deb, "Multi objective optimization using Evolutionary Algorithms" , John Wiley and Sons, 2008.
3. Kalyanmoy Deb, "Optimization for Engineering Design",Prentice hall of India first edition,1988.
4. Carlos A.Coello Coello, Gary B.Lamont, David A.Van Veldhuizen, "Evolutionary Algorithms for solving Multi Objective Problems", 2ndEdition, Springer, 2007.
5. SolimanAbdel Hady,Abdel Aal Hassan Mantawy, "Modern optimization techniques with applications in Electric Power Systems" ,Springer,2012.
6. Jizhong Zhu," Optimization of power system operation",John Wiley and sons Inc publication,2009.
7. Kwang Y.Lee,Mohammed A.El Sharkawi, "Modern heuristic optimization techniques", John Wiley and Sons,2008.

MTEPS205-2 FINANCE MANAGEMENT

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS205-2	**FINANCE MANAGEMENT**	**Elective-V**	**3-0-0**	**42**

Pre-Requisites: Basic knowledge of finance principles

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Course Objectives:

- To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
- To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Course outcomes:

Upon successful completion of this course the student will be able to:

CO1	Apply selection criteria and select an appropriate project from different options
CO2	Write work break down structure for a project and develop a schedule based on it.
CO3	Identify opportunities and threats to the project and decide an approach to deal with them strategically.
CO4	Use Earned value technique and determine & predict status of the project.
CO5	Capture lessons learned during project phases and document them for future reference

Course Contents:

Unit-I Overview of Indian Financial System [8]

Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills.

Financial Markets: Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market.

Financial Institutions: Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-MerchantBanks and Stock Exchanges

Unit-II Concepts of Returns and Risks [8]

Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio.

Time Value of Money: Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.

Unit-III Overview of Corporate Finance [8]

Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.

Financial Ratio Analysis: Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.

Unit-IV Capital Budgeting [8]

Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR).

Unit-V Working Capital Management [10]

Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity‘s Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.

REFERENCES:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham

and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

MTEPS205-3 ENERGY MANAGEMENT AND AUDITING

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS205-3	**ENERGY MANAGEMENT AND AUDITING**	**Elective-II**	**3-0-0**	**42**

Evaluation scheme:

Theory	Test	Continuous Assessment	Total	Credits
60	20	20	100	3

Pre-Requisites: Power plant engineering , Power system operation and control

Course Objectives:-

- To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
- To introduce performance evaluation criteria of various electrical and hermal installations to facilitate the energy management
- To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Course Outcomes:

Upon successful completion of this course the student will be able to:

CO1	Understand principles of energy audit and energy management
CO2	Evaluate economic load models and apply load management technique
CO3	Identify and describe present state of energy security and its importance
CO4	Understand use of various energy metering tools in energy mamnagement
CO5	Identify and describe the basic principles and methodologies adopted in energy audit of utility.
CO6	Describe the energy performance evaluation of some common electrical and thermal installations and identify the energy saving opportunities.
CO7	Analyze the data collected during performance evaluation and recommend energy saving measures

MTEPS105-3 ENERGY MANAGEMENT AND AUDITING

Course Content:

UNIT-I: Basic Principles of Energy Audit [7 Hours]

Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, Sankey diagrams, load profiles, Energy conservation schemes- Energy audit of industries- energy saving potential, energy audit of process industry, thermal power station, building energy audit Need for energy management – energy basics – designing and starting an energy management program – energy audit process

Need for energy management – energy basics – designing and starting an energy management program – energy accounting – energy monitoring, targeting and reporting-

UNIT II – Energy Cost and Load Management [7 Hours]

Important concepts in an economic analysis – economic models – time value of money –utility rate structures – cost of electricity – loss evaluation. Load management: demand control techniques – utility monitoring and control system-HVAC and energy management – economic justification.

UNIT-III: Energy Efficient Motors [7 Hours]

Energy efficient motors , factors affecting efficiency, loss distribution , constructional details, characteristics - variable speed , variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit applications to Systems and equipment such as : electric motors – transformers and reactors – capacitors and synchronous machines.

UNIT-IV Metering For Energy Management[7 Hours]

Relationships between parameters – Units of measure – typical cost factors – utility meters – timing of meter disc for kilowatt measurement – demand meters – paralleling of current transformers – instrument transformer burdens – multitasking solid-state meters – metering location vs. requirements – metering techniques and practical examples.

UNIT-V Lighting Systems And Cogeneration[7 Hours]

Concept of lighting systems – the task and the working space – light sources – ballasts – luminaries – lighting controls – optimizing lighting energy – power factor and effect of harmonics on power quality – cost analysis techniques – lighting and energy standards. Cogeneration: forms of cogeneration – feasibility of cogeneration – electrical interconnection.

UNIT-VI: Economic Aspects and Analysis[7 Hours]

Economics Analysis-Depreciation Methods, time value of money, rate of return , present worth method , replacement analysis, life cycle costing analysis- Energy efficient motors- calculation of simple payback method, net present worth method- Power factor correction, lighting - Applications of life cycle costing analysis, return on investment.

References:-

1. Energy Efficiency for Engineers and Technologists,Eastop T.D and Croft D.R, Logman Scientific & Technical, 1990.
2. Industrial Energy Conservation , Reay D.A., first edition, Pergamon Press, 1977 .
3. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
4. Handbook on Energy Audits and Management,Amit K. Tyagi, TERI, 2003.
5 Guide to Energy Management, Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Fifth Edition, The Fairmont Press, Inc., 2006.

MTEPS206. SEMINAR-I

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS206	**SEMINAR-I**	**compulsory**	**0-4-0**	**42**

Evaluation scheme:

PR/OR	Test	Continuous Assessment	Total	Credits
50	0	50	100	2

Course Objective: To develop the analytical and practical skills in the students.

Course Outcomes:

Upon successful completion of this Seminar-I the student will be able to:

CO1	Develops writing technical report writing skill
CO2	Develops presentation skill

A candidate is required to develop report writing skills by studying recent technical topics based on knowledge of undergraduate courses and topics studied in the first/ second semester of his/ her interest and develop presentation skills through seminar.

MTEPS207 P G LABORATORY II / MINI PROJECT

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS207	**POWER SYSTEM LABORATORY –II or MINI- PROJECT**	**compulsory**	**0-4-0**	**42**

Evaluation scheme:

PR/OR	Test	Continuous Assessment	Total	Credits
50	0	50	100	2

Course Objective: To develop the analytical and practical skills in the students.

Course Outcomes:

Upon successful completion of this LAB-II / mini project the student will be able to:

CO1	Model the different electrical and electronics systems practically
CO2	Simulate and test the circuit performance for comparative study
CO3	Apply the knowledge to design the practical circuits for applications.

Representation of Power System Elements like Synchronous machines, transformers, transmission lines, loads, power system load flow, short circuit studies and power system stability studies using MATLAB-SIMULINK, PSCAD, CAPS softwares. Study of power semiconductor devices, study AC to DC, DC to DC converter circuits etc using softwares as well as by building up the circuits in laboratories

OR

MINI PROJECT

Project work based on signal analysis, signal conditioning, state of art, professional software acquaintance like MATALAB, ETAP, PSCAD, PSIM similar work.

MTME301 PROJECT MANAGEMENT AND INTELLECTUAL PROPERTY RIGHTS

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTME301	**PROJECT MANAGEMENT AND INTELLECTUAL PROPERTY RIGHTS**	**compulsory**	**0-0-0**	**-**

Evaluation scheme:

PR/OR	Test	Continuous Assessment	Total	Credits
50	0	50	100	2

Course Objectives:

Course Outcomes: At the end of the course the student will be able to:

CO1	Enumerate and demonstrate fundamental terms such as copy-rights ,Patents ,Trademarks etc.,
CO2	Interpret and follow Laws of copy-rights, Patents, Trademarks and various IP registration Processes to register own project research.
CO3	Exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms' commercial strategies.
CO4	Develop awareness at all levels (research and innovation) of society to develop patentable technologies.
CO5	Apply trade mark law, copy right law, patent law and also carry out intellectual property audits

CO6	Manage and safeguard the intellectual property and protect it against unauthorized use

Course Contents:

A. Project Management:

Unit-1

- Introduction to Project management**:** Characteristics of projects, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization. Work definition: Defining work content, Time Estimation Method, Project Cost Estimation and budgeting, Project Risk Management, Project scheduling and Planning Tools: Work Breakdown structure, LRC, Gantt charts, CPM/PERT Networks.

Unit-2

- Developing Project Plan (Baseline), Project cash flow analysis, Project scheduling with resource constraints: Resource Leveling and Resource Allocation. Time Cost Trade off: Crashing Heuristic.

Unit-3

- Project Implementation: Project Monitoring and Control with PERT/Cost, Computers applications in Project Management, Contract Management, and ProjectProcurement Management. Post-Project Analysis.

B. IPR:

Unit-4

- Introduction to IPR; Overview & Importance; IPR in India and IPR abroad; Patents ;their definition; granting; infringement ;searching & filing; Utility Models an introduction;

Unit-5

- Copyrights ; their definition; granting; infringement ;searching & filing, distinction between related and copy rights; Trademarks ,role in commerce ,importance , protection, registration; domain names;

Unit-6

- Industrial Designs ; Design Patents; scope; protection; filing infringement; difference between Designs & Patents' Geographical indications , international protection; Plant varieties; breeder's rights, protection; biotechnology& research and rights managements; licensing, commercialization; ; legal issues, enforcement ;Case studies in IPR.

TEXT BOOKS/REFERENCES:

1. Shtub,BardandGloberson,ProjectManagement:Engineering,Technology,andImplementation,Prentice Hall, India
2. Lock, Gower, Project Management Handbook.
3. Prabuddha Ganguli, IPR published by Tata McGraw Hill 2001

MTEPS302: PROJECT PHASE-I

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS302	**PROJECT PHASE-I**	**compulsory**	**0-0-0**	**-**

Evaluation scheme:

PR/OR	Test	Continuous Assessment	Total	Credits
50	0	50	100	14

Course Objectives: To apply engineering knowledge to solve problem industry or society

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify suitable area of work and conduct detailed literature survey
CO2	Formulate the problem statement
CO3	Define aim and objectives of with probable solution methodology

The candidate who has presented will now formulate an appropriate problem statement for topic selected and define the aim and objectives along with then probable methodologies useful for the solution for the problem statement at the end of semester he/ she will make a comprehensive project Phase-I report in detail and make the presentations along with the future work towards fulfillment of the Project Phase-I.

MTEPS401: PROJECT PHASE-II

Teaching Scheme:

Course code	Course name	Course	Teaching (L-P-T)	Total teaching hours
MTEPS401	**PROJECT PHASE-II**	**compulsory**	**0-0-0**	**-**

Evaluation scheme:

PR/OR	Test	Continuous Assessment	Total	Credits
100	0	100	200	28

Course Objectives: To design and analyze the performance of developed system

Course Outcomes: At the end of the course the student will be able to:

CO1	Design and test the developed system
CO2	Analyze the performance of the system
CO3	Write the technical report
CO4	Publish research paper

Based on the total work carried out in semester III and satisfactory performance, a candidate will be allowed to prepare the Project report for the final submission and evaluation.

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M.Tech (EPS) Semester: I Subject: Power System modeling

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Modeling of Power System Components**: The need for modeling of power system Different areas of power system analysis.	Chalk and board
	02	Description and modeling of boiler and steam turbine **Numerical**	PP T &Chalk and board
	03	Description and modeling of hydro turbine boiler **Numerical**	PP T &Chalk and board
	04	Description and modeling of governor system.	PP T &Chalk and board
	05	Description and modeling tap-changing transformer.	Chalk and board
	06	Description and modeling of phase shifting transformer.	Chalk and board
	07	**Numerical**	Chalk and board
	08	**Revision & Assignment**	Chalk and board
02	**09**	**Synchronous machine modeling.** Description construction of synchronous machine. Basic modeling equations of synchronous machine.	Chalk and board
	10	d-q transformation analysis	Chalk and board
	11	Design and development of synchronous machine modeling for steady state analysis.	Chalk and board
	12	Per unit model Numerical	Chalk and board
	13	Design and development of synchronous machine modeling for dynamic studies using flux linkage method	PP T & Chalk and board
	14	Design and development of synchronous machine modeling for dynamic studies using current linkage method	PP T & Chalk and board
	15	Design and development of synchronous machine modeling for simulation studies.	PP T & Chalk and board
	16	**Revision & Assignment**	Chalk and board
03	**17**	**Analysis of synchronous machine modeling** Analysis of Synchronous machine connected to an infinite bus (SMIB)	PP T & Chalk and board
	18	Numerical analysis	Chalk and board
	19	SMIB for steady state analysis	PP T & Chalk and board
	20	Numerical	
	21	Simulation for steady-state condition.	
04	**22**	**Excitation systems** Functions and Performance Requirements.Elements of an Excitation System.	PP T & Chalk and board
	23	Types Excitation Systems: DC Excitation Systems:	PP T & Chalk and

			board
	24	AC excitation systems	PP T & Chalk and board
	25	Staticexcitation systems	PP T & Chalk and board
	26	Control and Protective Functions	PP T & Chalk and board
	27	Dynamic performance measure large signal analysis	Chalk and board
	28	Dynamic performance measure small signal analysis	Chalk and board
05	**29**	**Excitation system modeling.** Modeling of Separately excited dc exciter	PP T & Chalk and board
	30	Modeling of Self-excited dc exciter	PP T & Chalk and board
	31	Modeling of *AC Exciter and Rectifier*	PP T & Chalk and board
	32	Modeling of *excitation system components*	PP T & Chalk and board
	33	Modeling of Complete Excitation Systems models	PP T & Chalk and board
	34	Modeling of Complete Excitation Systems models	PP T & Chalk and board
	35	Revision	
06	**36**	**Transmission line, SVC and load modeling:** Transmission line modeling	Chalk and board
	37	Numerical, Static load modeling	Chalk and board
	38	Dynamic load modeling, load modeling parameter acquisition methods	Chalk and board
	39	Induction motor modeling, Definition, need of static VAR compensators	Chalk and board
	40	classification of static VAR compensators, Design and Modeling of TCR	PP T & Chalk and board
	41	Design and Modeling of TSC	Chalk and board
	42	Design and Modeling of FC+TCRAND TSC+TCR	PP T & Chalk and board

References:

1. An Introduction to High Voltage Engineeril)g by Subir Ray, Prentice Hall of India Private Limited, New Delhi - 110 001.
2. Direct Current Transmission Vol-I, Kimbark E. W , Wiley Interscience
3. HVDC Transmission- Adamson C. Hingorani N. G.
4. EHV AC Transmission Rakosh Das Begamudre, New Age Publishers
5. HVAC and HVDC Transmission, Engineering and practice: S. Rao, Khanna Publisher, Delhi.
6. Electric Power Systems: B.M. Weddy and B.J. Cory, John Wiely and Sons, Fourth edition (2002)

7. Power System Analysis and Design : J. Duncan Glover, Mulukutla S. Sarma, Thomson Brooks/cole/ Third Edition (2003)

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: I **Subject**: Renewable Energy Sources

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Energy Scenario** Classification of Energy Sources., Energy resources (Conventional and nonconventional),	Chalk and board
	02	Energy needs of India and energy consumption patterns. World-wide Potentials of these sources.	PP T &Chalk and board
	03	Energy efficiency and energy security.	PP T &Chalk and board
	04	Energy and its environmental impacts.	PP T &Chalk and board
	05	Global environmental concern, Kyoto Protocol,	Chalk and board
	06	Concept of Clean Development Mechanism (COM) and Prototype Carbon Funds (PCF).	Chalk and board
	07	Factors favoring and against renewable	Chalk and board
02	**08**	**Solar Energy** Solar thermal Systems: Types of collectors,	Chalk and board
	09	Collection systems, efficiency calculations, applications.	Chalk and board
	10	Photo voltaic (PV) technology: Present status, - solar cells , cell technologies,	Chalk and board
	11	Characteristics of PV systems, equivalent circuit, array design ,	Chalk and board
	12	Building integrated PV system, its components, sizing and economics	Chalk and board
	13	Peak power operation.	PP T &Chalk and board
	14	Standalone and grid interactive systems	PP T &Chalk and board
03	**15**	**Wind Energy** Wind speed and power relation,	PP T &Chalk and board
	16	Power extracted from wind, wind distribution and wind speed predictions.	PP T &Chalk and board
	17	Wind power systems: system components, suitability of generators, turbine rating,	Chalk and board

	18	Electrical load matching, Variable speed operation,	PP T &Chalk and board
	19	Maximum power operation, control systems,	Chalk and board
	20	System design features, stand alone and grid connectivity,	PP T &Chalk and board
	21	Environmental impacts of wind farms.	PP T &Chalk and board
04	**22**	**Other Energy Sources** Biomass - various resources, energy contents, technological advancements,	PP T &Chalk and board
	23	Conversion of biomass in other form of energy - solid, liquid and gases, Gasifiers.	PP T &Chalk and board
	24	Biomass fired boilers, Co firing, Municipal solid waste systems.	Chalk and board
	25	Problems in harnessing, Hydro energy - feasibility of small.	Chalk and board
	26	mini and micro hydel plants scheme layout economics.	PP T &Chalk and board
	27	Tidal and wave energy - schemes, feasibility and viability.	PP T &Chalk and board
	28	Geothermal and Ocean thermal energy conversion (OTEC) systems - schemes, feasibility and viability, Fuel Cell Technology.	PP T &Chalk and board
05	**29**	**Energy storage and hybrid system configurations** Energy storage: Battery' - types, equivalent circuit, performance characteristics	PP T &Chalk and board
	30	Battery design, charging and charge regulators.	PP T &Chalk and board
	31	Battery management.	Chalk and board
	32	Fly wheel- energy relations, components, benefits over battery.	Chalk and board
	33	Stand alone systems,	Chalk and board
	34	Hybrid systems - hybrid with diesel, with fuel cell, solar-wind, wind - hydro systems,	Chalk and board
	35	Mode controller, load sharing, system sizing, Hybrid system economics	PP T &Chalk and board
06	**36**	**Grid Integration** Grid connected system and their electrical performance: Interface requirements	PP T &Chalk and board
	37	Synchronization with grid, inrush	PP T &Chalk and board
	38	Stable operation, load transient, safety.	PP T &Chalk and board
	39	Operating limits of voltage, frequency, stability margin,	PP T &Chalk and board
	40	Energy storage, and IQad scheduling.	PP T &Chalk and board

	41	Quality of power- harmonic distortion, voltage transients and sags, voltage flickers	PP T &Chalk and board
	42	Dynamic reactive power support. Systems stiffness, Effect of Utility restructuring.	PP T &Chalk and board

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

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: I **Subject**: Advanced Power Electronics

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Overview Of Switching Power Devices:** Solid State Power Semi-conducting Devices: Review of the thyristors, traic,	Chalk and board
	02	Review of GTO, transistor MOSFET	PP T &Chalk and board
	03	Commutation methods	PP T &Chalk and board
	04	Other modern power devices (IGBT, SIT) characteristics ratings	PP T &Chalk and board
	05	Other modern power devices (SITCH, MCT), characteristics ratings,	Chalk and board
	06	Commutation methods	Chalk and board
	07	Protection and requirement of firing circuits	Chalk and board
	08	Revision	
02	**09**	**Phase Controlled Rectifiers:** Principle of phase controlled converter operation- single phase full converter	Chalk and board
	10	Principle of phase controlled converter operation- semi converters- dual converters	Chalk and board
	11	Three phase full and semi converters	Chalk and board
	12	Reactive power- power factor improvements	Chalk and board
	13	extinction angle control	Chalk and board
	14	Reactive power- power factor improvements	PPT &Chalk and board
	15	Symmetrical angle control.	PPT &Chalk and board
	16	PWM control- SPWM control.	PPT &Chalk and board
03	**17**	**DC-DC Converters:** Study of Class – A- B- choppers- non-isolated	PPT &Chalk and board
	18	C- and D choppers- non-isolated	PPT &Chalk and board
	19	DC-DC converters	Chalk and board
	20	Buck-boost converters under continuous conduction operation	PP T &Chalk and board
	21	Buck-boost converters under discontinuous conduction operation	Chalk and board
	22	Isolated DC-DC converters: forward- fly-back- push-pull	PP T &Chalk and board

	23	Half-bridge- and full-bridge converters	PP T &Chalk and board
	24	Relationship between I/P and O/P voltages- expression for filter inductor and capacitors	PP T &Chalk and board
04	**25**	**Inverters:** Single-phase inverters- 120^0 and 180^0 modes of operation	PP T &Chalk and board
	26	Three-phase inverters- 120^0 and 180^0 modes of operation	PP T &Chalk and board
	27	PWM techniques: single PWM techniques	Chalk and board
	28	multiple- and sinusoidal PWM techniques	Chalk and board
	29	Selective harmonic elimination- space vector modulation	PP T &Chalk and board
	30	Current source inverter	PP T &Chalk and board
	31	Multi-level inverters	
	32	Techniques for reduction of harmonics	
05	**33**	Advanced power conversion techniques, Multilevel converters etc.	PP T &Chalk and board
	34	Resonant power conversion	PP T &Chalk and board
	35	Multi-Resonant Converters	Chalk and board
	36	Multilevel converters	Chalk and board
	37	Multilevel converters	PP T &Chalk and board
06	**38**	Power Electronics Controller for Wind Energy,	PP T &Chalk and board
	39	Electric Conversion Systems	PP T &Chalk and board
	40	Photo Voltaic Arrays	PP T &Chalk and board
	41	Energy Saving in AC Drives	PP T &Chalk and board
	42	Energy Saving in DC Drives	PP T &Chalk and board

Reference:

1. Power Electronics-circuits, Devices & Applications**,** M.H. Rashid **:** 3rd ed., PHI, 2005.

2. Power Electronics: Converters, Applications**,** Ned Mohan, T.M. Undeland, William P. Robbins**:** 3rd ed., John Wiley & Sons, 2009

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: I**Subject**: High Voltage Power Transmission

Unit	Period	Details of Coverage	Teaching aids used
Part I : HIGH VOLTAGE AC TRANSMISSION			
01	**01**	**Engineering Aspects of EHV AC Transmission System.** Principles, configuration, special features of high voltage AC lines,	Chalk and board
	02	Power transfer ability, reactive power compensation,	Chalk and board
	03	Audible noise, corona bundle conductors, Electric field, right of way	Chalk and board
	04	Clearances in a tower, phase to phase, phase to ground, phase to tower,	Chalk and board
	05	Factors to be considered, location of ground wire,	Chalk and board
	06	Angle of protection, clearances, tower configuration, Principles of radio interference.	Chalk and board
	07	origin of radio interference, method of propagation, Factors to be considered in line design.	Chalk and board
02	**08**	**Power system transients** Introduction, circuit closing transients, sudden symmetrical short circuit of alternator,	Chalk and board
	09	Recovery transients due to removal of short circuit, Traveling waves on transmission lines,	Chalk and board
	10	wave equation, surge impedance and wave velocity, Specifications of traveling waves, reflection and refraction of waves,	Chalk and board
	11	typical cases of line terminations , Equivalent circuit for traveling wave studies, forked lines,	Chalk and board
	12	reactive termination, successive reflections, Bewley lattice diagram, attenuation and distortion, arcing grounds,	Chalk and board
	13	Capacitance switching, current chopping, lightning phenomenon, Over voltages due to lightning,	Chalk and board
	14	Line design based on direct strokes, Protection of systems against surges, statistical aspects of insulation coordination	Chalk and board
03	**15**	Biological effects of electric field, Safe values of electric field,	Chalk and board
	16	Requirements of transmission line, Live line maintenance	Chalk and board
	17	Special tools for line maintenance	Chalk and board
	18	Procedure for line maintenance	Chalk and board
	19	Methods of voltage control, tap changing,.	Chalk and board
	20	Shunt compensation	Chalk and board
	21	Shunt rectors and shunt capacitors	Chalk and board

04	**22**	**General background** EHV AC versus HVDC transmission, Power flow through HVDC link	Chalk and board
	23	Equation for HVDC power flow, HVDC power flow - effect of delay angle	Chalk and board
	24	HVDC power flow - angle of advance, bridge connections	Chalk and board
	25	Waveform of six pulse, commutation, phase control, angle of extinction, control of DC voltage,	Chalk and board
	26	Waveform of twelve pulse bridge converter, commutation, phase control, angle of extinction, control of DC voltage,	Chalk and board
	27	Three phase six pulse converter bridges, voltage and current waveforms	Chalk and board
	28	Twelve pulse converter bridges, voltage and current waveforms	Chalk and board
05	**29**	Bipolar HVDC terminal, converter transformer connections,	Chalk and board
	30	switching arrangements in DC yard for earth return to metallic return, HVDC switching system,	Chalk and board
	31	switching arrangements in a bipolar HVDC terminal, sequence of switching operations,	Chalk and board
	32	HVDC circuit breakers, DC current interruption, commutation principle,	Chalk and board
	33	probable types and applications of HVDC circuit breakers, multi-terminal HVDC systems,	Chalk and board
	34	parallel tapping, reversal of power, configurations and types of multi-terminal HVDC systems,	Chalk and board
	35	commercial multi terminal systems.	Chalk and board
			Chalk and board
06	**36**	Faults and abnormal condition in bipolar, two terminal HVDC system,	Chalk and board
	37	Pole-wise segregation, protective zones, clearing of DC line faults and reenergizing	Chalk and board
	38	Protection .of converters, transformer, converter valves, DC yards, integration of protection 'and controls	Chalk and board
	39	Hierarchical levels of control, block diagram, schematic diagram, current control, power control	Chalk and board
	40	DC voltage control, commutation channel, master control, station control	Chalk and board
	41	Lead station, trail station, pole control, equidistant firing control,	Chalk and board
	42	Synchronous HVDC link, asynchronous HVDC Link	Chalk and board

References:

1. An Introduction to High Voltage Engineering by Subir Ray, Prentice Hall of India Private Limited, New Delhi - 110 001.

2. Direct Current Transmission Vol-I, Kimbark E. W , Wiley Interscience

3. HVDC Transmission- Adamson C. Hingorani N. G.

4. EHV AC Transmission Rakosh Das Begamudre, New Age Publishers

5. HVAC and HVDC Transmission, Engineering and practice: S. Rao, Khanna Publisher, Delhi.

6. Electric Power Systems: B.M. Weddy and B.J. Cory, John Wiely and Sons, Fourth edition (2002) .

7. Power System Analysis and Design : J. Duncan Glover, Mulukutla S. Sarma,Thomson Brooks/cole/ Third Edition (2003)

8. Power System Analysis and Design, B.R. Gupta, S.Chand and Company (2004)

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: I **Subject**: Advance Topics In Power System

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	Generation Control Loops	PPT, Chalk and board
	02	AVR Loop: Performance, AVR Loop: Response	PPT, Chalk and board
	03	Automatic Generation Control Of Single Area Systems	PPT, Chalk and board
	04	Automatic Generation Control Of Multi Area Systems	PPT, Chalk and board
	05	Static Response Of AGC Loops	PPT, Chalk and board
	06	Dynamic Response Of AGC Loops	PPT, Chalk and board
	07	Economic Dispatch And AGC	PPT, Chalk and board
02	**08**	Transient Stability Problem, Modeling Of Synchronous Machine	PPT, Chalk and board
	09	Modeling Of Loads Network	PPT, Chalk and board
	10	Modeling Of Excitation Systems	PPT, Chalk and board
	11	Turbine And Governing Systems	PPT, Chalk and board
	12	Trapezoidal Rule Of Numerical Integration Technique For Transient Stability Analysis	PPT, Chalk and board
	13	Data For Transient Stability Studies	PPT, Chalk and board
	14	Transient Stability Enhancement Methods	PPT, Chalk and board
03	**15**	Low Frequency Oscillations, Classification of Low Frequency Oscillations	
	16	Power System Model For Low Frequency Oscillation Studies	PPT, Chalk and board
	17	Eigen value analysis for Power System Modeling	PPT, Chalk and board
	18	Improvement Of System Damping With Supplementary Excitation Control	PPT, Chalk and board
	19	Damping Low Frequency Oscillation	PPT, Chalk and board
	20	Introduction To Sub Synchronous Resonance	PPT, Chalk and board

	21	Introduction To Counter measures	PPT, Chalk and board
04	**22**	Introduction to Voltage Stability Problem	PPT, Chalk and board
	23	Real Power Flow In Long Transmission Lines	PPT, Chalk and board
	24	Reactive Power Flow In Long Transmission Lines	PPT, Chalk and board
	25	Effect Of ULTC And Load Characteristics On Voltage Stability	PPT, Chalk and board
	26	Voltage Stability Limit ,Voltage Stability Assessment Using PV Curves	PPT, Chalk and board
	27	Voltage Collapse Proximity Indices	PPT, Chalk and board
	28	Voltage Stability Improvement Methods	PPT, Chalk and board
05	**29**	Contingency analysis ZBUS Method in Contingency Analysis	PPT, Chalk and board
	30	Adding & Removing Multiple Lines	PPT, Chalk and board
	31	Piecewise Solution of Interconnected Systems	PPT, Chalk and board
	32	Analysis of Single Contingencies	PPT, Chalk and board
	33	Analysis of Multiple Contingencies	PPT, Chalk and board
	34	Contingency Analysis of DC Model	PPT, Chalk and board
	35	System Reduction for Contingency and Fault Studies	PPT, Chalk and board
06	**36**	Introduction to power system security, System state classification	PPT, Chalk and board
	37	Load Forecasting & State Estimation	PPT, Chalk and board
	38	Estimation of average & periodic components of load	PPT, Chalk and board
	39	Estimation of stochastic components of load	PPT, Chalk and board
	40	Basic idea of state estimation of power system..	PPT, Chalk and board
	41	State estimation in power systems Security analysis	PPT, Chalk and board
	42	Revision	PPT, Chalk and board

Reference books:

1. Electric Energy System Theory: An Introduction. O.I. Elgard, .II Edition, McGraw Hill, New York, 1982.
2. Power Generation, Operation And Control., A.J. Wood, B.F. Wollenberg, .John Wiley And Sons, New York, 1984, 2nd Edition: 1996.
3. Computer Modeling Of Electrical Power Systems., J. Arrilaga, C.P. Arnold, B.J. Harker, Wiley, New York, 1983.
4. Power System Engineering, I.J. Nagrath, O.P. Kothari, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.
5. Electric Power System Dynamics, Yao-Nan-Yu,
6. Power System Stability and Control. P. Kundur McGraw Hill, New York, 1994.
7 Power System Dynamics, Stability and Control, K.R. Padiyar Interline Publishing (P) Ltd., Bangalore, 1999.
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9. Power System Analysis and Design. B.R. Gupta, III Edition, A.H. Wheeler & Co. Ltd., New Delhi, 1998.
10. Reactive Power Control in Electric Power Systems. T.J.E. Miller John Wiley and Sons, New York, 1982.

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE
DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: I **Subject**: Electrical Transients In Power System

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**REVIEW OF TRAVELLING WAVE PHENOMENA** Lumped and Distributed Parameters	PPT, Chalk and board
	02	Travelling-wave phenomena of three-phase transmission line	PPT, Chalk and board
	03	Line-to-ground travelling waves	PPT, Chalk and board
	04	Line-to-line travelling waves	PPT, Chalk and board
	05	Wave Equation – Reflection	PPT, Chalk and board
	06	Wave Equation Refraction	PPT, Chalk and board
	07	Behaviour of Travelling waves at the line terminations	PPT, Chalk and board
	08	Lattice Diagrams, Attenuation and Distortion	PPT, Chalk and board
			PPT, Chalk and board
02	**09**	**LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES** Lightning overvoltages	PPT, Chalk and board
	10	Interaction between lightning and power system	PPT, Chalk and board
	11	Ground wire voltage	PPT, Chalk and board
	12	Voltage across insulator	PPT, Chalk and board
	13	Switching overvoltage: Short line or kilometric fault	PPT, Chalk and board
	14	Energizing transients - closing and re-closing of lines	PPT, Chalk and board
	15	Methods of control	PPT, Chalk and board
	16	Temporary overvoltages: line dropping, load rejection; voltage induced by fault	PPT, Chalk and board
	17	Very fast transient overvoltage (VFTO)	PPT, Chalk and board
03	**18**	**PARAMETERS AND MODELLING OF OVERHEAD LINES**	PPT, Chalk and

		Review of line parameters for simple configurations: series resistance	board
	19	Line parameters for simple configurations: inductance	PPT, Chalk and board
	20	Line parameters for simple configurations: shunt capacitance	PPT, Chalk and board
	21	Bundle conductors : equivalent GMR and equivalent radius	PPT, Chalk and board
	22	Introduction to modal propagation in transmission lines	PPT, Chalk and board
	23	Modes on multiphase transposed transmission lines, α-β-0 transformation	PPT, Chalk and board
	24	Symmetrical components transformation, modal impedances	PPT, Chalk and board
	25	Analysis of modes on untransposed lines	PPT, Chalk and board
	26	Effect of ground return and skin effect; transposition schemes	PPT, Chalk and board
04	**27**	**PARAMETERS OF UNDERGROUND CABLES** Distinguishing features of underground cables: technical features	PPT, Chalk and board
	28	Distinguishing features of underground cables: electrical parameters	PPT, Chalk and board
	29	Overhead lines versus underground cables	PPT, Chalk and board
	30	Cable types; single-core self-contained cables, Series impedance of single-core self-contained cables	PPT, Chalk and board
	31	Shunt admittance of single-core self-contained cables	PPT, Chalk and board
	32	Impedance matrices for three phase system formed by three single-core self-contained cables	PPT, Chalk and board
	33	Admittance matrices for three phase system formed by three single-core self-contained cables	PPT, Chalk and board
	34	Approximate formulas for cable parameters	PPT, Chalk and board
05	**35**	**COMPUTATION OF POWER SYSTEM TRANSIENTS - EMTP** Digital computation of line parameters	PPT, Chalk and board
	36	Line parameter evaluation programs, Salient features of M.T. line	PPT, Chalk and board
	37	Constructional features of that affect transmission line parameters;	PPT, Chalk and board
	38	Elimination of ground wires bundling of conductors	PPT, Chalk and board
	39	Principle of digital computation of transients: features of EMTP	PPT, Chalk and board
	40	Principle of digital computation of transients: capabilities of EMTP	PPT, Chalk and board
	41	Steady state modules: basic solution methods	PPT, Chalk and board

	42	Time step solution modules: basic solution methods	

References:

1. Electrical Transients in Power System, Allan Greenwood Wiley & Sons Inc. New York, 1991.

2. Extra High Voltage AC Transmission Engineering, Rakosh Das Begamudre, (Second edition)

Newage International (P) Ltd., New Delhi, 1990.

3. High Voltage Engineering, Naidu M S and Kamaraju V, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

4.EMTP Theory Book, Hermann W. Dommel, second Edition, Microtran Power System Analysis Corporation, Vancouver, British Columbia, Canada, May 1992,

Last Update: April 1999.

5. EMTP Literature from www.microtran.com.

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Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: I **Subject**: Power System Planning And Reliability

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Load Forecasting** Introduction, Factors affecting Load Forecasting, Load Growth Characteristics	Chalk and board
	02	Classification of Load and Its Characteristics	PP T &Chalk and board
	03	Load Forecasting Methods (i) Extrapolation (ii) Co-Relation Techniques	PP T &Chalk and board
	04	Energy Forecasting, Peak Load Forecasting,	PP T &Chalk and board
	05	Reactive Load Forecasting, Non-Weather Forecasting	PP T &Chalk and board
	06	Weather Forecasting, Annual Forecasting	PP T &Chalk and board
	07	Monthly Forecasting, Total Forecasting	PP T &Chalk and board
02	**08**	**System Planning** Introduction to System Planning	Chalk and board
	09	Objectives of System Planning	Chalk and board
	10	Factors affecting to System Planning	Chalk and board
	11	Short Term Planning	Chalk and board
	12	Medium Term Planning	Chalk and board
	13	Long Term Planning	PP T &Chalk and board
	14	Reactive Power Planning	PP T &Chalk and board
03	**15**	**Reliability** Reliability, Failure, Concepts of Probability	PP T &Chalk and board
	16	Evaluation Techniques (i) Markov Process	PP T &Chalk and board
	17	Evaluation Techniques (ii) Recursive Technique	Chalk and board
	18	Stochastic Prediction of Frequency	PP T &Chalk and board
	19	Duration of Long Interruption	Chalk and board
	20	Duration of Short Interruption	PP T &Chalk and board
	21	Adequacy of Reliability, Reliability Cost	PP T &Chalk and board

04	**22**	**Generation Planning and Reliability** Objectives & Factors affecting Generation Planning	PP T &Chalk and board
	23	Generation Sources, Generation System Model	PP T &Chalk and board
	24	Loss of Load (Calculation and Approaches)	Chalk and board
	25	Outage Rate, Capacity Expansion	PP T &Chalk and board
	26	Scheduled Outage, Loss of Energy,	PP T &Chalk and board
	27	Evaluation Methods. Interconnected System	PP T &Chalk and board
	28	Factors Affecting Interconnection under Emergency Assistance	Chalk and board
05	**29**	**Transmission Planning and Reliability** Introduction, Objectives of Transmission Planning, Transmission system reliability evaluation	PP T &Chalk and board
	30	Security Analysis, Transmission Reliability Analysis	Chalk and board
	31	Generation reliability and its relationship to transmission system design	Chalk and board
	32	"Optimal" transmission plan	Chalk and board
	33	Network Reconfiguration	Chalk and board
	34	System and Load Point Indices	PP T &Chalk and board
	35	Data required for Composite System Reliability	PP T &Chalk and board
06	**36**	**Distribution Planning and Reliability** Radial Networks - Introduction, Network Reconfiguration	PP T &Chalk and board
	37	Evaluation Techniques, Interruption Indices	PP T &Chalk and board
	38	Effects of Lateral Distribution Protection Effects of Disconnects,	PP T &Chalk and board
	39	Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices	PP T &Chalk and board
	40	Parallel & Meshed Networks - Introduction, Basic Evaluation Techniques	PP T &Chalk and board
	41	Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure	PP T &Chalk and board
	42	Weather Effects, Breaker Failure	PP T &Chalk and board

References:

1. Modern Power System Planning - X. Wang & J.R. McDonald, McGraw Hill Book Company
2. Power System Planning - R.N. Sullivan, Tata McGraw Hill Publishing Company Ltd.
3. Electrical Power Distribution Engineering - T. Gonen, McGraw Hill Book Company
4. Reliability Evaluation of Power System - Roy Billinton & Ronald N. Allan,

Springer Publication
5. Generation of Electrical Energy - B.R. Gupta, S. Chand Publications
6. Electrical Power Distribution A.S. Pabla Tata McGraw Hill Publishing Company Ltd.
7.Electricity Economics & Planning - T.W.Berrie, Peter Peregrinus Ltd., London

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Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: I **Subject**: Power Quality Assessment And Mitigation

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Introduction** Importance of power quality	Chalk and board
	02	Terms and definitions of power quality as per IEEE std. 1159. such as transients	PPT &Chalk and board
	03	Short and long duration voltage variations, interruptions	PPT &Chalk and board
	04	Short and long voltage fluctuations, imbalance, flickers and transients	PPT &Chalk and board
	05	Symptoms of poor power quality	Chalk and board
	06	Definitions and terminology of grounding. Purpose of groundings	PPT &Chalk and board
	07	Good grounding practices and problems due to poor grounding	PPT &Chalk and board
02	**08**	**Flickers & transient voltages** RMS voltage variations in power system and voltage regulation per unit system, complex power	Chalk and board
	09	Principles of voltage regulation. Basic power flow and voltage drop	Chalk and board
	10	Various devices used for voltage regulation and impact of reactive power management	Chalk and board
	11	Various causes of voltage flicker and their effects	Chalk and board
	12	Short term and long term flickers. Various means to reduce flickers	Chalk and board
	13	Transient over voltages, sources, impulsive transients, switching transients	PP T &Chalk and board
	14	Effect of surge impedance and line termination, control of transient voltages	PP T &Chalk and board
03	**15**	**Voltage sag and interruptions** Definitions of voltage sag and interruptions. Voltage sags versus interruptions	PP T &Chalk and board
	16	Economic impact of voltage sag. Major causes and consequences of voltage sags. Voltage sag characteristics	PP T &Chalk and board
	17	Voltage sag assessment. Influence of fault location and fault level on voltage sag. Areas of vulnerability	Chalk and board
	18	Assessment of equipment sensitivity to voltage sags. Voltage sag requirements for computer equipment, CBEMA, ITIC, SEMI F 42 curves	PP T &Chalk and board
	19	Representation of the results of voltage sags analysis. Voltage sag indices	Chalk and board
	20	Mitigation measures for voltage sags, such as UPS, DVR, SMEs, CVT	PP T &Chalk and

		etc	board
	21	Utility solutions and end user solutions	PP T &Chalk and board
04	**22**	**Waveform Distortion** Definition of harmonics, inter-harmonics, sub-harmonics. Causes and effect of harmonics.	PP T &Chalk and board
	23	Voltage versus current distortion. Overview of Fourier analysis, Harmonic indices. A.C. quantities under non-sinusoidal conditions.	PP T &Chalk and board
	24	Triplen harmonics, characteristics and non characteristics harmonics. Harmonics series and parallel resonances.	Chalk and board
	25	Consequences of harmonic resonance. K-rated transformer. Principles for controlling harmonics	Chalk and board
	26	Reducing harmonic currents in loads. Harmonic study procedure. Computer tools for harmonic analysis	PP T &Chalk and board
	27	Locating sources of harmonics. Harmonic filtering, passive and active filters	PP T &Chalk and board
	28	Modifying the system frequency response. IEEE Harmonic standard 519-1992	PP T &Chalk and board
05	**29**	**Power quality monitoring** Need of power quality monitoring, Approaches followed in power quality monitoring	PP T &Chalk and board
	30	Power quality monitoring objectives and requirements	PP T &Chalk and board
	31	Initial site survey. Power quality Instrumentation	Chalk and board
	32	Selection of power quality monitors, selection of monitoring location & period	Chalk and board
	33	System wide and discrete power quality monitoring	Chalk and board
	34	Setting thresholds on monitors, data collection and analysis. Selection of transducers.	Chalk and board
	35	Harmonic monitoring , Transient monitoring, event recording and flicker monitoring	PP T &Chalk and board
			PPT &Chalk and board
06	**36**	**Power Quality Assessment and Mitigation** Power Quality assessment, Power quality indices,	PPT &Chalk and board
	37	Standards for assessment disturbances, waveform distortion	PPT &Chalk and board
	38	Voltage and current unbalances	PPT &Chalk and board
	39	Power assessment under waveform distortion conditions	PPT &Chalk and board
	40	Power quality state estimation, State variable model	PP T &Chalk and board
	41	Observity analysis, capabilities of harmonic state estimation. Test systems	PP T &Chalk and board

	42	Mitigation techniques at different environments	PP T &Chalk and board

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1. Understanding power quality problems, voltage sag and interruptions - M. H. J. Bollen IEEE press, 2000, series on power engineering.
2. Electrical power system quality - Pogei G. Dugan, Mark F. McGranghan, Surya santoso, H. Wayne Beaty, second edition, McGraw Hill Pub.
3. Power system quality assessment - J. Arrillaga, M.R. Watson, S. Ghan, John Wiley and sons.

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: II **Subject**: Energy Management And Auditing

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Basic principles of energy audit** Energy audit- definitions, concept , types of audit, energy index, cost index ,pie charts, sankey diagrams, load profiles,	Chalk and board
	02	Energy conservation schemes	Chalk and board
	03	Energy audit of industries- energy saving potential,	Chalk and board
	04	Energy audit of process industry, thermal power station	Chalk and board
	05	Building energy audit Need for energy management and energy basics	Chalk and board
	06	Designing and starting an energy management program ,energy audit process	Chalk and board
	07	Energy accounting – energy monitoring, targeting and reporting	Chalk and board
02	**08**	**Energy cost and load management** Important concepts in an economic analysis	Chalk and board
	09	Economic models	Chalk and board
	10	Time value of money ,utility rate structures	Chalk and board
	11	Cost of electricity ,loss evaluation.	Chalk and board
	12	Load management: demand control techniques	Chalk and board
	13	Load management: utility monitoring and control system	Chalk and board
	14	HVAC and energy management – economic justification	Chalk and board
03	**15**	**Energy efficient motors** Energy efficient motors , factors affecting efficiency,	Chalk and board
	16	Loss distribution , constructional details ,	Chalk and board
	17	Characteristics - variable speed , variable duty cycle systems,	Chalk and board
	18	RMS hp- voltage variation-voltage unbalance	Chalk and board

	19	Capacitors and synchronous machines	Chalk and board
	20	Over motoring- such as : electric motors – transformers and reactors	Chalk and board
	21	Motor energy audit applications to Systems and equipment	Chalk and board
04	**22**	**Metering for energy management** Relationships between parameters :-units of measure; typical cost factors	Chalk and board
	23	Utility meters, Timing of meter disc for kilowatt measurement	Chalk and board
	24	Demand meters – paralleling of current transformers	Chalk and board
	25	Instrument transformer burdens	Chalk and board
	26	Multitasking solid-state meters	Chalk and board
	27	Metering location vs. Requirements.	Chalk and board
	28	Metering techniques and practical examples	Chalk and board
05	**29**	**Lighting systems and cogeneration** Concept of lighting systems – the task and the working space –	Chalk and board
	30	Light sources — ballasts –luminaries – lighting controls	Chalk and board
	31	Optimizing lighting energy–	Chalk and board
	32	Power factor and effect of harmonics on power quality	Chalk and board
	33	Cost analysis techniques – lighting and energy standards.	Chalk and board
	34	Cogeneration: forms of cogeneration	Chalk and board
	35	Cogeneration: feasibility of cogeneration, Cogeneration: electrical interconnection.	Chalk and board
06	**36**	**Economic aspects and analysis** Economics analysis-depreciation methods,	Chalk and board
	37	Time value of money ,rate of return	Chalk and board
	38	,Present worth method , replacement analysis	Chalk and board
	39	Life cycle costing analysis- Energy efficient motors	Chalk and board

	40	Calculation of simple payback method	Chalk and board
	41	Net present worth method- Power factor correction	Chalk and board
	42	Lighting - Applications of life cycle costing analysis, Return on investment.	Chalk and board

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1. Energy Efficiency for Engineers and Technologists, Eastop T.D and Croft D.R, Logman Scientific & Technical, 1990.
2. Industrial Energy Conservation , Reay D.A., first edition, Pergamon Press, 1977 .
3. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.
4. Handbook on Energy Audits and Management, Amit K. Tyagi, TERI, 2003.
5 Guide to Energy Management, Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Fifth Edition, The Fairmont Press, Inc., 2006.

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: I **Subject**: Communication Skill

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Communication and Communication Processes:** Introduction to Communication,	Chalk and board
	02	Forms and functions of Communication, Barriers to Communication,	Chalk and board
	03	Overcoming them, Verbal and Non-verbal Communication,	Chalk and board
	04	Ways of Effective Communication.	Chalk and board
02	**06**	**OralCommunication** Use of Language in Spoken Communication,	Chalk and board
	07	Features of Good Communication, Principles and Practice of Group Discussion,	Chalk and board
	08	Public Speaking (Addressing Small Groups and Making Presentation), Interview Techniques,	Chalk and board
	09	Appropriate Use of Non-verbal Communication, Presentation Skills,	Chalk and board
	10	Telephonic Etiquettes, Extempore, Elocution, Describing Experiences and Events.	Chalk and board
03	**11**	**Study of Sounds in English** Introduction to phonetics,	Chalk and board
	12	Study of Speech Organs, Study of Phonemic Script,	Chalk and board
	13	Articulation of Different Sounds in English,	Chalk and board
	14	Stress Mark.	Chalk and board
04	**15**	**English Grammar** Grammar: Forms of Tenses, Articles, Prepositions,	Chalk and board
	16	Use of Auxiliaries and Modal Auxiliaries, Synonyms and Antonyms,	Chalk and board
	17	Common Errors, Sentence Formation and Sentence Structures,	Chalk and board
	18	Use of Appropriate Diction.	Chalk and board
05	**19**	**Writing Skills** Features of Good Language, Difference between Technical Style and Literary Style,	Chalk and board

	20	Writing Emails, Formal and Informal English, Business Writing,	Chalk and board
	21	Advertisements, Essay Writing, (Technical, Social, and Cultural Topics),	Chalk and board
	22	Technical Reports: Report Writing: Format, Structure and Types, Writing Memorandum, Circulars, Notices, Agenda and Minutes, Technical Manuals, Brochures	Chalk and board
	23	Letter Writing: Types, Parts, Layouts, Letters and Applications,	Chalk and board
	24	Use of Different Expressions and Style, Writing Job Application Letter and Resume.	Chalk and board
06	**25**	**Reading Skills & Listening Skills** **Reading:** Introduction to Reading, Barriers to Reading,	Chalk and board
	26	Types of Reading: Skimming, Scanning, Fast Reading,	Chalk and board
	27	Strategies for Reading, Comprehension.	Chalk and board
	28	**Listening :** Importance of Listening, Types of Listening, Barriers to Listening.	Chalk and board

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1. *Communications Skills for Engineers*, Mohd. Ashraf Rizvi, Tata McGraw Hill
2. *Communication Skills*, Sanjay Kumar, Pushp Lata Oxford University Press, 2016
3. *Communication Skills*, Meenakshi Raman, Sangeeta Sharma,Oxford University Press, 2017
4. Michael Gamble, *Communication Works*, Teri Kwal Gamble, Tata McGraw Hill Education, 2010

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: II **Subject**: Power System Dynamics And Control

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**DYNAMICS OF SYNCHRONOUS GENERATOR CONNECTED TO INFINITE BUS** Review of Classical Methods System model	Chalk and board
	02	States of operation and system security	Chalk and board
	03	Steady state stability, transient stability	Chalk and board
	04	Simple representation of excitation control	Chalk and board
	05	System model, synchronous machine model	Chalk and board
	06	Calculation of Initial conditions, system simulation	Chalk and board
	07	Other machine models, inclusion of SVC model	Chalk and board
02	**08**	**ANALYSIS OF SINGLE AND MULTI-MACHINE SYSTEM** Small signal analysis	Chalk and board
	09	Applications of Routh-Hurwitz criterion	Chalk and board
	10	Analysis of synchronizing and damping torque	Chalk and board
	11	State equation for small signal model	Chalk and board
	12	Simplified model, Improved model of the system for linear load	Chalk and board
	13	Inclusion of dynamics of load and SVC	Chalk and board
	14	Introduction to analysis of large power system	Chalk and board
03	**15**	**POWER SYSTEM STABILIZERS** Basic concepts of control signals in PSS	Chalk and board
	16	Structure of PSS	Chalk and board
	17	Tuning of PSS	Chalk and board
	18	Field implementation and operating experiences	Chalk and board
	19	Example of PSS design and application	Chalk and board
	20	Future trends of PSS	Chalk and board
04	**21**	**SMALL-SIGNAL STABILITY ANALYSIS WITHOUT CONTROLLERS** Classification of Stability	Chalk and board
	22	Basic Concepts and Definitions: Rotor angle stability	Chalk and board
	23	The Stability Phenomena	Chalk and board
	24	Fundamental Concepts of Stability of Dynamic Systems	Chalk and board
	25	Statespace representation, stability of dynamic system, Linearization,	Chalk and board
	26	Eigen properties of the state matrix: Eigen values and eigenvectors, modal matrices, Eigen value and stability, mode shape and participation	Chalk and board

		factor.	
	27	Single-Machine Infinite Bus (SMIB) Configuration: Classical Machine Model stability analysis with numerical example	Chalk and board
	28	Effects of Field Circuit Dynamics: synchronous machine, network and linearised system equations, block diagram representation with K-constants; expression for K-constants (no derivation)	Chalk and board
	29	Effect of field flux variation on system stability: analysis with numerical example.	Chalk and board
05	**30**	**SMALL-SIGNAL STABILITY ANALYSIS WITH CONTROLLERS** Effects Of Excitation System: Equations with definitions of appropriate K-constants	Chalk and board
	31	Simple thyristor excitation system, AVR block diagram with the excitation system	Chalk and board
	32	Analysis of effect of AVR on synchronizing and damping components using a numerical example	Chalk and board
	33	Power System Stabilizer: Block diagram with AVR and PSS, Illustration of principle of PSS application with numerical example	Chalk and board
	34	Block diagram of PSS with description, system state matrix including PSS, analysis of stability with numerical a example	Chalk and board
	35	Multi-Machine Configuration: Equations in a common reference frame, equations in individual machine rotor coordinates	Chalk and board
	36	Illustration of formation of system state matrix for a two-machine system with classical models for synchronous machines, illustration of stability analysis using a numerical example	Chalk and board
	37	Principle behind small-signal stability improvement methods: delta-omega and delta P-omega stability	Chalk and board
06	**38**	**ENHANCEMENT OF SMALL SIGNAL STABILITY** Power System Stabilizer – Stabilizer based on shaft speed signal	Chalk and board
	39	Delta –P-Omega stabilizer, Frequency-based stabilizers	Chalk and board
	40	Digital Stabilizer – Excitation control design	Chalk and board
	41	Exciter gain – Phase lead compensation	Chalk and board
	42	Stabilizing signal washout stabilizer gain	Chalk and board
	43	Stabilizer limits	Chalk and board

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1.Power System Dynamics and Stability, P. W. Sauer and M. A. Pai,, Stipes Publishing Co, 2007

2. Dynamic Models for Steam and Hydro Turbines in Power System Studies, IEEE Committee Report, IEEE Trans., Vol.PAS-92, pp 1904-1915, November/December, 1973. on Turbine-Governor Model.

3. Power System Control and Stability, P.M Anderson and A.A Fouad, Iowa State University Press, Ames, Iowa, 1978.

4. Power System Dynamics Analysis and Simulation, R.Ramunujam, PHI Learning Private Limited, New Delhi, 2009

5. Power System Stability and Control, P. Kundur, McGraw-Hill, 1993.

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: II **Subject**: Advanced Power System Protection

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Static relays** Advantages of static relays-basic construction of static relays	Chalk and board
	02	Level detectors	Chalk and board
	03	Replica impedance	Chalk and board
	04	Mixing circuits	Chalk and board
	05	General equation for two input phase and amplitude comparators	Chalk and board
	06	Duality between amplitude and phase comparators	Chalk and board
	07	AMPLITUDE COMPARATORS: Circulating current type	Chalk and board
	08	Opposed voltage type- rectifier bridge comparators,	Chalk and board
	09	Direct and Instantaneous comparators	Chalk and board
02	**10**	**Phase comparators** Coincidence circuit type	Chalk and board
	11	Block spike phase comparator	Chalk and board
	12	Techniques to measure the period of coincidence, Integrating type-Rectifier	Chalk and board
	13	Vector product type- Phase comparators.	Chalk and board
	14	STATIC OVER CURRENT RELAYS: Instantaneous over-current relay	Chalk and board
	15	STATIC OVER CURRENT RELAYS: Time over-current relays	Chalk and board
	16	Definite time over-current relays	Chalk and board
	17	Inverse definite time over-current relays	Chalk and board
03	**18**	**STATIC DIFFERENTIAL RELAYS** Analysis of Static Differential Relays	PP T &Chalk and board
	19	Analysis of Static Relay schemes	Chalk and board
	20	Analysis of Duo bias transformer differential protection	Chalk and board
	21	Analysis of Harmonic restraint relay	Chalk and board
	22	Static distance relays: Static impedance-reactance relay sampling comparator	Chalk and board
	23	MHO relay sampling comparator	Chalk and board
	24	Angle impedance relay sampling comparator	Chalk and board

	25	Realization of reactance using sampling comparator	Chalk and board
	26	Realization of MHO relay using sampling comparator.	Chalk and board
04	**27**	**MULTI-INPUT COMPARATORS** Conic section characteristics-Three input amplitude comparator –Hybrid comparator	PP T &Chalk and board
	28	Switched distance schemes	PP T &Chalk and board
	29	Poly phase distance schemes	Chalk and board
	31	Phase fault scheme	Chalk and board
	32	Three phase scheme, Combined and ground fault scheme.	PP T &Chalk and board
	33	POWER SWINGS: Effect of power swings on the performance of distance relays	PP T &Chalk and board
	34	Power swing analysis-Principle of out of step tripping and blocking relays	PP T &Chalk and board
	35	Effect of line and length and source impedance on distance relays.	PP T &Chalk and board
05	**36**	**Microprocessor based protective relays** (block diagram and flowchart approach only)-over current relays.	PP T &Chalk and board
	37	Impedance relays	Chalk and board
	38	Directional relay-reactance relay	Chalk and board
	39	Generalized mathematical expressions for distance relays-	Chalk and board
	40	Measurement of resistance and reactance	Chalk and board
	41	MHO and offset MHO relays, Realization of MHO characteristics, Realization of offset MHO characteristics	Chalk and board
	42	Basic principle of Digital computer relaying.	Chalk and board

TEXT BOOK:

1. Power system protection and Switch gear ,Badri Ram and D.N.Vishwakarma, “TMH publication New Delhi 1995.

REFERENCES:

1 Static relays, T.S.Madhava Rao, TMH publication, second edition 1989.

2. Protection and Switchgear, Bhavesh Bhalja, R. P. Maheshwari, Nilesh G. Chothani, Oxford University Press.

3. Electrical Power System Protection, C. Christopoulos and A. Wright, Springer International.

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DEPARTMENT of ELECTRICAL ENGINEERING
Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: II **Subject:**Power System Economics, Regulation & Restructuring

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Power Sector in India** Introduction to various institutions in an Indian Power sector such as CEA, Planning Commissions, ,	Chalk and board
	02	Introduction to various institutions in an Indian Power sector such as PGCIL, PFC	Chalk and board
	03	Introduction to various institutions in an Indian Power sector such as Ministry of Power, state and central governments	Chalk and board
	04	Introduction to various institutions in an Indian Power sector such as REC, utilities and their roles.	Chalk and board
	05	Critical issues challenges before the Indian power sector,	Chalk and board
	06	Salient features of Electricity act 2003,.	Chalk and board
	07	Various national policies and guidelines under this act	Chalk and board
02	**08**	**Power sector economics and regulation** Typical cost components and cost structure of the power sector, ,	Chalk and board
	09	Different methods of comparing investment options	Chalk and board
	10	Concept of life cycle cost , annual rate of return , ,	Chalk and board
	11	methods of calculations of Internal Rate of Return (IRR) and Net Present Value (NPV) of project	Chalk and board
	12	Short term and long term marginal costs, Different financing options for the power sector	Chalk and board
	13	Different stakeholders in the power sector, Role of regulation and evolution of regulatory commission in India,	Chalk and board
	14	Types and methods of economic regulation, regulatory process in India.	Chalk and board
03	**15**	**Power tariff** Different tariff principles (marginal cost, cost to serve, average cost), consumer tariff structures and considerations,	Chalk and board
	16	Different consumer categories,	Chalk and board
	17	Telescopic tariff, fixed and variable charges	Chalk and board
	18	Time of day, interruptible tariff, etc	Chalk and board
	19	Different tariff based penalties and incentives	Chalk and board
	20	Subsidy and cross subsidy, life line tariff	Chalk and board
	21	Comparison of different tariff structures for different load patterns etc.	Chalk and board

	22	**Power sector restructuring and market reform** Different industry structures and ownership models Competition in the electricity sector- conditions, barriers,	Chalk and board
	23	Different industry structures and ownership models Competition in the electricity sector- different types, benefits and challenges etc.	Chalk and board
04	**24**	Different market and trading models arrangements	Chalk and board
	25	Key market entities- ISO, Genco, Transco,	Chalk and board
	26	Key market entities- Disco, Retailco	Chalk and board
	27	Power market types -Energy market, ancillary service market, transmission market	Chalk and board
	28	Forward and real time markets, market power.	Chalk and board
05	**29**	**Electricity Markets Pricing and Non-price issues** Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs.,	Chalk and board
	30	Dynamic, spot pricing and real time pricing	Chalk and board
	31	Dispatch based pricing, Power flows and prices,	Chalk and board
	32	Optimal power flow Spot prices for real and reactive power	Chalk and board
	33	Unconstrained real spot prices, constrains and real spot prices.	Chalk and board
	34	Non price issues in electricity restructuring (quality of supply and service, environmental and social considerations)	Chalk and board
	35	Global experience with electricity reforms in different countries	Chalk and board
06	**36**	**Transmission Planning and pricing** Transmission planning, Different methods of transmission pricing, Different transmission services,	Chalk and board
	37	Congestion issues and management, Transmission cost allocation methods,	Chalk and board
	38	Locational marginal price, firm transmission right, Transmission ownership and control,	Chalk and board
	39	Transco and ISO, Transmission pricing Model in India Availability based tariff,	Chalk and board
	40	role of load dispatch centers (ldcs) Salient features of Electricity act 2003, Price based Unit commitment,	Chalk and board
	41	Concept of arbitrage in Electricity markets, Game theory methods in Power System,	Chalk and board
	42	Security constrained unit commitment, Ancillary services for restructuring, Forward ancillary service auction	Chalk and board

References

1. Regulation in infrastructure SeNices: Progress and the way forward - TERI, 2001
2. Paper "The real challenges in Power sector Restructuring: Instilling Public Control Through TApn, Prayas Energy Group, Energy for Sustainable Development, September 2001, www.DravaSDune.org
3. Privatization or Democratization The Key to the Crises in the ElectricitySector - The Case

of Maharashtra 2002, www.prayaspune.org
4. Maharashtra Electricity Regulatory Commission Regulations and Orders – www.mercindia.com
5. Various publications, reports and presentations by Prayas, Energy Group, Pune
6. Central Electricity Regulatory Commission, Regulations and Orders - www.cercind.ora
7. Electricity Act 2003 and National Policies - www.Dowermin.nic.in
8. Sally Hunt, "Making Competition Work in Electricityn, 2002, John Wiley Inc
9. Electric Utility Planning and Regulation, Edward Kahn, American Council for Energy Efficient Economy
10. Market Operations in Electric Power Systems Forecasting, Scheduling and Risk Management

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: II **Subject**: Smart Grid Design And Analysis

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Introduction to Smart Grid**: What is Smart Grid?	Chalk and board
	02	Working definitions of Smart Grid and Associated Concepts	
	03	Smart Grid Functions	Chalk and board
	04	Comparison of Traditional Power Grid and Smart Grid	Chalk and board
	05	New Technologies for Smart Grid – Advantages	Chalk and board
	06	Indian Smart Grid – Key Challenges for Smart Grid	Chalk and board
	07	Revision & Assignment	
02	**08**	**Smart grid architectural designs** Smart grid – power system enhancement – communication and standards	Chalk and board
	09	General View of the Smart Grid Market Drivers	Chalk and board
	10	Smart Grid Market Drivers - Stakeholder Roles and Function	Chalk and board
	11	Smart grid market drivers - measures - representative architecture	Chalk and board
	12	Functions of Smart Grid Components- -	Chalk and board
	13	Wholesale energy market in smart grid	Chalk and board
	14	Smart vehicles in smart grid.	Chalk and board
03	**15**	**Smart grid communications and measurement technology** Communication and Measurement – Monitoring	Chalk and board
	16	communication architectures in Smart grid	Chalk and board
	17	Phasor Measurement Unit (PMU), Smart Meters	Chalk and board
	18	Wide area monitoring systems (WAMS)	Chalk and board
	19	Advanced metering infrastructure	Chalk and board
	20	Functional Requirements of Advanced Metering Infrastructure	Chalk and board
	21	GIS and Google Mapping Tools	Chalk and board
04	**22**	**Performance Analysis Tools For Smart Grid Design** Introduction to Load Flow Studies, Information available from load-flow studies	Chalk and board
	23	Challenges to Load Flow in Smart Grid and	Chalk and board
	24	Weaknesses of the Present Load Flow Methods	Chalk and board
	25	Load Flow State of the Art: Classical	Chalk and board
	26	Load Flow State of the Art: Extended Formulations	Chalk and board

	27	Load Flow State of the Art: Algorithms	Chalk and board
	28	Load flow for smart grid design, Contingencies studies for smart grid	Chalk and board
05	**29**	**STABILITY ANALYSIS TOOLS FOR SMART GRID** Voltage Stability Analysis Tools, Voltage Stability evolution by modal Analysis	Chalk and board
	30	Voltage Stability Assessment Techniques, Voltage Stability Assessment using Numerical Bifurcation Technique	Chalk and board
	31	Voltage Stability Indexing	Chalk and board
	32	Application and Implementation Plan of Voltage Stability in smart grid	Chalk and board
	33	Angle stability assessment in smart grid	Chalk and board
	34	Approach of smart grid to State Estimation	Chalk and board
	35	Energy management in smart grid	Chalk and board
06	**36**	**RENEWABLE ENERGY AND STORAGE** Renewable Energy Resources-Sustainable Energy Options for the Smart Grid	Chalk and board
	37	Penetration and Variability Issues Associated with Sustainable Energy Technology	Chalk and board
	38	Demand Response Issues	Chalk and board
	39	Electric Vehicles and Plug-in Hybrids	Chalk and board
	40	PHEV Technology	Chalk and board
	41	Environmental Implications-Storage Technologies-	Chalk and board
	42	Grid integration issues of renewable energy sources.	Chalk and board

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1) Smart Grid: Fundamentals of design and analysis, James Momoh John Wiley & sons Inc, IEEE press 2012.
2) Smart Grid: Technology and Applications, Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, John Wiley & sons inc, 2012.
3) Smart Grid: Integrating Renewable, Distributed & Efficient Energy, Fereidoon P. Sioshansi, Academic Press, 2012.
4) The smart grid: Enabling energy efficiency and demand response, Clark W.Gellings, Fairmont Press Inc, 2009.

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Lesson Plan for the academic year _____

Class: M. Tech (EPS) **Semester**: II **Subject**: Distributed Generation And Microgrid

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**INTRODUCTION** Conventional power generation: advantages and disadvantages, Energy crises	PPT, Chalk and board
	02	Non-conventional energy (NCE) resources	PPT, Chalk and board
	03	Review of Solar PV	PPT, Chalk and board
	04	Wind Energy systems	PPT, Chalk and board
	05	Fuel Cells	PPT, Chalk and board
	06	Micro-turbines	PPT, Chalk and board
	07	Biomass	PPT, Chalk and board
	08	Tidal sources	PPT, Chalk and board
02	**09**	**DISTRIBUTED GENERATIONS (DG)** Concept of distributed generations,	PPT, Chalk and board
	10	Topologies of distributed generations	PPT, Chalk and board
	11	Selection of sources	PPT, Chalk and board
	12	Regulatory standards/ framework	PPT, Chalk and board
	13	Standards for interconnecting Distributed resources to electric power systems: IEEE 1547	PPT, Chalk and board
	14	DG installation classes	PPT, Chalk and board
	15	Security issues in DG implementations	PPT, Chalk and board
	16	Energy storage elements: Batteries, ultra-capacitors, flywheels	PPT, Chalk and board
	17	Captive power plant	PPT, Chalk and board
03	**18**	**IMPACT OF GRID INTEGRATION** Requirements for grid interconnection, limits on operational parameters	PPT, Chalk and board
	19	Limits on operational parameters: Voltage	PPT, Chalk and board

	20	Limits on operational parameters,: Frequency	PPT, Chalk and board
	21	Limits on operational parameters: THD	PPT, Chalk and board
	22	Response to grid abnormal operating conditions	PPT, Chalk and board
	23	Islanding issues	PPT, Chalk and board
	24	Impact of grid integration with NCE sources on existing power system	PPT, Chalk and board
	25	Reliability, stability issues, Power quality issues	PPT, Chalk and board
04	**26**	**MICROGRIDS** Concept and definition of microgrid,	PPT, Chalk and board
	27	Microgrid drivers and benefits	PPT, Chalk and board
	28	Review of sources of microgrids	PPT, Chalk and board
	29	Typical structure and configuration of a microgrid, AC and DC microgrids	PPT, Chalk and board
	30	Power Electronics interfaces in DC and AC microgrids	PPT, Chalk and board
	31	Communication infrastructure	PPT, Chalk and board
	32	Modes of operation and control of microgrid: grid connected and islanded mode	PPT, Chalk and board
	33	Active and reactive power control, protection issues	PPT, Chalk and board
	34	Anti-islanding schemes: passive, active	PPT, Chalk and board
	35	Communication based techniques	PPT, Chalk and board
05	**36**	**POWER QUALITY ISSUES IN MICROGRIDS** Power quality issues in microgrids	PPT, Chalk and board
	37	Power Quality Improvement With Controllers	PPT, Chalk and board
	38	Modelling analysis of Microgrid	PPT, Chalk and board
	39	Stability analysis of Microgrid	PPT, Chalk and board
	40	Microgrid stability controller (MSC)	PPT, Chalk and board
	41	Regulatory standards	PPT, Chalk and board
	42	Microgrid economics, Introduction to smart microgrids	PPT, Chalk and board

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1. Understanding of FACTs., Hingorani, N. G.; IEEE Press 1996.

2. Power Quality.; Heydt G.T.; Stars in a Circle Pblications , Indiana, 1991.

3. Static Reactive Power Compensation.; Miller T.J.E.; John Wiley & Sons, New York, 1982

4. Flexible AC Transmission System. (FACTs).; Yong Hua Song.; IEE 1999.

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M.Tech (EPS) **Semester**: II **Subject**: Applications of power electronics to power system

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	Review of semiconductor devices	Chalk and board
	02	Review of semiconductor devices	Chalk and board
	03	Steady state and dynamic problems in AC systems,	Chalk and board
	04	Power flow Studies	
	05	basic principle of conventional active and reactive power flow control in power systems	Chalk and board
	06	problems associated with long distance power transmission.	Chalk and board
	07	Revision & Assignment	Chalk and board
02	**08**	**Introduction to FACTS**	Chalk and board
	09	Flexible AC transmission systems (FACTS): Basic realities & roles,	Chalk and board
	10	Types of facts controller	Chalk and board
	11	Types of facts controller	Chalk and board
	12	Principles of series compensation	Chalk and board
	13	Principles of shunt compensation	Chalk and board
	14	Revision & Assignment	
03	**15**	Description of static var compensators (SVC)	PPT &Chalk and board
	16	Thyristor Controlled series compensators (TCSC),	PPT & Chalk and board
	17	Static phase shifters (SPS),	PPT & Chalk and board
	18	Static condenser (STATCON),	PPT & Chalk and board
	19	Static synchronous series compensator (SSSC)	PPT & Chalk and board
	20	Unified power flow controller (UPFC).	PPT & Chalk and board
	21	Unified power flow controller (UPFC).	PPT & Chalk and board
	22	Revision & Assignment	PPT & Chalk and

			board
04	**23**	**Modelling of FACTS controllers.** **Introduction**	PPT & Chalk and board
	24	Modelling of FACTS controllers.	PPT & Chalk and board
	25	Modelling of FACTS controllers.	PPT & Chalk and board
	26	Analysis of FACTS controllers	PPT & Chalk and board
	27	Analysis of FACTS controllers	PPT & Chalk and board
	28	Control strategies to improve system stability.	PPT & Chalk and board
	29	Power Quality problems in distribution systems	PP T &Chalk and board
	30	Power Quality problems in distribution systems & Revision	
05	**31**	**Harmonics**	PPT & Chalk and board
	32	harmonics creating loads,	PPT & Chalk and board
	33	modelling, Series and parallel resonances	PPT & Chalk and board
	34	harmonic power flow,	PPT & Chalk and board
	35	Mitigation of harmonics,.	PPT & Chalk and board
	36	filters, passive filters	PPT & Chalk and board
	37	Assignment	PPT & Chalk and board
06	**38**	**Introduction to filters**	PPT & Chalk and board
	39	Active filters	PPT & Chalk and board
	40	shunt, series hybrid filters,	PPT & Chalk and board
	41	voltage sags & swells, voltage flicker.	PPT & Chalk and board
	42	Mitigation of power quality problems using power electronic conditioners.	PPT & Chalk and board

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2. Heydt G.T.; Power Quality.; Stars in a Circle Pblications , Indiana, 1991.

3. Miller T.J.E.; Static Reactive Power Compensation.; John Wiley & Sons, New York, 1982

4. Yong Hua Song.; Flexible AC Transmission System. (FACTs).; IEE 1999.

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M.Tech (EPS) **Semester**: II **Subject**: **MODELING & SIMULATION OF POWER ELECTRONIC SYSTEMS**

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Introduction:** Challenges in computer simulation	Chalk and board
	02	Simulation process	Chalk and board
	03	Mechanics of simulation -	Chalk and board
	04	Solution techniques for time domain analysis	Chalk and board
	05	Equation solvers	Chalk and board
	06	circuit-oriented simulators	Chalk and board
	07	Revision	Chalk and board
02	**08**	**Simulation Of Power Electronic Converters: Introduction**	Chalk and board
	09	State-space representation of power electronic converters (with buck converter as a representative example)	Chalk and board
	10	- Trapezoidal integration -	Chalk and board
	11	M & N method for simulating power electronic converters (with buck converter as a representative example)	Chalk and board
	12	- Introduction to MATLAB and Simulink -	Chalk and board
	13	Simulation of rectifiers - choppers and inverter circuits along with PWM techniques	Chalk and board
	14	Assignment	Chalk and board
03	**15**	**Simulation Of Electric Drives:** Modeling of power electronic converters with transportation delay -	Chalk and board
	16	Concept of control gain - linearization of rectifiers with inverse cosine control -	Chalk and board
	17	State space model of 3-Ph IM	Chalk and board
	18	- Principle of Vector control -	Chalk and board
	19	Modeling and simulation of Vector controlled 3-Ph IM with a 3-level inverter drive	Chalk and board
	20	Numerical	Chalk and board
04	**21**	**Modeling - Simulation Of Switching Converters With State Space Averaging:** **Introduction**	Chalk and board
	22	State Space Averaging Technique–	Chalk and board
	23	Modeling AND linearization of converter transfer functions	PPT &Chalk and board
	24	Simulation of power electronic converters using State-space averaged models	PPT&Chalk and board
	25	Design of power electronic converters using State-space averaged	PPT &Chalk and

		models	board
	26	Design of power electronic converters using State-space averaged models	PPT & Chalk and board
	27	Revision &Assignment	
05	**28**	**Modeling and simulation of impedance based compensators** Introduction	Chalk and board
	29	Modeling of series static Var Compensators:	Chalk and board
	30	Modeling of shunt static Var Compensators:	Chalk and board
	31	analysis of series static Var Compensators:	Chalk and board
	32	analysis of shunt static Var Compensators:	Chalk and board
	33	Comparison of Series & Shunt Compensators	Chalk and board
	34	Revision &Assignment	Chalk and board
06	**35**	**Modeling and simulation of converter based compensators.**	Chalk and board
	36	Modeling and Analysis of STATCOM,	Chalk and board
	37	Modeling and Analysis of SSSC,	Chalk and board
	38	Modeling and Analysis of UPFC	Chalk and board
	39	Modeling and Analysis of UPFC	Chalk and board
	40	Comparative analysis of STATCOM, SSSC & UPFC	Chalk and board
	41	Comparative analysis of STATCOM, SSSC & UPFC	
	42	Revision & Assignment	

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1.**:** *Simulation of Power Electronic Converters***,** M. B. Patil - V. Ramnarayanan, V. T. Ranganathan ,1st ed., Narosa Publishers, 2010

2. Power Electronics: Converters, Design and control, Ned Mohan, Undeland and Robbins**, -** 2nd ed., John Wiley

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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M.Tech (EPS) **Semester**: II **Subject**: AI Techniques in power systems

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	Introduction to AI	Chalk and board
	02	Definition, Applications, Components of an AI program; production system. Problem Characteristics.	Chalk and board
	03	Overview of searching techniques. Knowledge representation : Knowledge representation issues; and overview.	Chalk and board
	04	Representing knowledge using rules; procedural versus declarative knowledge.	Chalk and board
	05	Logic programming, forward versus backward reasoning,	Chalk and board
	06	Matching. Control knowledge.	Chalk and board
	07	Revision & Assignment	
02	**08**	Statistical Reasoning: Introduction	Chalk and board
	09	Probability and Daye's theorem.	Chalk and board
	10	Certainty factor and rule based systems.	Chalk and board
	11	Baysian Networks,	Chalk and board
	12	Dampster Shafer theorem,	Chalk and board
	13	Semantic nets and frames, Scripts.	
	14	Examples of knowledge based systems & Revision	Chalk and board
03	**15**	Pattern Recognition: Introduction,	Chalk and board
	16	automatic pattern recognition scheme.	Chalk and board
	17	Design Concepts, Methodologies,	Chalk and board
	18	Concepts of Classifier, concept of feature selection.	Chalk and board
	19	Feature selection based on means and covariances.	Chalk and board
	20	Statistical classifier design algorithms;	Chalk and board

	21	increment-correction and LMSE algorithms. Applications.	Chalk and board
04	**22**	Artificial Neural Networks: Introduction	Chalk and board
	23	Biological Neuron, Neural Net,	Chalk and board
	24	use of neural 'nets, applications	Chalk and board
	25	Perception, idea of single layer and multilayer neural nets,	Chalk and board
	26	back propagation,	Chalk and board
	28	Hopfield nets,	Chalk and board
	29	supervised and unsupervised learning.	Chalk and board
	30	Revision and assignment	Chalk and board
05	**31**	Expert Systems: Introduction.	Chalk and board
	32	Study of some popular expert systems,	Chalk and board
	33	Expert System building tools and Shells,	Chalk and board
	34	Design of Expert Systems.	Chalk and board
	35	Design of Expert Systems.	Chalk and board
	36	Revision & Assignment	Chalk and board
06	**37**	Applications of AI Techniques to Load forecasting	Chalk and board
	38	Load flow studies, Economic load dispatch	Chalk and board
	39	Load frequency control	Chalk and board
	40	Single area system and two area system	Chalk and board
	41	Small Signal Stability (Dynamic stability) Reactive power control	Chalk and board
	42	Revision and assignment	Chalk and board

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1. Neural Networks, Fuzzy Logic & Genetic Algorithms, S.Rajasekaran and G.A.V.Pai,- PHI, New Delhi, 2003.

2. Computing Theory & Practice, P.D.Wasserman,Van Nostrand Reinhold, Neural- New York,1989.
3. Neural Network & Fuzzy System, Bart Kosko, Prentice Hall, 1992.
4. Fuzzy sets,Uncertainty and Information, G.J.Klir and T.A.Folger, PHI, Pvt.Ltd,1994.
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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M.Tech (EPS) Semester: II Subject: Modern Optimization Techniques In Power Systems

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**UNIT I - FUNDAMENTALS OF OPTIMIZATION -Introduction**	Chalk and board
	02	Definition-Classification of optimization problems	Chalk and board
	03	Unconstrained and Constrained optimization, Optimality conditions	PP T &Chalk and board
	04	Classical Optimization techniques (Linear and non linear programming, Quadratic programming, Mixed integer programming)	PP T &Chalk and board
	05	Intelligent Search methods -Optimization neural network	PP T &Chalk and board
	06	Evolutionary algorithms, Tabu search, Particle swarm optimization,	Chalk and board
	07	Application of fuzzy set theory	Chalk and board
	08	**Revision & Assignment**	Chalk and board
02	**09**	**UNIT II - EVOLUTIONARY COMPUTATION TECHNIQUES - Introduction** Evolution in nature-Fundamentals of Evolutionary algorithms,	Chalk and board
	10	Working Principles of Genetic Algorithm	
	11	Evolutionary Strategy and Evolutionary Programming, Genetic Operators-Selection, Crossover and Mutation	
	12	Issues in GA implementation- GA based Economic Dispatch solution	Chalk and board
	13	Fuzzy Economic Dispatch including losses	PP T &Chalk and board
	14	Tabu search algorithm for unit commitment problem-GA for unit commitment	PP T &Chalk and board
	15	GA based Optimal power flow- GA based state estimation.	PP T &Chalk and board
	16	**Revision & Assignment**	Chalk and board
03	**17**	**UNIT III - PARTICLE SWARM OPTIMIZATION - Introduction**	PPT &Chalk and board
	18	Fundamental principle-Velocity Updating	PPT &Chalk and board
	19	Advanced operators Parameter selection	PPT &Chalk and board
	20	Hybrid approaches (Hybrid of GA and PSO, Hybrid of EP and PSO)	Chalk and board
	21	Binary, discrete and combinatorial PSO	PPT &Chalk and board
	22	Implementation issues-Convergence issue	PPT &Chalk and board
	23	PSO based OPF problem and unit commitment	PPT &Chalk and board

	24	PSO for reactive power and voltage control	PPT &Chalk and board
	25	PSO for power system reliability and security.	PPT &Chalk and board
	26	Revision & Assignment	
04	**27**	**UNIT IV - ADVANCED OPTIMIZA TION METHODS - Introduction** Simulated annealing algorithm	PPT &Chalk and board
	28	Tabu search algorithm	PPT &Chalk and board
	29	SA and TS for unit commitment	PPT &Chalk and board
	30	Ant colony optimization	PPT &Chalk and board
	31	Bacteria Foraging optimization	PPT &Chalk and board
	32	Revision & Assignment	PPT &Chalk and board
05	**33**	**UNIT V -MULTI OBJECTIVE OPTIMIZATION** **Introduction,**	PPT &Chalk and board
	34	Concept of pareto optimality	PPT &Chalk and board
	35	Conventional approaches for MOOP	PPT &Chalk and board
	36	Multi objective GA	PPT &Chalk and board
	37	Fitness assignment-Sharing function	PPT &Chalk and board
	38	Economic Emission dispatch using MOGA	PPT &Chalk and board
	39	Multi objective PSO (Dynamic neighbourhood PSO,	PPT &Chalk and board
	40	Vector evaluated PSO,	PPT &Chalk and board
	41	Multi objective OPF problem.	
	42	Revision & Assignment	PPT

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1. D.P.Kothari and J.S.Dhillon, “Power System Optimization”, 2ndEdition, PHI learning private limited, 2010.
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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M.Tech (EPS) **Semester**: II **Subject**: **Finance Management**

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Overview of Indian Financial System-Introduction**	Chalk and board
	02	Characteristics, Components and Functions of Financial System.	PPT & Chalk and board
	03	**Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments,	PPT & Chalk and board
	04	Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills.	PPT & Chalk and board
	05	**Financial Markets:** Meaning, Characteristics and Classification of Financial Markets Capital Market,	Chalk and board
	06	Money Market and Foreign Currency Market.	Chalk and board
	07	**Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions	Chalk and board
	08	Commercial Banks, Investment-Merchant Banks and Stock Exchanges	
02	**09**	**Concepts of Returns and Risks- Introduction**	Chalk and board
	10	Measurement of Historical Returns	Chalk and board
	11	Expected Risk of a Single Security and a Two-security Portfolio.	Chalk and board
	12	**Time Value of Money:** Future Value of a Lump Sum,	Chalk and board
	13	Ordinary Annuity, and Annuity Due;	Chalk and board
	14	Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due;	PPT & Chalk and board
	15	Continuous Compounding and Continuous Discounting.	PPT & Chalk and board
	16	Revision and assignment	Chalk and board
03	**17**	**Overview of Corporate Finance** Objectives of Corporate Finance;	PPT & Chalk and board
	18	Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision.	PPT & Chalk and board
	19	**Financial Ratio Analysis:** Overview of Financial Statements	Chalk and board
	20	Balance Sheet, Profit and Loss Account, and Cash Flow Statement;	PP T & Chalk and board
	21	Purpose of Financial Ratio Analysis;	Chalk and board
	22	Liquidity Ratios; Efficiency or Activity Ratios; Profitability Ratios;	PP T &Chalk and board

	23	Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	PP T &Chalk and board
	24	Revision and assignment	Chalk and board
04	**25**	**Capital Budgeting- Introduction**	PP T &Chalk and board
	26	Meaning and Importance of Capital Budgeting;	PP T &Chalk and board
	27	Inputs for CapitalBudgeting Decisions;	Chalk and board
	28	Investment Appraisal Criterion,	Chalk and board
	29	Accounting Rate of Return, Payback Period,	PP T &Chalk and board
	30	Discounted Payback Period, Net Present Value(NPV),	PP T &Chalk and board
	31	Profitability Index, Internal Rate of Return (IRR), and	PP T &Chalk and board
	32	Modified Internal Rate of Return (MIRR).	PP T &Chalk and board
05	**33**	**Working Capital Management- Introduction** Concepts of Meaning Working Capital;	PP T &Chalk and board
	34	Importance ofWorking Capital Management;	PP T &Chalk and board
	35	Factors Affecting an Entity‘s Working Capital Needs;	Chalk and board
	36	Estimation of Working Capital Requirements;	Chalk and board
	37	Estimation of Working Capital Requirements;	
	38	Management of Inventories;	PP T &Chalk and board
	39	Management of Receivables; and Management of Cash and Marketable Securities.	
	40	Management of Receivables; and Management of Cash and Marketable Securities.	Chalk and board
	41	Examples	Chalk and board
	42	Revision & Assignment	Chalk and board

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1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.
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DEPARTMENT of ELECTRICAL ENGINEERING

Lesson Plan for the academic year _____

Class: M.Tech (EPS) **Semester**: II **Subject**: Advanced Control System

Unit	Period	Details of Coverage	Teaching aids used
01	**01**	**Control system design by root locus method- Introduction**	Chalk and board
	02	lead, lag and lead lag compensation,	PP T &Chalk and board
	03	PI&PD controllers design procedures,	PP T &Chalk and board
	04	PID controllers design procedures,	
	05	Control system design by frequency response approach- lead, lag and lead lag compensation.	PP T &Chalk and board
	06	Control system design by frequency response approach- lead, lag and lead lag compensation.	
	07	Numerical on PI, PD and PID controllers design	PP T &Chalk and board
	08	Revision & Assignment	PPT
02	**09**	**EIGEN VALUE AND EIGENVECTOR SENSITIVITIES IN LINEAR SYSTEM THEORY: Introduction**	Chalk and board
	10	Continuous time systems	Chalk and board
	11	first-order Eigen value sensitivities,	Chalk and board
	12	first order eigen vector sensitivities,	Chalk and board
	13	second-order Eigen value sensitivities,	Chalk and board
	14	second order Eigen vector sensitivities.	Chalk and board
	15	Revision& Assignment	Chalk and board
03	**16**	**MODE-CONTROLLABILITY MATRIX: introduction**	PP T &Chalk and board
	17	Distinct Eigen-values,	PP T &Chalk and board
	18	confluent Eigen-values associated with single Jordan block,	Chalk and board
	19	confluent Eigen-values associated with number of distinct Jordan blocks	Chalk and board
	20	confluent Eigen-values associated with a number of non-distinct Jordan block Mode	PP T &Chalk and board
	21	Controllability structure of multivariable linear systems: Introduction	Chalk and board
	22	Numerical on Eigen Values	PP T ,Chalk and board
	23	Revision & Assignment	Chalk and board
04	**24**	**OBSERVABILITY MATRICES:** Distinct Eigen-values, confluent Eigen-values,	PP T &Chalk and board
	25	mode observability	PP T &Chalk and

			board
	26	structure of multivariable linear systems: Introduction	Chalk and board
	27	Distinct Eigen-values, confluent Eigenvalues.	Chalk and board
	28	Nonlinear systems: Common physical nonlinearities: the phase plane method – basic concept, singular points,	PP T &Chalk and board
	29	construction of phase trajectories – Isocline and delta methods, Describing function	PP T &Chalk and board
	30	basic concept – derivation of describing functions – stability analysis by describing function method.	PP T &Chalk and board
	31	Numerical	
	32	Revision & Assignment	
05	**33**	**LYAPUNOV STABILITY ANALYSIS: Introduction**	PP T &Chalk and board
	34	Second method of Lyapunov,	PP T &Chalk and board
	35	Stability in the sense of Lyapunov,	Chalk and board
	36	construction of Lyapunov functions	Chalk and board
	37	construction of Lyapunov functions	
	38	Krasovskii's and variable gradient methods,	Chalk and board
	39	Krasovskii's and variable gradient methods,	
	40	Lyapunov stability analysis of linear time varying systems.	Chalk and board
	41	Numerical	
	42	Revision & Assignment	

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