Course Structure

&

Detailed Syllabus

M.Tech

Electrical Power System

Academic Regulations-R25

Applicable for the Batches Admitted from 2025-2026

AVANTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Autonomous)

(Approved by A.I.C.T.E., New Delh i& Affiliated to J.N.T.U.H, Hyderabad)

NAAC "A" Accredited Institute

Gunthapally(V),Abdullapurmet(M),R.R(Dist),Near Ramojifilm City, Hyderabad,Pin -501512.

www.aietg.ac.in,principalavih@avanthi.edu.in

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

AVANTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

Vision and Mission of the Institute

VISION

To develop highly skilled professionals with ethics & human values.

MISSION

1. To provide high-quality education along with professional training and exposure to the workplace.
2. To encourage a professional mindset that goes beyond academic achievement.
3. To promote holistic education among Department students by means of integrated pedagogy and scholarly mentoring for excellence in both personal and professional domains.
4. To consistently enhance the teaching and learning procedures in order to prepare students for successful careers in business or overseas or in further education.
5. To carefully prepare students to be globally employable professionals who will meet societal demands and contribute to the nation's technological advancement through their research and innovative talents.

QUALITY POLICY

AIET focuses a strong emphasis on the moral principles of delivering cutting edge skilling by establishing the best infrastructure through interactive & activity-based learning. It also strives for an ambitious & effective governance that is responsive in every aspect, and makes use of the latest developments in knowledge and communication technology to encourage students to adopt a global perspective

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

AVANTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

PROGRAM: M.TECH - ELECTRICAL POWER SYSTEM

Regulation: R25

Vision and Mission of the Department

DEPARTMENT VISION

To become center of eminence in Electrical and Electronics Engineering through innovative, excellence in teaching, research and service.

DEPARTMENT MISSION

1. To offer high quality education in Electrical and Electronics Engineering and to prepare students for professional career or higher studies
2. The department promotes excellence in teaching, research, collaborative activities and positive contributions to society
3. To harness human capital for sustainable competitive edge and social relevance.

DEPARTMENT OF ELECTRICAL AND ELETRONICS ENGINEERING
Course Structure
Program– M. Tech Electrical Power Systems
Regulation-R25
(Applicable from the academic year 2025-2026 to 2028-2029)

Program: M.Tech Electrical Power Systems **Regulation: R25**
I Year I Semester-Course Structure

S.No	Category	Course Code	Course Title	Hours per Week			
				Lecture	Tutorial	Practical	Credits
1	PC	MTEP1101	**Professional Core-1** Advanced Power System Analysis	3	0	0	3
2	PC	MTEP1102	**Professional Core-2** Economic Operation of Power Systems	3	0	0	3
3	PE	MTEP11031 MTEP11032 MTEP11033 MTEP11034	**Professional Elective-1** 1. Power Converters Analysis 2. Sustainable Energy Solutions 3. Smart Grid Technologies 4. Modern Control Theory	3	0	0	3
4	PE	MTEP11041 MTEP11042 MTEP11043 MTEP11044	**Professional Elective-2** 1. HVDC Transmission 2. Electrical Power Distribution System 3. Reactive Power Compensation and Management 4. Electric Vehicle Technologies	3	0	0	3
5	CC	MTMB1105	Research Methodology & IPR	2	0	0	2
6	PC	MTEP1105	**Laboratory-1** Power Systems Computation Lab-I	0	0	4	2
7	PC	MTEP1106	**Laboratory-2** Advanced Power Systems Lab	0	0	4	2
8	AC	MTAC1108 MTAC1109	**Audit Course – I** 1.English for Research Paper Writing 2.Disaster Management	2	0	0	0
			Total	**16**	**0**	**08**	**18**

Category	Courses	Credits
Professional Core Course	04	10
Professional Elective Course	02	06
Compulsory Course	01	02
Audit Course	1	0
Total	08	18

DEPARTMENT OF ELECTRICAL AND ELETRONICS ENGINEERING

Program: M.Tech Electrical Power System **Regulation: R25**

I Year II Semester- Course Structure

S.No	Category	Course Code	Course Title	Hours per Week			
				Lecture	Tutorial	Practical	Credits
1	PC	MTEP1201	**Professional Core-3** Digital Protection of Power System	3	0	0	3
2	PC	MTEP1202	**Professional Core-4** Power System Dynamics	3	0	0	3
3	PE	MTEP12031 MTEP12032 MTEP12033 MTEP12034	**Professional Elective-3** 1. Restructured Power Systems 2. Power Quality Improvement Techniques 3. EHVAC Transmission 4. Evolutionary Algorithms Applications in Power Engineering.	3	0	0	3
4	PE	MTEP12041 MTEP12042 MTEP12043 MTEP12044	**Professional Elective-4** 1. Data Science Applications in Power Engineering 2. Electric Vehicle Charging Techniques 3. Digital Control Systems 4. Real-Time Control of Power Systems	3	0	0	3
5	PJ	MTEP1205	Mini Project with Seminar	0	0	4	2
6	PC	MTEP1206	**Laboratory-3** Power Systems Computation Lab-II	0	0	4	2
7	PC	MTEP1207	**Laboratory-4** Power System Protection Lab	0	0	4	2
8	AC	MTAC1208 MTAC1209	**Audit Course – II** 1.Constitution of India 2.Pedagogy Studies	2	0	0	0
			Total	**14**	**0**	**12**	**18**

Category	Courses	Credits
Professional Core Courses	4	10
Professional Elective Courses	2	06
Project	1	02
\ G Audit Courses	1	00
Total	08	18

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MTEP1101 **3 0 0 3**

ADVANCED POWER SYSTEM ANALYSIS

(Program Core-I)

Prerequisite: Computer Methods in Power Systems

Course Objectives:

- To build the Nodal admittance and Nodal impedance matrices of a practical network.
- To study various methods of load flow and their advantages and disadvantages.
- To understand how to analyze various types of faults in power system.
- To understand power system security concepts and study the methods to rank the contingencies.
- To understand need of state estimation and study simple algorithms for state estimation.

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

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Build/construct YBUS and ZBUS of any practical network.	2	3	3	3	2	L1,L2, L3
CO2	Calculate voltage phasors at all buses, given the data using various methods of load flow.	3	2	2	2	2	L1,L2, L3,L4
CO3	Calculate fault currents in each phase.	2	3	2	2	3	L1, L2, L4
CO4	Rank various contingencies according to their severity.	3	2	2	2	3	L1, L2, L4
CO5	Estimate the bus voltage phasors given various quantities viz. power flow, voltages, taps, CB status etc.	2	3	2	3	3	L1,L2, L3,L4

SYLLABUS

UNIT-I: **12 Hours**

NETWORK MATRICES

Introduction, Bus Admittance Matrix, Network Solution, Network Reduction (Kron Reduction), YBUS structure and manipulation, Bus Impedance matrix, Methods to determine columns of ZBUS. CO's - CO1

UNIT-II: **13 Hours**

LOAD FLOW STUDIES

Overview of Gauss-Seidel, Newton-Raphson, Fast decoupled load flow methods, Convergence properties, Sparsity techniques, Handling Qmax violations in constant matrix, Inclusion in frequency effects, AVR in load flow, Handling of discrete variable in load flow.
CO's - CO2

UNIT-III: **10 Hours**

FAULT CALCULATIONS

Symmetrical faults, Fault calculations using ZBUS, Equivalent circuits, Selection of circuit breakers, Unsymmetrical faults, Problems on various types of faults.
CO's - CO3

UNIT-IV: **13 Hours**
CONTINGENCY ANALYSIS
Security Analysis: Security state diagram, Contingency analysis, Generator shift distribution factors, Line outage distribution factor, multiple line outages, Overload index ranking.
CO's - CO4

UNIT-V: **10 Hours**
STATE ESTIMATION
Sources of errors in measurements, Virtual and Pseudo measurements, Observability concepts, tracking state Estimation, Weighted Least Square method, Bad Data detection and estimation.
CO's - CO5

Board of Studies : Electrical and Electronics Engineering
Approved in BOS No: 01, 12-09-2025
Approved in ACM No: 01.26-09-2025

TEXTBOOKS:

1. J.J. Grainger &W.D.Stevenson, "Power system analysis", McGraw Hill, 2003.
2. A. R. Bergen & Vijay Vittal, "Power System Analysis", Pearson, 2000.

REFERENCES:

1. L.P. Singh, "Advanced Power System Analysis and Dynamics", New Age International, 2006.
2. G.L. Kusic, "Computer aided power system analysis", Prentice Hall India, 1986.
3. A.J. Wood, "Power generation operation and control", John Wiley, 1994.
4. P.M. Anderson, "Faulted power system analysis", IEEE Press, 1995.

Internal Assessments Pattern:

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	20%	20%
L2	30%	30%
L3	35%	35%
L4	15%	15%
L5	5%	5%
TOTAL(%)	100	100

Level based questions:

Level 1: Recall & Understanding
1. **CO1**:zDefine the nodal admittance matrix (Ybus) and explain its significance in power system analysis.
2. **CO2**: State the basic assumptions made in the Gauss-Seidel method for load flow analysis.
3. **CO3**: List the different types of faults that can occur in a power system.
4. **CO4**: What is meant by system security in the context of power systems?
5. **CO5**: Explain the concept of state estimation in power systems and its importance.

Level 2: Application

1. **CO1**: Given a simple power system network, construct its Ybus matrix using the direct inspection method.
2. **CO2**: Apply the Newton-Raphson method to solve the load flow problem for a 3-bus system.
3. **CO3**: Calculate the fault current for a single line-to-ground fault at a bus in a given power system.
4. **CO4**: Rank a set of contingencies based on their severity using a given performance index.
5. **CO5**: Estimate the bus voltage magnitudes and angles using a weighted least squares state estimation technique.

Level 3: Analysis

1. **CO1**: Analyze the impact of adding a new branch to the power system network on the Ybus matrix.
2. **CO2**: Compare the convergence characteristics of the Gauss-Seidel and Newton-Raphson methods for load flow analysis.
3. **CO3**: Discuss the effects of different fault types on the system's voltage profile and fault currents.
4. **CO4**: Evaluate the effectiveness of different contingency ranking methods in identifying critical outages.
5. **CO5**: Analyze the impact of measurement errors on the accuracy of state estimation results.

Level 4: Application & Analysis

1. **CO1**: Given a 10-bus power system with specified line impedances and transformer ratings, construct the Ybus matrix using the singular value decomposition method. Analyze the impact of a line outage on the system's admittance matrix.
2. **CO2**: Implement the Newton-Raphson load flow method to solve the power flow equations for a 30-bus system. Compare the convergence rates and computational efficiency with the Gauss-Seidel method.
3. **CO3**: For a given power system network, perform a fault analysis for a three-phase fault at a specific bus. Calculate the fault currents and determine the post-fault voltage profiles using the Zbus matrix.
4. **CO4**: Develop a contingency ranking algorithm based on the sensitivity of voltage magnitudes and line flows to system disturbances. Apply this algorithm to a 14-bus system and identify the most critical contingencies.
5. **CO5**: Design a state estimation algorithm using the weighted least squares method for a 6-bus system. Incorporate real and reactive power measurements, and perform bad data detection to ensure the accuracy of the estimated states.

Level 5: Synthesis & Evaluation

1. **CO1**: Propose an optimal method for constructing the Ybus matrix for a large-scale power system with multiple interconnected regions. Evaluate the computational complexity and accuracy of your proposed method compared to traditional approaches.
2. **CO2**: Critically assess the advantages and limitations of various load flow methods (Gauss-Seidel, Newton-Raphson, Fast Decoupled) in terms of convergence speed, robustness, and applicability to large-scale systems. Recommend the most suitable method for a 1000-bus system and justify your choice.
3. **CO3**: Analyze the impact of different fault types (single line-to-ground, line-to-line, double line-to-ground, three-phase) on the stability and protection coordination of a power system. Propose a fault detection and classification scheme using phasor measurement units (PMUs) and evaluate its effectiveness.
4. **CO4**: Design a comprehensive security assessment framework that integrates contingency analysis, voltage stability, and transient stability for a multi-area power

system. Evaluate the effectiveness of your framework in identifying potential system vulnerabilities under various operating conditions.

5. **CO5**: Develop a hybrid state estimation algorithm that combines traditional weighted least squares with machine learning techniques to improve accuracy and robustness in the presence of noisy measurements. Apply your algorithm to a real-world power system dataset and assess its performance.

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MTEP1102

ECONOMIC OPERATION OF POWER SYSTEMS 3 0 0 3

(Program Core-II)

Prerequisite: Electrical Power Systems

Course Objectives:

- To formulate and derive the necessary conditions for economical load scheduling problem.
- To understand various constraints, problem formulation and methods to solve the unit commitment problem.
- To understand the constraints related to hydel power plants, problem formulation and solution techniques for hydro-thermal scheduling problem.
- To understand the necessity, factors governing the frequency control and analyze the uncontrolled and controlled LFC system.
- To understand the basic difference between ELS and OPF problem, formulation of the OPF problem and solution techniques.

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

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Solve the economic load scheduling with and without network losses both in classical method and iterative methods.	2	3	3	3	2	L1,L2, L3
CO2	Solve the unit commitment problem using priority-list method and forward-dynamic method.	3	2	2	2	2	L1,L2, L3,L4
CO3	Solve hydro-thermal scheduling problem for short-term and long-term range.	2	3	2	2	3	L1, L2, L4
CO4	Analyze the single area and two area systems for frequency deviation under sudden change in load.	3	2	2	2	3	L1, L2, L4
CO5	Solve the OPF problem using AC and DC load flow methods.	2	3	2	3	3	L1,L2, L3,L4

SYLLABUS

UNIT-I: **12 Hours**

ECONOMIC LOAD SCHEDULING

Characteristics of Steam Turbine, Variations in steam unit characteristics, Economic dispatch with piecewise linear cost functions, Lambda Iterative method, LP method, Economic dispatch under composite generation production cost function, Base point and Participation factors, Thermal system Dispatching with Network losses considered. CO's -CO1

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UNIT-II: **10 Hours**
UNIT COMMITMENT
Unit Commitment: Definition, Constraints in Unit Commitment, Unit Commitment solution methods, Priority–List Methods, Dynamic Programming Solution. CO's -CO2

UNIT-III: **14 Hours**
HYDRO THERMAL SCHEDULING
Characteristics of Hydroelectric units, Introduction to Hydrothermal coordination, Long-Range and Short-Range Hydro-Scheduling, Hydroelectric plant models, Hydrothermal scheduling with storage limitations, Dynamic programming solution to hydrothermal scheduling. CO's -CO3

UNIT-IV: **12 Hours**
LOAD FREQUENCY CONTROL
Control of generation, Models of power system elements, Single area and two area block diagrams, Generation control with PID controllers, Implementation of Automatic Generation control (AGC) and its features. CO's -CO4

UNIT-V: **12 Hours**
OPTIMAL POWER FLOW
Introduction to Optimal power flow problem, OPF calculations combining economic dispatch and power flow, OPF using DC power flow, Algorithms for solution of the ACOPF, Optimal Reactive Power Dispatch. CO's -CO5

Board of Studies : Electrical and Electronics Engineering
Approved in BOS No: 01, 12-09-2025
Approved in ACM No: 01.26-09-2025

TEXTBOOKS:

1. J.J. Grainger & W.D.Stevenson, "Power system analysis", McGraw Hill, 2003.
2. Allen J. Wood,Bruce F.Wollenberg, Gerald B. Sheblé, "Power Generation Operation and Control" Wiley-Interscience, 2013.

REFERENCES:

1. Olle l. Elgerd, "Electric Energy Systems Theory an Introduction", TMH, 2nd Edition, 1983.

Internal Assessments Pattern:

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	20%	20%
L2	30%	30%
L3	35%	35%
L4	15%	15%
L5	5%	5%
TOTAL(%)	100	100

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Level based questions:

L1 – Remember (Basic Recall)

1. **Define** economic load dispatch. *(CO1)*
2. **List** the constraints considered in unit commitment problems. *(CO2)*
3. **State** the main difference between hydro and thermal units in scheduling. *(CO3)*
4. **Mention** the objective of Load Frequency Control (LFC). *(CO4)*
5. **Define** Optimal Power Flow (OPF). *(CO5)*

L2 – Understand (Explain Concepts)

1. **Explain** the significance of transmission losses in economic load scheduling. *(CO1)*
2. **Describe** the role of spinning reserve in unit commitment. *(CO2)*
3. **Explain** the basic structure of a hydro-thermal coordination system. *(CO3)*
4. **Differentiate** between uncontrolled and controlled LFC systems. *(CO4)*
5. **Summarize** the advantages of DC load flow over AC in OPF studies. *(CO5)*

L3 – Apply (Solve Problems)

1. **Calculate** the economic load dispatch for a two-generator system without considering losses. *(CO1)*
2. **Apply** the priority list method to solve a simple unit commitment problem. *(CO2)*
3. **Solve** a short-term hydro-thermal scheduling problem with given data. *(CO3)*
4. **Compute** the steady-state frequency deviation for a given load disturbance in a single-area system. *(CO4)*
5. **Determine** the OPF using DC load flow for a 3-bus power system. *(CO5)*

L4 – Analyze (Break Down / Interpret)

1. **Analyze** the effect of network losses on the economic scheduling outcome. *(CO1)*
2. **Compare** dynamic programming and priority list methods for unit commitment. *(CO2)*
3. **Analyze** the impact of water inflow constraints on hydro scheduling. *(CO3)*
4. **Examine** the frequency response of a two-area system after a load change. *(CO4)*
5. **Interpret** the results of an AC OPF solution for voltage and power control. *(CO5)*

L5 – Evaluate (Justify / Critique)

1. **Evaluate** the suitability of lambda-iteration method for large-scale economic dispatch. *(CO1)*
2. **Justify** the use of forward dynamic programming for complex unit commitment cases. *(CO2)*
3. **Assess** the effectiveness of hydro-thermal coordination under variable load conditions. *(CO3)*
4. **Critique** the performance of a decentralized LFC system. *(CO4)*
5. **Evaluate** the trade-offs between using AC and DC methods in OPF. *(CO5)*

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MTEP11031

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POWER CONVERTERS ANALYSIS
(Program Elective-I.1)

Prerequisite: Power Electronics, Power Electronic Converters

Course Objectives:

- To understand various advanced power electronics devices.
- To describe the operation of multi-level inverters with switching strategies for high power applications.
- To comprehend the design of resonant converters and switched mode power supplies.

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

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Develop and analyze various converter topologies.	2	3	3	3	2	L1,L2, L3
CO2	Design AC or DC switched mode power supplies.	3	2	2	2	2	L1,L2, L3,L4

SYLLABUS

UNIT-I: **12 Hours**
MODERN POWER SEMICONDUCTOR DEVICES
Modern power semiconductor devices – Insulated Gate Bipolar Transistor (IGBT) –MOSFET-MOS Turn off Thyristor (MTO) – Emitter Turn Off Thyristor (ETO) – Integrated Gate-Commutated Thyristor (IGCTs) – MOS- controlled thyristors (MCTs)– Power integrated circuits (PICs) – symbol, structure and equivalent circuit – comparison of their features. CO’s - CO1
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UNIT-II: **12 Hours**
RESONANT PULSE INVERTERS
Resonant pulse inverters – series resonant inverters – series resonant inverters with unidirectional switches – series resonant inverters with bidirectional switches – analysis of half bridge resonant inverter – evaluation of currents and voltages of a simple resonant inverter – analysis of half bridge and full bridge resonant inverter with bidirectional switches – Frequency response of series resonant inverters – for series loaded inverter – for parallel loaded inverter – For series and parallel loaded inverters – parallel resonant inverters – Voltage control of resonant inverters – class E resonant inverter – class E resonant rectifier – evaluation of values of C’s and L’s for class E inverter and Class E rectifier – numerical problems.
CO’s - CO1

UNIT-III: **10 Hours**
RESONANT CONVERTERS
Resonant converters – zero current switching resonant converters – L type ZCS resonant converter – M type ZCS resonant converter – zero voltage switching resonant converters – comparison between ZCS and ZVS resonant converters – Two quadrant ZVS resonant converters – resonant dc-link inverters – evaluation of L and C for a zero current switching inverter – Numerical problems.
CO’s - CO1
UNIT-IV: **13 Hours**
MULTILEVEL INVERTERS
Multilevel concept – Classification of multilevel inverters – Diode clamped Multilevel inverter – principle of operation – main features – improved diode Clamped inverter – principle of operation –

Flying capacitors multilevel inverter-principle of operation – main features – cascaded multilevel inverter – principle of operation – main features – Multilevel inverter applications – reactive power compensation – back to back intertie system – adjustable drives - Switching device currents – dc link capacitor voltage balancing – features of Multilevel inverters – comparisons of multilevel converters.
CO's - CO1

UNIT-V: **13 Hours**
D.C & A.C POWER SUPPLIES
DC power supplies – classification - switched mode dc power supplies – fly back Converter – forward converter – push-pull converter – half bridge converter – Full bridge converter – Resonant d c power supplies – bidirectional power supplies – Applications.
AC power supplies – classification – switched mode ac power supplies – Resonant AC power supplies – bidirectional ac power supplies – multistage conversions – control circuits – applications. Introduction – power line disturbances – power conditioners – Uninterruptible Power supplies – applications.
CO's - CO2

Board of Studies : Electrical and Electronics Engineering (EPS)
Approved in BOS No: 01, XXXX
Approved in ACM No: 01.

TEXTBOOKS:

1. Mohammed H. Rashid – "Power Electronics"– Pearson Education-Third Edition – first Indian reprint -2004.
2. Ned Mohan, Tore M. Undeland and William P. Robbins- "Power Electronics"– John Wiley & Sons – Second Edition.

REFERENCES:

1. Milliman Shepherd and Lizang – "Power converters circuits" – Chapter 14 (Matrix converter) PP- 415-444,
2. M.H.Rashid - Power electronics hand book –
3. Marian P. Kaźmierkowski, Ramu Krishnan, Frede Blabjerg Edition:" Control in power electronics" illustrated Published by Academic Press, 2002.
4. NPTEL online course, "Pulse width Modulation for Power Electronic Converters" Dr., G. Narayanan, https://www.youtube.com/playlist?list=PLbMVogVj5nJQoZqyLxx-cg_dYE-Dt2UMH

Internal Assessments Pattern:

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	20%	20%
L2	30%	30%
L3	30%	30%
L4	15%	15%
L5	5%	5%
TOTAL(%)	100	100

Level based questions:

L1 – Remember / Define

1. Define Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS).
2. List common multilevel inverter topologies.
3. State the key advantages of resonant converters over hard-switched converters.

L2 – Understand / Explain

1. Explain how a Cascaded H-Bridge multilevel inverter works and how PWM is applied.
2. Describe why soft switching reduces switching losses and stress on devices.
3. Explain the difference between current mode control and voltage mode control in SMPS.

L3 – Apply / Solve

1. Given parameters, design a buck converter in CCM mode with desired output voltage and evaluate its transfer function.
2. For a 3-level NPC inverter, derive the modulation scheme and
3. Waveform for one switching cycle.
4. Using small-signal modeling, find the transfer function of a forward converter
5. Design a compensator.

L4 – Analyze / Compare

1. Compare the performance (losses, switching stress, complexity) of a resonant converter vs conventional hard switching converter for the same specs.
2. Analyze how capacitor voltage imbalance happens in a multilevel converter and propose measures to mitigate it.
3. Given a converter layout with parasitic inductances, analyze the impact on switching waveforms and EMI

Level-5 Questions

1. **Evaluate** the trade-offs of using **Modular Multilevel Converter (MMC)** versus **Cascaded H-Bridge (CHB)** on metrics such as scalability, fault tolerance, control complexity, and efficiency, especially in high voltage, high power applications.
2. **Critique** the use of wide-bandgap devices (GaN, SiC) in high frequency resonant converters: analyze when they bring benefit, limitations (e.g. cost, reliability), and how they affect converter topology choices.
3. **Assess** the suitability of **ZVS** vs **ZCS** resonant converter topologies for a given power / voltage / load scenario. Justify which one you'd choose and why, considering switching losses, component stresses, control complexity, and dynamic response.
4. **Justify** the design of a multi-stage SMPS (e.g., isolated + nonisolated stages) for tight regulation, isolation, and efficiency. Compare it against using a single stage converter, examining losses, control stability, component count, size, and cost.

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MTEP11032 **SUSTAINABLE ENERGY SOLUTIONS** **3 0 0 3**

(Program Elective-I.2)

Prerequisite: Power Systems and Electrical Machines

Course Objectives:

- To understand the concept of sustainability, global energy scenario, Indian initiatives, and UN 2030 goals for affordable and clean energy.
- To learn the working principles of various sustainable energy sources such as solar, wind, hydro, biomass, hydrogen, wave, and tidal energy.
- To Explore sustainable utilization of energy through smart grids, storage technologies, waste-to-energy, and carbon capture methods.
- To comprehend the role of e-mobility in sustainability, including electric and hybrid vehicles, regenerative braking, and V2G technologies.
- To apply concepts of energy economics and management for analyzing, conserving, and managing energy resources effectively.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Explain the concept of sustainability and analyze the present global and Indian energy scenario with reference to initiatives and UN goals.	2	3	3	3	2	L1,L2, L3
CO2	Describe the working principles of solar, wind, hydro, biomass, hydrogen, wave, and tidal power generation systems.	3	2	2	2	2	L1,L2, L3,L4
CO3	Analyze smart grid technologies, energy storage, waste-to-energy, and carbon capture solutions for sustainable utilization of energy.	2	3	2	2	3	L1, L2, L4
CO4	Examine the operation, advantages, and sustainability impact of electric vehicles, hybrid vehicles, regenerative braking, and V2G technologies.	3	2	2	2	3	L1, L2, L4
CO5	Evaluate energy systems using economic indicators (NPV, IRR, payback, life cycle cost) and propose strategies for energy management and conservation.	2	3	2	3	3	L1,L2, L3,L4

SYLLABUS

UNIT- I: **12 Hours**

GLOBAL ENERGY SCENARIO:

Concept of Sustainability (Social, Economic and Environmental impacts). Sustainable and non-sustainable energy sources. Present global and Indian scenario. Bureau of energy efficiency. Initiatives and incentives for promoting sustainability. UN 2030 goals for clean and affordable energy. CO's - CO1

UNIT-II: **10 Hours**

SOURCES OF SUSTAINABLE ENERGY:

Working principles of: Solar Thermal Power Generation, Solar Photovoltaic Power Generation, Wind Power Generation, Hydro Power Generation, Hydrogen energy and fuel cells.
CO's - CO2

UNIT-III: **11 Hours**

SUSTAINABLE UTILIZATION OF ENERGY:

Smart grid technologies - overview, penetration of renewable energy sources. Energy storage technologies. Renewable energy to Hydrogen.
CO's - CO3

UNIT-IV: **11 Hours**

SUSTAINABILITY THROUGH E-MOBILITY:

Electric vehicles. Advantages and environmental impact. Regenerative braking. Hybrid electric vehicles, modes of operation. Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) Technologies- fundamentals. CO's - CO4

UNIT-V: **12 Hours**

ENERGY ECONOMICS AND MANAGEMENT

Energy Economics: Cost analysis, interest, accounting rate of return, Payback, Discounted cash flow, Net present value, Internal rate of return, Inflation and life cycle analysis of energy systems. Energy Management: Definition, objectives, resource conservation, climate protection and cost savings. CO's - CO5

Board of Studies : Electrical and Electronics Engineering (EPS)
Approved in BOS No: 01, 12-09-2025
Approved in ACM No: 01.26-09-2025

TEXTBOOKS:

1. Energy, the Environment, and the Sustainability, 1st Edition, Efstathios E. Michaelides, CRC Press, 2018.
2. Modern Electric, Hybrid Electric and Fuel cell vehicles, Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi, 3rd Edition, CRC Press, 2018.
3. Energy Economics Concepts, Issues, Markets and Governance, 2nd Edition, S. C. Bhattacharyya,

Springer, 2019.

REFERENCES:

1. Renewable Energy: Power for a Sustainable Future, G. Boyle (Editor), 3rd Edition, Oxford University Press, 2012.

ONLINE RESOURCES:

1. https://nptel.ac.in/courses/112106318
2. https://nptel.ac.in/courses/127103236

Internal Assessments Pattern:

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	20%	20%
L2	30%	30%
L3	35%	35%
L4	10%	10%
L5	5%	5%
TOTAL(%)	100	100

Level based questions:

Remember / Recall (L1)

1. What is the full form of V2G?
2. List four types of renewable energy sources.
3. What is the meaning of "payback period" in energy project economics?
4. Name two energy storage technologies used in smart grids.
5. What is the UN Sustainable Development Goal (SDG) number for "Affordable and Clean Energy"?

Understand / Comprehension (L2)

1. Explain in your own words how regenerative braking recovers energy in electric vehicles.
2. Describe the difference between wave energy and tidal energy.
3. Summarize how a pumped-storage hydro plant works.
4. What is the role of carbon capture in reducing emissions from fossil-based power plants?
5. Explain how Smart Grids help in balancing variable renewable energy.

Apply (L3)

1. Suppose a solar irradiation is 5 kWh/m²/day. If you need to supply 1,000 kWh per day and your system efficiency including losses is 15%, compute the required PV panel area.
2. A microgrid sees a load fluctuation of ±50 kW for 3 hours. What storage capacity (in kWh) is needed (ignoring losses)?
3. A hybrid EV recovers 10 kW during braking for 5 minutes in a day—calculate the energy recovered in kWh.
4. A project costs ₹5 lakh and gives annual savings of ₹50,000. Find its payback period.
5. Given a flue gas flow rate and CO_2 concentration, calculate mass of CO_2 captured (you may assume ideal gas behaviour, molecular weights, etc.).

Analyze (L4)

1. Compare lithium-ion batteries and flow batteries in terms of cycle life, cost, and suitability for grid storage.
2. Analyze how a high penetration of EV charging during evening peak times would affect grid

stability.

3. Examine the limitations and challenges in integrating tidal power into the main grid.
4. Given two energy projects (A and B) with different cost, cash flows and lifetimes, analyze which is better using NPV vs IRR.
5. Compare the strengths and weaknesses of waste-to-energy vs biomass combustion as renewable sources.

Evaluate (L5)

1. Evaluate the feasibility of deploying a solar + battery + diesel hybrid system in a remote rural village (considering cost, reliability, environment).
2. Critique the use of CCUS (carbon capture, utilization, and storage) in a coal plant: what are the pros and cons?
3. Given the lifecycle emissions and resource costs of EVs, assess whether widespread EV adoption is truly sustainable.
4. A renewable project has negative NPV but strong social benefits. Should it be approved? Justify your stance.
5. Evaluate a policy (e.g. feed-in tariff, net metering) from both economic and social perspectives for promoting clean energy.

Chairperson

Board of Studies (EEE)

MTEP11033

SMART GRID TECHNOLOGIES **3 0 0 3**

(Program Elective-I.3**)**

Prerequisite: Power Systems

Course Objectives:

- To understand concept of smart grid and its advantages over conventional grid
- To know smart metering techniques
- To learn wide area measurement techniques
- To understand the problems associated with integration of distributed generation & its solution through smart grid.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Appreciate the difference between smart grid & conventional grid	2	3	3	3	2	L1,L2, L3
CO2	Apply smart metering concepts to industrial and commercial installations	3	2	2	2	2	L1,L2, L3,L4
CO3	Formulate solutions in the areas of smart substations, distributed generation and wide area measurements	2	3	2	2	3	L1, L2, L4
CO4	Come up with smart grid solutions using modern communication technologies	3	2	2	2	3	L1, L2, L4

SYLLABUS

UNIT-I: **10 Hours**

Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self-Healing Grid Present development & International policies in Smart Grid CO's - CO1

UNIT-II: **13 Hours**

Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation.
CO's - CO2

UNIT-III: **12 Hours**

Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). CO's - CO3

UNIT-IV: **14 Hours**

Concept of micro-grid, Need& applications of micro-grid, Formation of micro-grid, Issues of interconnection, Protection & control of micro-grid, Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, Fuel-cells, micro-turbines, Captive power plants, Integration of renewable energy sources. CO's - CO4

UNIT-V: **12 Hours**

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit. Advanced Metering Infrastructure (AMI) and Various Communication means and IP based Protocols. CO's - CO4

Board of Studies : Electrical and Electronics Engineering.(EPS)
Approved in BOS No: 01, 12-09-2025
Approved in ACM No: 01. 26-09-2025

TEXTBOOKS:

1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE, 2011.
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press, 2009.

REFERENCES:

1. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, "Smart Grid: Technology and Applications",Wiley, 2012.
2. Stuart Borlase, "Smart Grid: Infrastructure, Technology and solutions", CRC Press.
3. A.G.Phadke, "Synchronized Phasor Measurement and their Applications", Springer.

Internal Assessments Pattern:

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	20%	20%
L2	30%	30%
L3	30%	30%
L4	15%	10%
L5	5%	10%
TOTAL(%)	100	100

Level based questions:

Remember / Recall (L1)

1. What is a smart grid?
2. List two differences between a smart grid and a conventional grid.
3. What is a smart meter?
4. Define wide area measurement in power systems.
5. Name a communication technology used in smart grids.

Understand / Comprehension (L2)

1. Explain how smart metering provides benefits over conventional metering.
2. Describe the role of Phasor Measurement Units (PMUs) in wide area monitoring.
3. Illustrate what is meant by "distribution automation" in a smart grid context.
4. Explain one major challenge in integrating distributed generation into a power grid.
5. Describe how communication technologies are used in smart substations.

Apply (L3)

1. Suppose a commercial facility uses 500 kW, and the utility offers time-of-use pricing. Sketch or compute how a smart meter could shift load to off-peak to reduce cost.

2. You have to place 3 PMUs in a small grid of 10 buses. Propose their placement so that the grid is observable (you may assume simple topology).
3. For a smart substation, choose a suitable communication protocol (e.g. IEC 61850) and justify your choice in a given scenario (say, latency constraint).
4. Given a small distributed generator (say 100 kW solar) connected to a feeder, show how voltage control devices (like voltage regulators) can be operated in a smart grid to maintain voltage limits.
5. Using a given set of measurement data from PMUs, compute the phase angle difference between two buses.

Analyze (L4)

1. Compare two communication technologies (e.g. Ethernet vs wireless mesh) in the context of smart grid constraints (latency, reliability, security).
2. Analyze how increasing penetration of distributed generation can lead to reverse power flows and how smart grid controls can mitigate that.
3. Examine the trade-offs in placing instrumentation (sensors, PMUs) densely vs sparsely in a grid.
4. Given a failure scenario (e.g. a feeder fault), analyze how smart grid features (fault detection, isolation, restoration) can reduce outage duration.
5. Analyze how smart metering data analytics can detect non-technical losses (theft) in a distribution network.

Evaluate (L5)

1. Evaluate whether a utility should invest in full smart metering rollout (all consumers) vs partial (only large consumers). What factors influence the decision?
2. Critically assess the use of wireless communications in critical smart grid infrastructure considering security, reliability, and cost.
3. Given two alternative architectures for a smart substation (centralized vs distributed IEDs), evaluate which is better under constraints of cost, performance, reliability.
4. A distributed generator injects power during low load hours, causing overvoltage problems. Evaluate possible smart grid strategies to resolve this.
5. Given a budget limit, decide which components (smart meters, PMUs, communication links) you would prioritize implementing first in a distribution grid, and justify.

Chairperson
Board of Studies (EEE)

MODERN CONTROL THEORY **3 0 0 3**

(Program Elective-I.4**)**

MTEP11034

Prerequisite: Control Systems

Course Objectives:

- To explain the concepts of basics and modern control system for the real time analysis and design of control systems.
- To explain the concepts of state variables analysis.
- To study and analyze nonlinear systems.
- To analyze the concept of stability for nonlinear systems and their categorization.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Know various terms of basic and modern control system for the real time analysis and design of control systems.	2	3	3	3	2	L1,L2, L3
CO2	Perform state variables analysis for any real time system.	3	2	2	2	2	L1,L2, L3,L4
CO3	Examine a system for its stability, controllability and observability.	2	3	2	2	3	L1, L2, L4
CO4	Implement basic principles and techniques in designing linear control systems.	3	2	2	2	3	L1, L2, L4
CO5	Apply knowledge of control theory for practical implementations in engineering and network analysis.	2	3	2	3	3	L1,L2, L3,L4

UNIT I: **14 Hours**

MATHEMATICAL PRELIMINARIES AND STATE VARIABLE ANALYSIS

Fields, Vectors and Vector Spaces, Linear combinations and Bases, Linear Transformations and Matrices, Scalar Product and Norms, Eigen values, Eigen Vectors and a Canonical form representation of Linear systems, The concept of state, State space model of Dynamic systems, Time invariance and Linearity, Non uniqueness of state model, State diagrams for Continuous-Time State models, Existence and Uniqueness of Solutions to Continuous-Time State Equations, Solutions of Linear Time Invariant Continuous-Time State Equations, State transition matrix and it's properties.Complete solution of state space model due to zero input and due to zero state.

CO's - CO1

UNIT II: **12 Hours**

CONTROLLABILITY AND OBSERVABILITY

General concept of controllability, Controllability tests, Different state transformations such as diagonalization, Jordon canonical forms and Controllability canonical forms for Continuous-Time Invariant Systems, General concept of Observability, Observability tests for Continuous-Time Invariant Systems, Observability of different State transformation forms. CO's - CO2

UNIT III: **12 Hours**

STATE FEEDBACK CONTROLLERS AND OBSERVERS

State feedback controller design through Pole Assignment, using Ackkermans formula. State observers: Full order and Reduced order observers. CO's - CO3

UNIT IV: **13 Hours**

NON-LINEAR SYSTEMS

Introduction to Non-Linear Systems, Types of Non-Linearities, Saturation, Dead-Zone, Backlash, Jump Phenomenon etc., Linearization of nonlinear systems, Singular Points and its types, describing function, describing function of different types of nonlinear elements, Stability analysis of Non-Linear systems through describing functions.

Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, Stability analysis of nonlinear systems based on phase-plane method. CO's - CO4

UNIT V: **10 Hours**

STABILITY ANALYSIS

Stability in the sense of Lyapunov, Lyapunov's stability and Lypanov's instability theorems, Stability Analysis of the Linear continuous time invariant systems by Lyapunov second method, Generation of Lyapunov functions, Variable gradient method, Krasooviski's method. CO's - CO5

Board of Studies : Electrical and Electronics Engineering.(EPS)
Approved in BOS No: 01, 12-09-2025
Approved in ACM No: 01.

TEXTBOOKS:

1. M.Gopal, "Modern Control System Theory", New Age International, 1984.
2. Ogata. K, "Modern Control Engineering", Prentice Hall, 1997.

REFERENCES:

1. N K Sinha, "Control Systems", New Age International, 3rd Edition.
2. Donald E.Kirk, "Optimal Control Theory an Introduction", Prentice Hall Network series, 1stEdition.

Internal Assessments Pattern:

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	20%	20%
L2	25%	30%
L3	30%	30%
L4	20%	15%
L5	5%	5%
TOTAL(%)	100	100

Level based questions:

Remember / Recall (L1)

1. Define **state variable** in control systems.

2. What is the **state transition matrix**?
3. Name two conditions for system controllability.
4. What is a **Lyapunov function**?
5. State the difference between classical and modern control approaches.

Understand / Comprehension (L2)

1. Explain why a system in state-space form is beneficial compared to transfer function representation.
2. Describe the concept of **observability** in a control system.
3. Explain the principle of Lyapunov's direct method for stability analysis.
4. Illustrate how pole placement works in a state feedback controller.
5. Describe how nonlinearity complicates control design compared to linear systems.

Apply (L3)

1. Given the system $\dot{x} = \begin{pmatrix} 0 & 1 \\ -5 & -6 \end{pmatrix} x + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u,$
   determine if the pair $(A, B)$is controllable (i.e. compute the controllability matrix).

2. For the above system, design a state feedback control law $u = -Kx$to place the closed-loop poles at $-2$and -3.
3. Given the nonlinear system $\dot{x} = x - x^3$, use a Lyapunov function candidate $V(x) = \frac{1}{2}x^2$and analyze stability of the equilibrium at $x = 0$.
4. Given a third-order system with measured output only the first state, design a full-order observer to estimate the other states.
5. Compute the state transition matrix $e^{At}$for $A = \begin{pmatrix} 0 & 1 \\ -2 & -3 \end{pmatrix}$

Analyze (L4)

1. Compare advantages and disadvantages of state feedback versus classical PID control in a MIMO system.
2. Analyze the impact of an unmodeled nonlinear term (for example, friction) on the stability of a linear controller designed via pole placement.
3. Given a system that is controllable but not observable (with certain C), analyze the consequences of trying to design both a controller and observer.
4. For a candidate Lyapunov function $V(x) = x^T P x$, analyze how to choose P(solve Lyapunov equation) such that $\dot{V}$is negative definite.
5. Examine the region of attraction for a nonlinear system $\dot{x} = -x + x^3 - x^5$: sketch / deduce where trajectories converge to equilibrium.

Evaluate (L5)

1. A linear controller gives good performance near an operating point, but large disturbances push system into nonlinear regime. Evaluate whether gain scheduling or sliding mode control is a better approach.
2. Critique the use of quadratic Lyapunov functions $V = x^T P x$for nonlinear systems. Under what conditions might they fail?
3. You have two candidate control strategies: one simpler but slightly suboptimal, another more complex but optimal. Evaluate tradeoffs (complexity, robustness, implementation) and decide which to pick.

4. Given limited sensor availability (less outputs), evaluate whether you should invest in additional sensors or design robust estimation algorithms.
5. A control design suggests very fast pole placement (large gains). Evaluate practical limitations (actuator saturation, noise amplification) and whether you would accept that design.

Chairperson
Board of Studies (EEE)

MTEP11041 **HVDC TRANSMISSION** **3 0 0 3**

Prerequisite: Power Systems and Power Electronics

Course Objectives:

- To understand the state-of-the-art HVDC technology.
- To learn the methods to carry out modeling and analysis of HVDC system frontier-area power flow regulation.
- To analyze the converter and dc grid faults and methods to mitigate them.
- To Understand the HVDC converter
- To learn how to identify reactive power requirements and necessary means to address those issues.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Expose to the basics of HVDC technology.	3	2	2	3	2	L1,L2,
CO2	Gain Knowledge of modelling and analysis of HVDC system for inter-area power flow regulation.	3	3	2	2	2	L2,L3,
CO3	Analyze the converter and dc grid faults and methods to mitigate them.	2	3	3	2	3	L1, L2, L4
CO4	Understand the HVDC converter	3	3	2	2	3	L2, L3,L4
CO5	Identify reactive power requirements and identifying the necessary means to address those issues.	2	3	3	3	3	L3,L4, L5

UNIT-I: **12 Hours**

GENERAL ASPECTS OF DC TRANSMISSION

Evolution of HVDC transmission, Comparison of HVDC and HVAC systems, Types of DC links, Components of a HVDC system, Valve characteristics, Properties of converter circuits, Assumptions, Single phase and Three-phase Converters, Pulse number, Choice of best circuit for HVDC converters. CO's - CO1

UNIT-II: **11 Hours**

ANALYSIS OF BRIDGE CONVERTER

Analysis of simple rectifier circuits, required features of rectification circuits for HVDC transmission. **Analysis of HVDC converter**: Different modes of converter operation, Output voltage waveforms and DC voltage in rectification, Output voltage waveforms and DC in inverter operation, Thyristor/Valve voltages, Equivalent electrical circuit. CO's - CO2

UNIT-III: **10 Hours**

DC LINK CONTROL

Grid control, Basic means of control, Power reversal, Limitations of manual control, Constant current versus Constant Voltage, Desired features of control.

Actual control characteristics: Constant-minimum-ignition-angle control, Constant-current control, Constant-extinction-angle control, Stability of control, Tap-changer control, Power control and current limits, Frequency control. CO's - CO3

UNIT-IV: **10 Hours**

CONVERTER FAULTS & PROTECTION

Converter mal-operations, Commutation failure, Starting and shutting down the converter bridge, Converter protection. CO's - CO4

UNIT-V: **12 Hours**

REACTIVE POWER MANAGEMENT & AC-DC POWER FLOW ANALYSIS

Smoothing reactor and DC Lines, Reactive power requirements, Harmonic analysis, Filter design. Power flow Analysis in AC/DC systems, Modelling of DC links, Solutions of AC-DC Power flow. CO's - CO5

Board of Studies : Electrical and Electronics Engineering
Approved in BOS No: 01, 12-09-2025.
Approved in ACM No: 01.

TEXTBOOKS:

1. J. Arrillaga, "High Voltage Direct Transmission", Peter Peregrinus Ltd. London, 1983.
2. K. R. Padiyar, "HVDC Power Transmission Systems", Wiley Eastern Ltd., 1990.

REFERENCES:

1. E. W. Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, 1971.
2. Erich Uhlmann, "Power Transmission by Direct Current", B.S. Publications, 2004.
3. SN.Singh, "Electric Power Generation, Transmission and Distribution, PHI, New Delhi, 2nd Edition, 2008.
4. V. Kamaraju, "HVDC Transmission", Tata McGraw-Hill Education Pvt Ltd, New Delhi, 2011.

Internal Assessment Pattern

Cognitive Level	**Internal Assessment #1(%)**	**Internal Assessment #2(%)**
L1	10%	10%
L2	30%	25%
L3	25%	30%
L4	20%	25%
L5	15%	10%
Total (%)	**100%**	**100%**

Level-Based Questions: HVDC Transmission

L1 – Remember

1. Define HVDC transmission and mention its two main types.
2. What is a converter station in HVDC systems?
3. List the main components of an HVDC transmission system.
4. State two advantages of HVDC over HVAC.
5. What are the typical causes of DC grid faults?

L2 – Understand

1. Explain how HVDC is used for long-distance bulk power transmission.
2. Describe the working principle of a Line-Commutated Converter (LCC).
3. Explain the concept of inter-area power flow regulation using HVDC.
4. Discuss how a DC fault differs from an AC fault in transmission systems.
5. Illustrate the need for reactive power compensation in HVDC systems.

L3 – Apply

1. Develop a basic model of an HVDC transmission system using block diagrams.
2. Apply appropriate techniques to analyze a simple two-terminal HVDC system.
3. Simulate an HVDC converter using MATLAB/Simulink or any equivalent tool.
4. Calculate the reactive power required for an HVDC terminal under steady-state operation.
5. Apply methods for detecting and isolating DC faults in a grid-connected system.

L4 – Analyze

1. Analyze the impact of converter faults on system stability.
2. Differentiate between VSC and LCC HVDC converters in terms of operation and control.
3. Analyze the performance of multi-terminal HVDC systems under faulted conditions.
4. Identify critical issues in reactive power management in HVDC systems.
5. Examine the protection strategies used in modern HVDC grids.

L5 – Evaluate

1. Evaluate the different methods used for reactive power compensation in HVDC systems.
2. Justify the use of Voltage Source Converter (VSC) in offshore wind HVDC applications.
3. Assess the advantages and limitations of HVDC in interconnecting asynchronous grids.
4. Recommend optimal locations for reactive power support devices in a given HVDC layout.
5. Critically evaluate fault mitigation techniques and their effectiveness in HVDC systems.

Chairperson
Board of Studies (EEE)

MTEP11042

Electrical Power Distribution System **3 0 0 3**

(Program Elective-II.2**)**

Prerequisite: Power Systems

Course Objectives:

- To learn about power distribution system
- To learn different Methods and Constraints, Power Factor Correction.
- To learn of SCADA system
- To learn calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial Distribution Systems
- To understand distribution automation

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Gain knowledge of power distribution system	3	3	2	1	2	L1,L2,
CO2	Study the distribution automation and its application in practice.	2	3	2	2	3	L1,L2
CO3	Learn SCADA system	3	3	3	2	2	L1, L2, L3
CO4	Calculation of Optimum Number of Switches, Capacitors	3	3	2	3	2	L2, L3,L4
CO5	AI techniques applied to Distribution Automation.	2	3	3	2	3	L4,L5

UNIT-I: **11 Hours**

Distribution of Power, Management, Power Loads, Load Forecasting Short-term & Long-term, Power System Loading, Technological Forecasting. CO's - CO1

UNIT-II: **12 Hours**

Advantages of Distribution Management System (D.M.S.), Distribution Automation: Definition, Restoration / Reconfiguration of Distribution Network, Different Methods and Constraints, Power Factor Correction. CO's - CO2

UNIT-III: **13 Hours**

Interconnection of Distribution, Control & Communication Systems, Remote Metering, Automatic Meter Reading and its implementation.

SCADA: Introduction, Block Diagram, SCADA Applied to Distribution Automation, Common Functions of SCADA, Advantages of Distribution Automation through SCADA. CO's - CO3

UNIT-IV: **11 Hours**

Calculation of Optimum Number of Switches, Capacitors, Optimum Switching Device Placement in Radial Distribution Systems, Sectionalizing Switches, Types, Benefits, Bellman's Optimality Principle, Remote Terminal Units, Energy efficiency in electrical distribution & Monitoring. CO's - CO4

UNIT-V: **12 Hours**
Maintenance of Automated Distribution Systems, Difficulties in Implementing Distribution, Automation in Actual Practice, Urban/Rural Distribution, Energy Management, AI techniques applied to Distribution Automation. CO's - CO5

Board of Studies : Electrical and Electronics Engineering
Approved in BOS No: 01, 12-09-2025.
Approved in ACM No: 01.

TEXTBOOKS:

A.S. Pabla, "Electric Power Distribution", Tata McGraw Hill Publishing Co. Ltd., 4th Edition.
M.K. Khedkar, G.M. Dhole, "A Text Book of Electrical Power Distribution Automation", University Science Press, New Delhi.

REFERENCES:

Anthony J Panseni, "Electrical Distribution Engineering", CRC Press.
James Momoh, "Electric Power Distribution automation protection & control", CRC Press.

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	10%	10%
L2	30%	25%
L3	25%	30%
L4	20%	25%
L5	15%	10%
Total (%)	**100%**	**100%**

L1 – Remember

Define a power distribution system.

What are the key components of a typical distribution network?

List the benefits of distribution automation.

What does SCADA stand for? Mention any two functions.

Define power factor and explain its importance in distribution systems.

L2 – Understand

Explain the difference between radial and ring distribution systems.

Describe how SCADA supports monitoring and control in distribution systems.

Explain the significance of power factor correction in distribution networks.

Describe the role of capacitor placement in a distribution system.

Illustrate the structure and working of a basic SCADA system.

L3 – Apply

1. Apply SCADA to detect faults in a distribution network.
2. Calculate the number of switches required in a given radial distribution system.
3. Determine the locations for capacitor placement in a small distribution feeder using given load data.
4. Apply AI techniques (e.g., fuzzy logic) to identify optimal load control strategies in automated systems.

L4 – Analyze

1. Analyze the impact of optimal capacitor placement on power loss reduction.
2. Compare manual and automated distribution systems in terms of efficiency and reliability.
3. Analyze the placement of switching devices to enhance fault isolation in radial distribution systems.
4. Examine the role of communication infrastructure in SCADA-based automation.

L5 – Evaluate

1. Evaluate the use of AI (e.g., machine learning) in improving distribution system performance.
2. Assess the effectiveness of SCADA in real-time fault detection and service restoration.
3. Critically evaluate different algorithms used for optimal switch placement in distribution automation

Chairperson
Board of Studies (EEE)

MTEP11043 **REACTIVE POWER COMPENSATION AND MANAGEMENT** **3 0 3 0**

(Program Elective-II.3)

Prerequisite: Power Systems

Course Objectives:

- To identify the necessity of reactive power compensation
- To describe load compensation
- To select various types of reactive power compensation in transmission systems
- To illustrate reactive power coordination system
- To characterize distribution side and utility side reactive power management.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Distinguish the importance of load compensation in symmetrical as well as unsymmetrical loads	3	3	2	2	2	L1,L2
CO2	Work out on various compensation methods in transmission lines	3	2	2	3	2	L2,L3, L4
CO3	Construct models for reactive power coordination	3	2	3	2	3	L3, L4
CO4	Distinguish demand side reactive power management	3	3	2	3	2	L2,L3, L4
CO5	Understand Reactive Power Management In Electric Traction Systems And Arc Furnaces	2	3	3	3	2	L3,L4, L5

UNIT-I: **12 Hours**

LOAD COMPENSATION

Objectives and specifications, Reactive power characteristics, Inductive and capacitive approximate biasing, Load compensator as a voltage regulator, Phase balancing and power factor correction of unsymmetrical loads, Examples. CO's - CO1

UNIT-II: **13 Hours**

STEADY–STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS

Uncompensated line, Types of compensation, Passive shunt and series and dynamic shunt compensation, Examples.

TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEMS

Characteristic time periods, Passive shunt compensation, Static compensation, Series capacitor compensation, Compensation using synchronous condenser, Examples. CO's - CO2

UNIT-III: **12 Hours**

REACTIVE POWER COORDINATION

Objective, Mathematical modeling, Operation planning, Transmission benefits, Basic concepts of quality of power supply, Disturbances, Steady–state variations, Effect of under-voltages, Frequency, Harmonics, Radio frequency and electromagnetic interference. CO's - CO3

UNIT-IV: **12 Hours**

DEMAND SIDE MANAGEMENT

Load patterns, Basic methods load shaping, Power tariffs, KVAR based tariffs penalties for voltage flickers and Harmonic voltage levels.
DISTRIBUTION SIDE REACTIVE POWER MANAGEMENT
System losses, Loss reduction methods, Examples, Reactive power planning, Objectives, Economics Planning capacitor placement, Retrofitting of capacitor banks. CO’s - CO4

UNIT-V: **13 Hours**
USER SIDE REACTIVE POWER MANAGEMENT
KVAR requirements for domestic appliances, Purpose of using capacitors, Selection of capacitors, Deciding factors, Types of available capacitor, Characteristics and Limitations.
REACTIVE POWER MANAGEMENT IN ELECTRIC TRACTION SYSTEMS AND ARC FURNACES
Typical layout of traction systems, Reactive power control requirements, Distribution transformers, Electric arc furnaces, Basic operation, Furnaces transformer, Filter requirements, Remedial measures, Power factor of an arc furnace.
CO’s - CO5

Board of Studies : Electrical and Electronics Engineering
Approved in BOS No: 01, 12-09-2025
Approved in ACM No: 01

TEXTBOOKS:

T.J.E.Miller, “Reactive power control in Electric power systems”, John Wiley and sons, 1982.
D.M. Tagare,” Reactive power Management”, Tata McGraw Hill, 2004.

REFERENCES:

Wolfgang Hofmann, Jurgen Schlabbach, Wolfgang Just, “Reactive Power Compensation: A Practical Guide”, Wiley Publication, April2012.

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	10%	15%
L2	20%	25%
L3	30%	30%
L4	25%	20%
L5	15%	10%
Total (%)	**100%**	**100%**

L1 – Remember

Define reactive power and explain its significance in power systems.

What is load compensation?

List the types of loads where compensation is required.

L2 – Understand

Explain the need for load compensation in unsymmetrical loads.

Discuss the difference between series and shunt compensation.

Explain how reactive power affects voltage stability.

Describe the concept of demand-side reactive power management.

L3 – Apply

1. Calculate the reactive power required to improve power factor from 0.7 to 0.95 for a given load.
2. Apply the concept of shunt compensation to a transmission line model.
3. Analyze the performance improvement of a transmission system using reactive power compensation.
4. Use compensation techniques for improving voltage profile in a distribution network.

L4 – Analyze

1. Compare fixed and dynamic compensation techniques in transmission systems.
2. Analyze how reactive power coordination systems enhance system stability.
3. Evaluate the effect of capacitor bank switching on system voltage profile.
4. Examine the reactive power behavior of arc furnaces and propose compensation methods.

L5 – Evaluate (Justifying decisions and making judgments)CO5

1. Evaluate different compensation techniques for electric traction systems.
2. Assess the effectiveness of SVC (Static VAR Compensator) vs STATCOM for reactive power support.
3. Critically evaluate utility-side compensation strategies and their impact on grid reliability

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MTEP11044 **ELECTRIC VEHICLE TECHNOLOGIES** **3 0 0 3**

(Program Elective-II.4)

Prerequisite: Power Semiconductor Drives, Electrical Drives and Control, Utilization of Electric Energy

Course Objectives:

- To understand the fundamental concepts and Mathematical models to describe vehicle performance.
- To know the history of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles.
- To learn basic concept of electric traction, introduction to various electric drive train topologies, Power flow control in electric drive-train topologies,
- To learn types of electric machines that can be used energy storage devices, etc.
- To learn Energy Management Strategies and Case Studies.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Understand the models to describe hybrid vehicles and their performance	3	3	2	3	2	L1,L2, L3
CO2	Undeerstand Social and environmental importance of hybrid and electric vehicles.	3	2	2	2	2	L2,L3
CO3	Evaluate the Power flow control in electric drive-train topologies	3	3	3	2	2	L3 L4
CO4	Understand the different possible ways of energy storage	2	3	2	2	3	L4
CO5	Understand the different strategies related to energy storage systems.	3	2	3	2	1	L4,L5

UNIT-I: **10 Hours**

INTRODUCTION

Conventional Vehicles: Basics of vehicle performance, Vehicle power source characterization, Transmission characteristics, Mathematical models to describe vehicle performance. CO's - CO1

UNIT-II: **11 Hours**

INTRODUCTION TO HYBRID ELECTRIC VEHICLES

History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies.

Hybrid Electric Drive-Trains: Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis. CO's - CO2

UNIT-III: **12 Hours**

ELECTRIC TRAINS

Electric Drive-Trains: Basic concept of electric traction, introduction to various electric drive train topologies, Power flow control in electric drive-train topologies, Fuel efficiency analysis.
Electric Propulsion Unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, Configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, Drive system efficiency. CO's - CO3

AIE

UNIT-IV: **12 Hours**

ENERGY STORAGE

Energy Storage: Introduction to Energy Storage, Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.
Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, Sizing the power electronics, selecting the energy storage technology, Communications, Supporting subsystems. CO's - CO4

UNIT-V: **10 Hours**

ENERGY MANAGEMENT STRATEGIES

Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, Classification of different energy management strategies, Comparison of different energy management strategies, Implementation issues of energy management strategies.
Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV). CO's - CO5

Board of Studies : Electrical and Electronics Engineering
Approved in BOS No: 01, 12-09-2025
Approved in ACM No: 01.

TEXTBOOKS:

C. Mi, M. A. Masrur and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.

REFERENCES:

M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
T. Denton, "Electric and Hybrid Vehicles", Routledge, 2016.

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	15%	10%
L2	25%	20%
L3	30%	35%
L4	20%	25%
L5	10%	10%
Total (%)	**100%**	**100%**

L1 (Recall / Define / List)

AIE

- Define a **hybrid electric vehicle (HEV)** and a **battery electric vehicle (BEV)**.
- List three types of electric motors used in EV drive trains.
- What is meant by **tractive effort** in vehicle dynamics?
- Define State of Charge (SoC) and State of Health (SoH) of a battery.
- List two advantages and two disadvantages of electric vehicles compared to internal combustion vehicles.

L2 (Understand / Explain / Describe)

- Explain how the power flow control works in a **series hybrid** drive train.
- Describe the environmental benefits of adopting electric vehicles over conventional vehicles.
- Explain the difference between energy density and power density in energy storage systems.
- Describe how regenerative braking works and its effect on battery charge.
- Explain why battery management is critical in EV battery systems.

L3 (Apply / Compute / Solve)

- Given vehicle parameters (mass, rolling resistance, drag coefficient), compute the power required at a given speed, and estimate battery current draw.
- A drive train has motor efficiency of 90% and gearbox efficiency of 95%. If battery provides 50 kW, compute wheel output power.
- Given a battery with 200 Wh/kg and a vehicle consumption of 200 Wh/km, estimate the battery mass required for a 300 km range (ignore losses).
- For a hybrid vehicle with given power split strategy, compute how much energy comes from battery vs engine over a drive cycle.
- For a given battery and load profile, compute the SOC variation over time with given charging/discharging currents.

L4 (Analyze / Compare / Critique)

- Compare the pros and cons of **series vs parallel hybrid** architectures in EV design.
- Analyze trade-offs between lithium-ion batteries and supercapacitors for high power demand in EVs.

- Given two energy storage options, evaluate which one gives better performance for a given EV duty cycle and justify.
- Critique an energy management strategy (e.g., always use battery first) — what are its limitations?
- Analyze the impact of drive train losses (motor, inverter, gearbox) on overall efficiency and range of the EV.

L5 (Design / Create / Evaluate)

- Design a battery sizing plan for an EV targeted to travel 250 km with a margin, considering energy consumption, losses, and degradation.
- Propose an energy management algorithm (rule-based or optimization) for a plug-in hybrid vehicle, explaining when to use battery vs engine.
- Create a comparative study framework to evaluate different energy storage technologies (Li-ion, solid-state, ultracapacitor) for an EV use case.

- Evaluate the feasibility of adding fast charging capability (e.g. 150 kW) to your EV design — what changes in components, battery, cooling would you need?
- Develop a simulation plan or block diagram to test different drive train topologies under varied driving cycles and compare performance

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MTMB1105 RESEARCH METHODOLOGY & IPR 2 0 0 2

Prerequisite: None

Course Objectives:

- To understand the research problem
- To know the literature studies, plagiarism and ethics
- To get the knowledge about technical writing
- To analyze the nature of intellectual property rights and new developments
- To know about the patent rights

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO 1	PO2	PO3	PSO1	PSO2	
CO1	Understand research problem formulation.	2	3	3	2	2	L1,L2, L3
CO2	Analyze the literature studies, plagiarism and ethics	3	3	2	1	2	L2,L3
CO3	Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept and creativity.	3	2	3	2	1	L2,L3
CO4	Understanding that when IPR would take such important place in growth of individuals &nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.	3	3	2	3	2	L2,L3, L4
CO5	Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products and in turn brings about economic growth and social benefits.	2	3	3	2	1	L3,L4, L5

UNIT-I: **12 Hours**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
Approaches of investigation of solutions for research problem, Data collection, Analysis, Interpretation, Necessary instrumentations. CO's - CO1

UNIT-II: **10 Hours**

Effective literature studies approaches, Analysis, Plagiarism, Research ethics. CO's - CO2

UNIT-III: **10 Hours**

Effective technical writing, How to write a report, paper in developing a research proposal, Format of research proposal, A presentation and assessment by a review committee. CO's - CO3

UNIT-IV: **12 Hours**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright.
Process of Patenting and Development: Technological research, Innovation, Patenting, Development.
International Scenario: International cooperation on Intellectual Property, Procedure for grant of patents,

Patenting under PCT. CO's - CO4

UNIT-V: 10 Hours

Patent Rights: Scope of Patent Rights, Licensing and transfer of technology, Patent information and databases, Geographical Indications.
New Developments in IPR: Administration of Patent System, New developments in IPR, IPR of Biological Systems, Computer Software etc. Traditional knowledge, Case Studies, IPR and IITs.
CO's - CO5

Board of Studies : Electrical and Electronics Engineering
Approved in BOS No: 01, 12-09-2025.
Approved in ACM No: 0

TEXTBOOKS:

Stuart Melville and Wayne Goddard, "Research methodology: An Introduction for science & engineering students".
Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction".

REFERENCES:

Ranjit Kumar, 2nd Edition, "Research Methodology: A Step-by-Step Guide for beginners".
Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
Mayall , "Industrial Design", McGraw Hill, 1992.
Niebel, "Product Design", McGraw Hill, 1974.
Asimov, "Introduction to Design", Prentice Hall, 1962.
Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New TechnologicalAge", 2016.
T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.

Internal Assessment Pattern

Cognitive Level	**Internal Assessment #1(%)**	**Internal Assessment #2(%)**
L1	20%	15%
L2	30%	25%
L3	30%	35%
L4	15%	20%
L5	5%	5%
Total (%)	100%	100%

L1 (Recall / Define / List)

Define "research problem."

List and briefly state the types of research.

What is meant by "plagiarism"?

Define "intellectual property."

Name three kinds of IPR (Intellectual Property Rights).

L2 (Understand / Explain / Describe)

1. Explain the difference between research **methods** and **methodology**.
2. Describe why literature review is important in research.
3. Explain the meaning and importance of "sampling design."
4. Describe the features of a good research design.
5. Explain how patent protection stimulates innovation.

L3 (Apply / Analyze)

1. Given a research topic, formulate 2–3 research questions and appropriate objectives.
2. For a small data collection scenario (e.g. survey), choose a sampling technique and justify why it is appropriate.
3. Given a short excerpt suspected of plagiarism, identify and rewrite it with proper citation.
4. Analyze a given patent abstract (or summary) and identify which type of IPR it represents and the novelty claim.
5. Compare two research designs (e.g. exploratory vs descriptive) for a given study situation and decide which is better and why.

L4 (Evaluate / Critique)

1. Critically evaluate the ethical issues involved in conducting interviews as part of research.
2. Given two research proposals, assess which one is more feasible and has better methodology.
3. Evaluate the strengths and limitations of patent protection in the context of public health (or technology).
4. Critique the use of non-probability sampling in quantitative research: when is it acceptable, when is it problematic?
5. Given a hypothetical case of plagiarism in a submitted thesis, design how you would check, penalize, and educate to prevent future instances.

L5 (Design / Create / Synthesize)

1. Design a mini research proposal, including research problem, objectives, methodology, data collection plan, and ethical considerations.
2. Propose an IP strategy for a startup in a technology domain (e.g. software, biotech), covering patents, copyrights, trade secrets.
3. Create a mechanism (policy) for a university to reduce plagiarism among students while encouraging original research.
4. Design a mixed-methods research plan combining qualitative and quantitative approaches for a social problem.
5. Develop a guide/checklist for ensuring a research manuscript meets ethical norms, citation correctness, and IPR compliances.

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MTEP1105 POWER SYSTEMS COMPUTATION LAB-I 0 0 4 2

Prerequisite: Power systems

Course Objectives:

- To construct Y-bus, Z-bus for a n-bus system.
- To analyze various Load flow studies.
- To know steady state, transient stability analysis.
- To understand economic load dispatch problem.
- To understand unit commitment problem.
- To understand state estimation of power system.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs				
		PO1	PO2	PO3	PSO1	PSO2
CO1	Construct Y-bus and Z-bus	3	3	2	2	1
CO2	Compare the different load flow methods	2	3	2	1	2
CO3	Analyze the different stability analysis of variety of power systems	3	3	2	1	2
CO4	Understand Economic load dispatch and Unit commitment problems.	3	2	2	2	3
CO5	Understand State estimation of power system.	2	3	3	2	1

List of Experiments:

1. Develop Program for Y_{BUS} formation by direct inspection method.
2. Develop Program for Y_{BUS} formation by Singular Transformation method.
3. Develop Program for G-S Load Flow Algorithm.
4. Develop Program for N-R Load Flow Algorithm in Polar Coordinates.
5. Develop Program for FDLF Algorithm.
6. Develop Program for DC load Flow Algorithm.
7. Develop Program for Z_{BUS} Building Algorithm.
8. Develop Program for Short Circuit Analysis using Z_{BUS} Algorithm.
9. Develop Program for Transient Stability Analysis for Single Machine connected to Infinite Bus
10. Develop Program for Economic Load Dispatch Problem using Lambda Iterative Method.
11. Develop Program for Unit Commitment Problem using Forward Dynamic Programming Method.
12. Develop Program for State Estimation of Power System.

Note: From the above list, minimum of 10 experiments are to be conducted using suitable software

L1 / L2 (Fundamental Tasks / Understanding)

Y-bus / Z-bus formation

For a given network (e.g. 4-bus or 5-bus), write code to form the Y matrix and Z matrix.

Load Flow: Gauss-Seidel method

Implement the Gauss-Seidel algorithm to solve for voltages, real & reactive power, for given load and generation.

Load Flow: Newton–Raphson method

Implement Newton–Raphson method for power flow and compare convergence with Gauss-Seidel.

Steady State Stability / Swing Equation

Simulate a simple two machine system and observe rotor angle dynamics (small disturbance).

Economic Load Dispatch (ELD)

For given generators and cost curves, compute optimal dispatch ignoring constraints (using lambda iteration or simple algorithm).

L3 / L4 (Analysis / Integration / Multi-component)

Unit Commitment Problem

Write a simple solver (e.g. dynamic programming or heuristic) for small system (3–5 units) over a time horizon.

State Estimation

For a small network with measurement data (with noise), implement weighted least squares state estimation to estimate bus voltages.

Transient Stability under Fault

Introduce a fault at a bus in a simulated system, clear it and simulate transient response (rotor angle, frequency) over time.

Comparative Study: Load Flow Methods

Compare Gauss-Seidel vs Newton–Raphson vs Fast Decoupled methods for several test systems: accuracy, convergence time, iteration count.

Integrated Project: Load Flow + State Estimation + Dispatch

For a small test network: run a load flow, simulate measurement errors, do state estimation, and then do dispatch based on estimated state.

L5 (Design / Optimization / Research Level)

Advanced Unit Commitment with Constraints

Add constraints like ramp rates, minimum up/down times, start-up costs, and solve the UC problem.

Adaptive State Estimation / Bad Data Detection

Incorporate bad data detection or robust estimation techniques in state estimation.

Optimization & Machine Learning Integration

Use ML or heuristic methods to improve dispatch or unit commitment for time-varying loads / renewables.

Simulation + Real Data Comparison

Use real or sample historical power system data, run your algorithms, compare performance, analyze deviations.

Tool / GUI Development

Build a small graphical tool (or script interface) that lets user pick network, measurement set, dispatch algorithm etc., and visualize results

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MTEP1106 **ADVANCED POWER SYSTEMS LAB** **0 0 4 2**

Prerequisite: Power systems and FACTS

Course Objectives:

- To determine transmission line parameters
- To determine transmission line regulation and efficiency
- To determine various fault calculations
- To perform load and line compensation

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs				
		PO1	PO2	PO3	PSO1	PSO2
CO1	Calculate transmission line parameters	3	2	3	2	2
CO2	Calculate transmission line regulation and efficiency	3	3	2	2	1
CO3	Calculate various fault parameters	3	2	2	2	1
CO4	Compare system parameters with and without compensation	2	3	2	3	2
CO5	Determination of Sequence impedance of Transmission Line and SIL analysis	3	3	2	1	2

List of Experiments:

1. Determination of Line Parameters R, L and C.
2. Determination of T/L efficiency and Regulation for a given load.
3. Analysis of Ferranti effect on Transmission Lines under light loadings.
4. Determination of ABCD parameters of a given Transmission Line Network.
5. Fault Analysis:
    1. Single Line to Ground fault (L-G).
    2. Line to Line fault (L-L).
    3. Double Line to Ground fault (L-L-G).
    4. Triple Line to Ground fault (L-L-L-G).
6. Analysis of Uncompensated lines and their voltage profiles.
7. Shunt compensation of Transmission lines (Capacitor/Reactors).
8. Load Compensation analysis.
9. Line Compensation using FACTS devices.
10. Analysis of Transmission lines under Surge Impedance Loading.
11. Determination of Sequence impedance of Transmission Line and SIL analysis.

L1 / L2 (Basic / Understanding / Computation)

Transmission Line Parameter Determination

Use standard laboratory methods (e.g. Murray's loop, nominal T / π model) to compute R, L, C per unit length.

Line Efficiency and Regulation

For a given transmission line data, compute voltage regulation and efficiency under load.

Single Line Fault Calculations

Using symmetrical components, compute currents and voltages for a single-line-to-ground fault.

Sequence Impedance Measurement

Determine sequence impedances (positive, negative, zero) of a short line using test setups.

Short-Circuit Level (SIL) Analysis

Compute the short-circuit MVA (SIL) at a bus given system parameters

L3 / L4 (Analysis / Comparative / Compensation)

Line Compensation Experiment

Add series / shunt compensation to a line and measure changes in regulation and efficiency.

Fault Response with Compensation

Introduce faults while compensation is active; compute and compare fault currents with and without compensation.

Comparative Study

Compare performance parameters (loss, regulation) of compensated vs uncompensated line under same load.

Effect of Loading Conditions

For different load power factors and magnitudes, analyze how regulation/efficiency vary for a given line.

Fault Analysis in a Network

Simulate multi-bus fault scenarios (e.g. three-phase fault) and analyze line parameters, compensation effects.

L5 (Design / Integration / Projects)

- **Design & Implementation**

Design the optimal compensation scheme (series capacitor, shunt reactor) to improve regulation & minimize losses for a given line.

- **Hybrid Fault-Compensation Project**

Combine fault analysis and compensation: optimize compensation such that fault levels remain safe while improving performance.

- **Software + Lab Integration**

Use MATLAB / PSSE / PowerWorld to simulate experiments and validate with lab results.

- **Optimization of Conductor / Compensation Layout**

Propose conductor or compensation layout chances (spacing, series/shunt device placement) to improve efficiency / fault behavior.

- **Comparative Study of Multiple Lines**

For multiple transmission lines of differing lengths and loads, design compensation strategies and rank them on performance metrics (efficiency, fault currents, stability).

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MTAC1108 ENGLISH FOR RESEARCH PAPER WRITING 2 0 0 0

Course objectives:

- To Understand that how to improve you writing skills and level of readability
- To Learn about what to write in each section
- To Understand the skills needed when writing aTitle Ensure the good quality of paper at very First-time submission

1. **Introduction to Research**

Definition ,purpose ,and importance of research ;Types of research :Basic vs. applied ,quantitative vs .qualitative ;Stages: Problem identification, literature review, design, data collection, analysis, reporting; Structure, objectives, methodology, timeline, budget;

2. **Formulating Research Questions and Hypotheses**

Characteristics of good research questions; Hypothesis types and formulation

3. **Literature Review**

Purpose ,process, and tools (e.g.,data bases, SCIMAGO and google scholar, etc.)

4. **Research Design**

Tools of data collection; Data collection through Surveys, questionnaires, experiments,structuredobservations;Interviews,focusgroups,ethnography, content analysis; types of research - Exploratory, descriptive, explanatory, experimental; Cross-sectional vs. longitudinal studies;
Sample size consider ations;

5. **Ethics in Research**

Informed consent, confidentiality, research with vulnerable populations; Institutional Review Boards(IRBs);plagiarism and how to avoid plagiarism; Proper citation and referencing

Publishing and Disseminating Research:

Journals, conferences, research reports; Peerreview process

TEXT BOOKS /REFERENCES:

1. Gold bort R (2006)Writing for Science,Yale University Press(availableonGoogleBooks)
2. Day R(2006) How to Write and PublishaScientificPaper,CambridgeUniversityPress
3. High manN(1998),Hand book of Writing for the Mathematical Sciences ,SIAM .Highman's book
4. AdrianWallwork,EnglishforWritingResearchPapers,SpringerNewYorkDordrec htHeidelberg London, 2011

MTAC1109 DISASTER MANAGEMENT 2 0 0 0

Course Objectives:

1. To learn to demonstrate critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. To evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. To develop an understanding of standards of human itarian response and practical relevance in specific types of disasters and conflict situations.
4. To understand the strengths and weaknesses of disaster management approaches,
5. To plan and program in different countries, particularly their home country or the countries they work

SYLLABUS

UNIT-I

Introduction: Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT-II

Repercussions of Disasters and Hazards: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Land slides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents ,OilSlicksand Spills,Out breaks of Disease and Epidemics, War and Conflicts.

UNIT-III

Disaster Prone Areasin India: Study of Seismic Zones; AreasPronetoFloodsandDroughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics.

UNIT-IV

Disaster Preparedness and Management: Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological and Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT-V

Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People’s Participation In Risk Assessment. Strategies for Survival.

UNIT-VI

Disaster Mitigation: Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

TEXTBOOKS/REFERENCES:

1. R. Nishith, Singh AK, “Disaster Managementin India: Perspectives, issues and strategies “’New Royal book Company.
2. Sahni,PardeepEt.Al.(Eds.),”DisasterMitigationExperiencesandReflections”, Prentice Hall Of India, New Delhi.
3. GoelS.L.,Disaster Administrad ManagementTextand CaseStudies”, Deep & Deep Publication Pvt. Ltd., New Delhi.

MTEP1201 **Digital Protection Of Power System** **3 0 0 3**

(Program Core-III)

Prerequisite: PowerSystemProtection

CourseObjectives:

- To study numerical relays.
- To develop mathematical approach to wards protection.
- To study digital Relaying Algorithms-I
- To studyt digital Relaying Algorithms-II
- To studya lgorithms for numerical protection.

After completion of the course,students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Learn the importance of Digital Relays.	3	2	2	3	2	L1
CO2	Apply Mathematical approach towards protection.	3	3	2	1	2	L1,L2
CO3	Study sinusoidal-Wave-Based algorithms: Sample and first-derivative methods, First and second-derivative methods, Two-sample technique, Three-sample technique, an early relaying scheme.	2	3	3	2	3	L2, L3,L4
CO4	Understand Fundamentals of Travelling-wave based protection, Bergeron's- equation based protection scheme, Ultra-high-speed polarity comparison scheme,	3	2	2	1	3	L3, L4
CO5	Develop Digital Protection Of Transformers And Transmission Lines.	3	3	2	2	3	L3,L4, L5

UNIT-I: **12 Hours**

MATHEMATICAL BACKGROUND TO DIGITAL PROTECTION

Overview of static relays, Transmission line protection, Transformer protection, Need for Digital protection. Performance and operational characteristics of Digital protection, Basic structure of Digital relays, Finite difference techniques, Interpolation formulas, Numerical differentiation, Curve fitting and smoothing, Fourier analysis, Walsh function analysis, Relationship between Fourier and Walsh coefficients.

UNIT-II: **10 Hours**

BASIC ELEMENTS OF DIGITAL PROTECTION

Basic components of a digital relay, Signal conditioning subsystems, Conversion subsystem, Digital relay subsystem, The digital relay as a unit.

UNIT-III: **11 Hours**

DIGITAL RELAYING ALGORITHMS-I

Sinusoidal-Wave-Based algorithms: Sample and first-derivative methods, First and second-

derivative methods, Two-sample technique, Three-sample technique, an early relaying scheme.
Fourier analysis-based algorithms: Full cycle window algorithm, Fractional-cycle window algorithms, Fourier-transform based algorithm, and Walsh-function-based algorithms.

UNIT-IV: 10 Hours
DIGITAL RELAYING ALGORITHMS-II
Least squares-based methods: Integral LSQ fit, Power series LSQ fit, multi-variable series LSQ technique, Determination of measured impedance estimates.
Differential equation-based techniques: Representation of transmission lines with capacitance neglected, Differential equation protection with selected limits, Simultaneous differential equation techniques.
Travelling-wave based protection: Fundamentals of Travelling-wave based protection, Bergeron’s- equation based protection scheme, Ultra-high-speed polarity comparison scheme, Ultra-high-speed wave differential scheme, Discrimination function-based scheme, superimposed component trajectory- b a s e d scheme.

UNIT-V: 10 Hours
DIGITAL PROTECTION OF TRANSFORMERS AND TRANSMISSION LINES
Principles of transformer protection, Digital protection of Transformer using FIR filter-based algorithm, least squares curve fitting-based algorithms, Fourier-based algorithm, and Flux-restrained current differential relay.
Digital Line differential protection: Current-based differential schemes, Composite voltage- and current- based scheme.

TEXTBOOKS:

A.G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, Wiley/Research studies Press, 2009.
A.T. Johns and S. K. Salman, “Digital Protection of Power Systems”, IEEE Press, 1999.

REFERENCES:

Gerhard Zeigler, “Numerical Distance Protection”, Siemens Publicis Corporate Publishing, 2006.
S.R.Bhide, “Digital Power System Protection”, PHI Learning Pvt.Ltd, 2014.

InternalAssessmentPattern

Cognitive Level	InternalAssessment#1(%)	InternalAssessment#2(%)
L1	15 %	10 %
L2	20 %	25 %
L3	35 %	30 %
L4	20 %	25 %
L5	10 %	10 %
Total(%)	100 %	100 %

Sample questions by cognitive levels

L1 (Recall / Define / List)

1.What is the need for digital protection in power systems
2. State the advantages of digital relays over static relays.
3. Define finite difference technique and its purpose.
4. What is the Fourier analysis used for in digital protection?
5. Define travelling wave in the context of protection.

L2 (Understand / Explain / Describe)

1.Explain the basic structure and operation of a digital relay.
2. Explain the concept of curve fitting and smoothing in signal processing.
3. Describe the conversion subsystem in a digital relay.
4. Explain the two-sample and three-sample techniques in digital relaying.
5. Discuss the difference between static and digital relays.

L3 (Application / Solve / Compute)

1.Apply *finite difference methods** to estimate the derivative of a sampled waveform
2. Implement a **first-derivative algorithm** to identify fault inception.
3. Use **numerical differentiation** to find the slope of a current waveform.
4. Apply Walsh function coefficients to identify fault characteristics.
5. Compute the impedance seen by a relay using the two-sample technique.

L4 (Analysis / Compare / Critique)

1.Analyze the performance characteristics of static vs. digital relays
2. Examine the limitations of the early relaying schemes.
3. Analyze how signal conditioning errors affect relay performance.
4. Compare integral LSQ and power series LSQ techniques.
5. Examine the impact of sampling rate on relay response time.

L5 (Evaluate / Synthesize / Design / Create)

1.Design a digital protection scheme for a transformer using Fourier-based algorithms
2. Evaluate the accuracy and reliability of LSQ-based methods for impedance estimation.
3. Propose a hybrid digital protection scheme combining multiple algorithms.
4. Develop a simulation model to test various fault scenarios on a transmission line.
5. Evaluate the effect of communication delay in digital differential protection systems.

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MTEP1202 **Power System Dynamics** **3 0 0 3**

(Program Core-IV)

Prerequisite: Power Systems and Electrical Machines

CourseObjectives:

- To Learn Power System Stability.
- Todevelopmathematicalmodelsforsynchronousmachine.
- To studySteady state equations and phasor diagrams, determining steady state conditions.
- Tostudypowersystemdynamicphenomenaandtheeffectsofexciterandgovernorcontrol.
- Toimprovedynamicstabilityofasystem.

After completion of the course, students will be ablet o:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Understand the modeling of synchronous machine indetails	3	3	2	2	2	L1
CO2	Under stand the modeling of Exciter and Governor control	2	3	2	1	2	L1,L2, L3
CO3	StudySteady state equations and phasor diagrams, determining steady state conditions.	3	2	1	3	3	L2, L3
CO4	Carryoutsimulationstudiesofpowersystemdynamicsusing MATLAB-SIMULINK,MI POWER	3	2	3	2	2	L2, L3,L4
CO5	Carry out stability analysis with and without power system stabilizer	3	2	2	3	2	L4,L5

UNIT-I: **12 Hours**

POWER SYSTEM STABILITY: A CLASSICAL APPROACH

Introduction, Requirements of a Reliable Electrical Power Service, Swing Equation, Power-Angle Curve, Stability analysis of SMIB system, Equal area criteria, Classical Model of a Multimachine System, Shortcomings of the Classical Model, Block Diagram of One Machine.

System Response to Small Disturbances: Types of Problems Studied the Unregulated Synchronous Machine, Modes of Oscillation of an Unregulated Multimachine System, Regulated Synchronous Machine.

UNIT-II: **11 Hours**

SYNCHRONOUS MACHINE MODELING-I

Introduction, Park's Transformation, Flux Linkage Equations, Voltage Equations, Formulation of State-Space Equations, Current Formulation, Per Unit Conversion, Normalizing the Voltage and Torque Equations, Equivalent Circuit of a Synchronous Machine, The Flux Linkage State-Space Model, Load Equations, Sub-transient and Transient Inductances and Time Constants, Simplified Models of the Synchronous Machine, Turbine Generator Dynamic Models.

UNIT-III: **10 Hours**

SYNCHRONOUS MACHINE MODELING-II

Steady state equations and phasor diagrams, determining steady state conditions, Evaluation of Initial conditions, Determination of machine parameters, Digital simulation of Synchronous machines, Linearization and Simplified Linear model and state-space representation of simplified model.

UNIT-IV: **12 Hours**

EXCITATION AND PRIME MOVER CONTROL

Simplified view of excitation control, Control configurations, Typical excitation configurations, Excitation control system definitions, Voltage regulator, Exciter buildup, Excitation system response, State-space description of the excitation system, Computer representation of excitation systems, Typical system constants, and the effects of excitation on generator power limits, Transient stability and dynamic stability of the power system.

Prime mover control: Hydraulic turbines and governing systems, Steam turbines and governing systems.

UNIT-V: **10 Hours**

SMALL SIGNAL STABILITY ANALYSIS

Fundamental concepts of stability of dynamic systems, Eigen properties of the state matrix, Small-signal stability of a single-machine infinite bus system, Effects of excitation system, Power system stabilizer, System state matrix with amortisseurs, Characteristics of small-signal stability problems.

TEXTBOOKS:

P. M. Anderson & A. A. Fouad, "Power System Control and Stability", Galgotia, New Delhi, 1981.
J Machowski, J Bialek & J. R W. Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997.

REFERENCES:

P.Kundur, "Power System Stability and Control", McGraw Hill Inc.,1994.
E.W. Kimbark, "Power system stability", Vol. I & III, John Wiley & Sons, New York, 2002.
L. Leonard Grigsby (Ed.), "Power System Stability and Control", 2nd Edition, CRC Press, 2007.

InternalAssessmentPattern

Cognitive Level	**InternalAssessment#1(%)**	**InternalAssessment#2(%)**
L1	20%	15 %
L2	20 %	25 %
L3	30 %	30 %
L4	15 %	25 %
L5	15 %	15 %
Total(%)	**100 %**	**100 %**

Sample questions by cognitive levels

L1 (Recall / Define / List)

1. Define power system stability.
2. Define Park's transformation.
3. Define steady state condition.
4. What is an AVR (Automatic Voltage Regulator)?
5. Define small signal stability.

L2 (Understand / Explain / Describe)

1. Explain the equal area criterion for stability analysis.
2. Explain the concept of Park’s transformation and its significance.
3. Explain the procedure to determine steady state conditions.
4. Discuss steam turbine governing systems.
5. Describe the characteristics of small signal stability problems.

L3 (Application / Solve / Compute)

1. Calculate critical clearing angle using the equal area criterion for a given fault.
2. Formulate voltage equations in dq0 frame.
3. Construct phasor diagrams for a given synchronous machine condition.
4. Calculate system response with given excitation parameters.
5. Determine damping using a power system stabilizer.

L4 (Analysis / Compare / Critique)

1. Analyze the impact of system inertia on power system stability.
2. Analyze the dynamic behavior of a turbine-generator model.
3. Analyze the simplified linear model for synchronous machines.
4. Compare different types of excitation control configurations.
5. Examine the impact of amortisseur windings on system stability.

L5 (Evaluate / Synthesize / Design / Create)

1. Evaluate the performance of a power system under small and large disturbances.
2. Evaluate the suitability of simplified synchronous machine models in stability studies.
3. Evaluate the accuracy of simplified models vs full order models in simulation studies.
4. Evaluate the performance of an excitation system under transient disturbances.
5. Justify control actions based on eigenvalue locations.

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MTEP12031

Restructured Power Systems **3 0 0 3**

(Program Elective-III.1**)**

Prerequisite: PowerSystemsandElectricalMachines

CourseObjectives:

- To understand what is meant by restructuring of the electricity market
- To understand the need behind requirement for deregulation of the electricity market
- To understand the money, power & Information flow in ade regulated powers ystem

After completion of the course,s tudents will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Describe various types of regulations in powersystems.	3	3	2	2	2	L1,L2
CO2	Identify the need ofregulationand deregulation.	3	2	2	1	2	L2,L3
CO3	Define and describe the Technical and Non-technical issues in Deregulated Power Industry.	3	2	2	2	2	L3
CO4	Identify and give examples of existing electricity markets.	3	3	3	2	1	L3,L4
CO5	Classifyvdifferent market mechanisms and summarize the role of various entities in the market	3	2	3	2	2	L4,L5

UNIT-I: **8 Hours**

Fundamentals of restructured system, Market architecture, Load elasticity, Social welfare maximization.

UNIT-II: **10 Hours**

OPF: Role in vertically integrated systems and in restructured markets, Congestion management.

UNIT-III: **9 Hours**

Optimal bidding, Risk assessment, Hedging, Transmission pricing, Tracing of power.

UNIT-IV: **8 Hours**

Ancillary services, Standard market design, Distributed generation in restructured markets.

UNIT-V: **12 Hours**

Developments in India, IT applications in restructured markets, working of restructured power systems, PJM, Recent trends in Restructuring.

TEXTBOOKS:

Lorrin Philipson, H. Lee Willis, “Understanding electric utilities and de-regulation”, Marcel Dekker Pub., 1998.
Steven Stoft, “Power system economics: designing markets for electricity”, John Wiley and Sons, 2002.

REFERENCES:

Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, “Operation of restructured power systems”, Kluwer Academic Pub., 2001.
Mohammad Shahidehpour, MuwaffaqAlomoush, “Restructured electrical power systems: operation, trading and volatility”, Marcel Dekker.

InternalAssessmentPattern

Cognitive Level	InternalAssessment#1(%)	InternalAssessment#2(%)
L1	20 %	15 %
L2	25 %	20 %
L3	25 %	30 %
L4	20 %	25 %
L5	10 %	10 %
Total(%)	**100 %**	**100 %**

Sample questions by cognitive levels

L1 (Recall / Define / List)
1. Define power system stability.
2. Define Park’s transformation.
3. Define steady state condition.
4. What is an AVR (Automatic Voltage Regulator)?
5. Define damping torque.

L2 (Understand / Explain / Describe)
1. Explain the equal area criterion for stability analysis.
2. Explain the importance of per unit conversion.
3. Explain how machine parameters are determined.
4. Describe excitation system configurations.
5. Describe the characteristics of small signal stability problems.

L3 (Application / Solve / Compute)
1. Calculate critical clearing angle using equal area criterion
2. Derive normalized voltage and torque equations.
3. Determine machine parameters from test data.
4. Derive the state-space model of an excitation system.
5. Determine damping using a power system stabilizer.

L4 (Analysis / Compare / Critique)
1. Examine the modes of oscillation in a multi-machine system.
2. Analyze the dynamic behavior of a turbine-generator model.
3. Analyze the simplified linear model for synchronous machines.
4. Compare different types of excitation control configurations.
5. Analyze the state matrix to assess system stability.

L5 (Evaluate / Synthesize / Design / Create)

1. Evaluate the performance of a power system under small and large disturbances.
2. Assess the impact of model simplifications on simulation results.
3. Recommend model improvements for better dynamic performance.
4. Evaluate the performance of an excitation system under transient disturbances.
5. Justify control actions based on eigen value locations.

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MTEP12032 Power Quality Improvement Techniques 3 0 0 3
(Program Core-I)

Prerequisite : Power Systems and Power Electronics

CourseObjectives:

- To know different terms of power quality.
- To illustrate power quality issues for short and long interruptions
- To study of characterization of voltage sag magnitude and three-phase unbalanced voltage sag.
- To know the behavior of power electronics loads, induction motors, synchronous motor etc. by the power quality issues.
- To know mitigation of power quality problems by using VSI converters

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Know the severity of power quality problems in distribution system	3	2	2	3	2	L1
CO2	Understand the concept of voltage sag transformation from up-stream (higher voltages) to down- stream (lower voltage)	3	3	2	1	2	L1,L2
CO3	Compute the power quality improvement by using various mitigating custom power devices.	2	3	3	2	3	L3,L4

UNIT-I: **10 Hours**

INTRODUCTION AND POWER QUALITY STANDARDS: Introduction, Classification of Power Quality Problems, Causes, Effects and Mitigation Techniques of Power Quality Problems, Power Quality Terminology, Standards,Definitions, Monitoring and Numerical Problems.

UNIT-II: **10 Hours**

CAUSES OF POWER QUALITY PROBLEMS: Introduction to Non-Linear Loads, Power Quality Problems caused by Non-Linear Loads, Analysis of NonLinear Loads, Numerical Problems.

UNIT-III: **11 Hours**

PASSIVE SHUNT AND SERIES COMPENSATION: Introduction, Classification and Principle of operation of Passive Shunt and Series Compensators, Analysis and Design of Passive Shunt Compensators for Single-Phase System, Three-Phase Three Wire System and Three-Phase Four Wire System.

UNIT-IV: **12 Hours**

ACTIVE SHUNT AND SERIES COMPENSATION

Introduction to Shunt compensators: Classification of DSTATCOM’s, Principle of Operation of DSTATCOM.

Different Control Algorithms of DSTATCOM: PI Controller, I-Cosφ Control Algorithm, Synchronous Reference Frame Theory, Single-Phase PQ theory and DQ Theory Based Control Algorithms, Analysis and Design of Shunt Compensators, Numerical Problems.

Introduction to Series Compensators: Classification of Series Compensators, Principle of Operation of DVR.

Different Control Algorithms of DVR: Synchronous Reference Frame Theory-Based Control of DVR, Analysis and Design of Active Series Compensators, Numerical Problems..

UNIT-V: **10 Hours**

UNIFIED POWER QUALITY COMPENSATORS : Introduction to Unified Power Quality Compensators (UPQC), Classification of UPQCs, Principle of Operation of UPQC. **Control of UPQCs**: Synchronous Reference Frame Theory-Based UPQC,
Analysis and Design of UPQCs, Numerical Problems.

TEXTBOOKS:

1. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality Problems and Mitigation Techniques", Wiley Publications, 2015.
2. Math H J Bollen, "Understanding Power Quality Problems", IEEE Press, 2000.

REFERENCES:

1. R.C. Dugan, M.F. McGranaghan and H.W. Beaty, "Electric Power Systems Quality", New York, McGraw-Hill, 1996.
2. 2. G.T. Heydt, "Electric power quality", McGraw-Hill Professional, 2007.
3. 3. J. Arrillaga, "Power System Quality Assessment", John wiley, 2000.
4. 4. G.T. Heydt," Electric Power Quality", 2ndEdition, West Lafayette, IN, Stars in Circle Publications,1994.
5. 5. R. SastryVedamMulukutlaS.Sarma, "Power Quality VAR Compensation in Power Systems", CRC Press.
6. 6. A Ghosh, G. Ledwich," Power Quality Enhancement Using Custom Power Devices", Kluwer Academic, 2002.

Internal Assessment Pattern

Cognitive Level	**Internal Assessment #1(%)**	**Internal Assessment #2(%)**
L1	15%	10%
L2	25%	20%
L3	30%	35%
L4	20%	25%
L5	10%	10%
Total (%)	**100%**	**100%**

L1 (Recall / Define / List)

1. Define **power quality** in the context of electrical distribution systems.
2. List three common types of power quality disturbances (e.g. sags, swells, harmonics).
3. What is a **voltage sag (dip)**? Wikipedia
4. Define **harmonic distortion** (THD).
5. Name two mitigation devices used in improving power quality (e.g., active filter, DVR).

L2 (Understand / Explain / Describe)

1. Explain how a voltage sag from the upstream system propagates to downstream equipment (voltage sag transformation).
2. Describe the behavior of a nonlinear load on power quality (how it generates harmonics).
3. Explain how custom power devices like a DVR (Dynamic Voltage Restorer) mitigate voltage sags. Wikipedia

4. Describe the difference between active and passive filters in harmonic compensation. Wikipedia
5. Explain why voltage interruptions (short or long) are detrimental to sensitive loads.

L3 (Application / Solve / Compute)

1. Given a nonlinear load current waveform, compute the harmonic content (THD) and propose an appropriate filter.
2. For a given voltage sag of 20% lasting 0.5 s, design a controller setting for a DVR to restore voltage to nominal.
3. Given a system with known impedance and harmonic currents, determine the required filter values (L, C) for a passive filter.
4. Model a three-phase unbalanced sag and compute the negative and zero sequence voltages.
5. Simulate or compute the effect of adding an active filter in parallel to cancel out specific harmonic orders for a power system.

L4 (Analysis / Compare / Critique)

1. Compare the effectiveness and limitations of active vs passive harmonic filtering in a distribution network.
2. Analyze the impact of voltage sags and interruptions on induction motors and sensitive electronic loads.
3. Given a choice of mitigation devices (DVR, STATCOM, active filter, custom power devices), analyze which is best suited for a specific disturbance scenario.
4. Critique the use of passive filters in a system where load harmonic spectrum changes dynamically.
5. Analyze how unbalanced three-phase sags degrade system performance and suggest mitigation strategies.

L5 (Evaluate / Design / Create)

1. Design a mitigation scheme (using DVR / active filters / hybrid filters) for a power distribution feeder that supplies sensitive loads (e.g. data centers).
2. Propose a control algorithm for an active power filter to dynamically compensate a varying harmonic spectrum.
3. Develop a comprehensive architecture for power quality monitoring + mitigation in an industrial plant, with placement of sensors, filters, and controllers.
4. Evaluate and compare multiple mitigation strategies for a test feeder (simulate and compare THD reduction, cost, response time) and decide the optimal solution.
5. Create a research proposal for improving power quality in microgrids with high penetration of renewable energy, focusing on voltage fluctuations and harmonics.

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MTEP12033 EHV AC TRANSMISSION 3 0 0 3
(Program Core-I)

Prerequisite : Power Systems

CourseObjectives:

- To identify the different aspects of Extra High Voltage AC and DC Transmission design
- To demonstrate EHV AC transmission system components, protection and insulation level.
- To understand the importance of modern developments of EHV and UHV transmission
- systems
- To demonstrate EHV AC transmission system components, protection and insulation
- To learn level for over voltages.analysis over voltages.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Understand the importance of EHV AC transmission	3	3	2	1	2	L1
CO2	Estimate choice of voltage for transmission, line losses and power handling capability of EHV Transmission.	3	2	2	1	2	L2
CO3	Analyze by applying the statistical procedures for line designs, scientific and engineering principles in power systems.	2	3	3	3	1	L3,L4

UNIT-I: **10 Hours**
E.H.V.A.C. Transmission line trends and preliminary aspect standard transmission voltages, Estimation at line and ground parameters, Bundled conductor systems, Inductance and Capacitance of E.H.V. lines, Positive,negative and zero sequence impedance, Line Parameters for Modes of Propagation.

UNIT-II: **11 Hours**
Electrostatic field and voltage gradients, Calculation of electrostatic field of AC lines, Effect of high electrostatic field on biological organisms and human beings, Surface voltage gradients and maximum gradients of actual transmission lines, Voltage gradients on sub conductor.

UNIT-III: **12 Hours**
Electrostatic induction in unenergized lines, Measurement of field and voltage gradients for three phase single and double circuit lines, Unenergized lines. Power Frequency Voltage control and over-voltages in EHV lines: No load voltage, charging currents at power frequency, Voltage control, Shunt and series compensation, Static VAR compensation.Compensators

UNIT-IV: **10 Hours**
Corona in E.H.V. lines, Corona loss formulae, Attention of traveling waves due to Corona, Audio noise due to Corona and its generation, Characteristic and limits. Measurement of audio noise radio interference due to Corona, Properties of radio noise, Frequency spectrum of RI fields, Measurement of RI and RIV

UNIT-V: **9 Hours**
Design of EHV lines based on steady state and transient limits, EHV cables and their characteristics..

TEXTBOOKS:

1. R. D. Begamudre, "EHVAC Transmission Engineering, New Age International (p) Ltd., 3rdEdition.
2. K.R. Padiyar, "HVDC Power Transmission Systems", New Age International (p) Ltd., 2nd revised Edition, 2012. REFERENCES: 1. S. Rao, "EHVAC and HVDC Transmission Engineering Practice", Khanna Publishers. 2. Arrillaga. J, "High Voltage Direct Current Transmission", 2nd edition (London) Peter Peregrines, IEE, 1998.
3. Padiyar.K.R, "FACTS Controllers in Power Transmission and Distribution", NewAge International Publishers, 2007.
4. Hingorani. H.G and Gyugyi. L, "Understanding FACTS- Concepts and Technology of Flexible AC Transmission Systems", New York, IEEE Press, 2000.

Internal Assessment Pattern

Cognitive Level	**Internal Assessment #1(%)**	**Internal Assessment #2(%)**
L1	15%	10%
L2	25%	20%
L3	30%	35%
L4	20%	25%
L5	10%	10%
Total (%)	100%	100%

L1 (Recall / Define / List)

1. Define **Extra High Voltage (EHV)** in the context of AC transmission.
2. List the main components of an EHV AC transmission system.
3. What is **corona discharge**?
4. Define **insulation coordination**.
5. State two environmental effects of EHV lines (e.g. audible noise, radio interference).

L2 (Understand / Explain / Describe)

1. Explain how increasing transmission voltage reduces line losses (i.e. I^2R losses).
2. Describe why conductors in EHV lines are often bundled (i.e. multi-wire bundle).
3. Explain the phenomenon of **overvoltages** in EHV systems (switching surge, lightning surge).
4. Describe how insulation levels are selected using statistical or risk-based approaches.
5. Illustrate the effect of corona on power loss and interference in EHV lines.

L3 (Application / Solve / Compute)

1. Given a 400 kV EHV line of length 200 km, line resistance 0.05 Ω/km and reactance 0.4 Ω/km, compute the approximate line losses and voltage drop if it carries 500 MW at 0.9 power factor.
2. Using the formula for corona onset voltage, compute the corona onset voltage for a conductor of given radius and line spacing under standard conditions.
3. For a specified line geometry and conductor size, calculate the surface voltage gradient and check whether corona occurs.

4. Using statistical lightning data (say, given thunderstorm parameters), compute the required insulation level (in kV) for a given line.
5. Given a π-model of a long EHV line with known parameters, compute the power transfer limit at a specified receiving voltage.

L4 (Analysis / Compare / Critique)

Compare the advantages and disadvantages of **EHV AC** vs **UHV AC** transmission.

Analyze how conductor bundling affects corona, line capacitance, and losses in EHV lines.

Given a design with certain insulation and surge arresters, analyze how a switching overvoltage event will stress the system, and propose mitigation.

Critique the use of series compensation in EHV AC systems—when is it beneficial, and what are the risks?

Examine how environmental factors (fog, pollution, humidity) influence insulation strength and corona formation in EHV systems.

L5 (Evaluate / Synthesize / Design / Create)

1. Design an insulation coordination strategy (select line insulators, surge arresters, clearances) for an EHV AC transmission line in a region with high lightning incidence
2. Propose a modern conductor configuration (material, bundling, spacing) to minimize losses and corona while managing cost.
3. Create a hybrid transmission scheme combining EHV AC and HVDC for a long-distance power corridor, justifying where each is used.
4. Evaluate the feasibility (technical, economic) of upgrading an existing 400 kV EHV line to 800 kV in your region.
5. Develop an optimization methodology to choose the best conductor, bundle, and insulation for a new EHV transmission line subject to minimizing losses, cost, and environmental impact

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MTP12034 Evolutionary Algorithms Applications In Power Engineering
(Program Elective-III.4) **3 0 0 3**

Prerequisite: Artificial Intelligence Techniques in Electrical Engineering
Course Objectives:

- To understand Evolutionary algorithms like GA, PSO, ANT COLONY and BEE COLONY etc.
- To apply these Evolutionary algorithms to solve power systems problems
- To learn Artificial bee colony (ABC) algorithms, Binary ABC algorithms, ACO and ABC algorithms for solving Economic Dispatch of thermal units
- To learn Bat algorithm, Echolocation of bats, Behavior of micro bats, Acoustics of echolocation and Shuffled frog algorithm.
- To also able to understand solution of multi-Objective optimization using these algorithms

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Discriminate the capabilities of bio-inspired system and conventional methods in solving optimization problems.	3	3	2	2	2	L1,L2
CO2	Examine the importance of exploration and exploitation of swarm intelligent system to attain near global optimal solution.	2	3	3	2	1	L2
CO3	Distinguish the functioning of various swarm intelligent systems.	3	3	3	2	3	L2, L3,
CO4	Employ various bio-inspired algorithms for power systems engineering applications.	3	2	2	1	3	L4

UNIT-I: **12 Hours**
FUNDAMENTALS OF SOFT COMPUTING TECHNIQUES
Definition, Classification of optimization problems, Unconstrained and constrained optimization optimality condition, Introduction to intelligent systems, Soft computing techniques, Conventional computing versus swarm computing, Classification of meta-heuristic techniques, Single solution based and population based algorithms, Exploitation and exploration in population based algorithms, Properties of Swarm intelligent Systems, Application domain, Discrete and continuous problems, Single objective and multi-objective problems.

UNIT-II: **10 Hours**
GENETIC ALGORITHM & PARTICLE SWARM OPTIMIZATION
Genetic algorithms, Genetic algorithm versus Conventional Optimization Techniques, Genetic representations and selection mechanisms: Genetic operators, Different types of crossover and mutation operators, Bird flocking and Fish Schooling-anatomy of a particle, Equations based on velocity and positions, PSO topologies, Control parameters, GA and PSO algorithms for solving ELD problems.

UNIT-III: **10 Hours**
ANT COLONY OPTIMIZATION & ARTIFICIAL BEE COLONY ALGORITHMS
Biological ant colony system, Artificial ants and assumptions, Stigmergic communications, Pheromone

updating, Local-global-pheromone evaporation, Ant colony system, ACO models, Touring ant colony system, Max min ant system, Concept of elastic ants, Task partitioning in honey bees, Balancing foragers and receivers, Artificial bee colony (ABC) algorithms, Binary ABC algorithms, ACO and ABC algorithms for solving Economic Dispatch of thermal units.

UNIT-IV: 11 Hours
SHUFFLED FROG-LEAPING ALGORITHM & BAT OPTIMIZATION ALGORITHM
Bat algorithm, Echolocation of bats, Behavior of micro bats, Acoustics of echolocation, Movement of Virtual bats, Loudness and pulse Emission, Shuffled frog algorithm, Virtual population of frogs, Comparison of memes and genes, Memeplex formation, Memeplex updation, BA and SFLA algorithms for solving ELD and optimal placement and sizing of the DG problem.

UNIT-V: 10 Hours
MULTI OBJECTIVE OPTIMIZATION
Multi-Objective optimization introduction, Concept of pareto optimality, non-dominant sorting technique, Pareto fronts, best compromise solution, Min-max method, NSGA-II algorithm and applications to power systems.

TEXTBOOKS:

1. Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation", Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb," Multi-Objective Optimization using Evolutionary Algorithms", John Wiley & Sons, 2001.

REFERENCES:

1. James Kennedy and Russel E Eberheart, "Swarm Intelligence", The Morgan Kaufmann Series in Evolutionary Computation, 2001.
2. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, "Swarm Intelligence- From natural to Artificial Systems", Oxford university Press, 1999.
3. David Goldberg, "Genetic Algorithms in Search, Optimization and Machine Learning", Pearson Education, 2007.
4. Konstantinos E. Parsopoulos and Michael N. Vrahatis," Particle Swarm Optimization and Intelligence: Advances and Applications", Information Science reference, IGI Global, 2010.
5. N P Padhy, "Artificial Intelligence and Intelligent Systems", Oxford University Press, 2005.

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	10%	5%
L2	20%	15%
L3	30%	25%
L4	25%	30%
L5	15%	25%
Total (%)	**100%**	**100%**

L1: Recall / Define

1. **Define** the term "Evolutionary Algorithms" and list at least three types used in power engineering.
2. **Explain** the basic concept of the Genetic Algorithm (GA) and its application in optimization problems.
3. **Identify** the primary objective of Economic Dispatch (ED) in power systems.
4. **Describe** the role of the Artificial Bee Colony (ABC) algorithm in solving optimization problems.
5. **List** the main differences between Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO).

L2: Understand / Explain

1. **Explain** how the exploration and exploitation mechanisms in PSO contribute to finding near-global optimal solutions.
2. **Discuss** the advantages of using bio-inspired algorithms over conventional methods in solving complex optimization problems in power systems.
3. **Illustrate** the working principle of the Bat Algorithm and its relevance to power system optimization.
4. **Analyze** the significance of multi-objective optimization in power system operations and planning
5. **Compare** the performance of ABC and GA in solving Economic Load Dispatch (ELD) problems.

L3: Apply / Solve

1. **Apply** the ABC algorithm to solve a simple Economic Dispatch problem with two thermal units.
2. **Implement** a PSO-based approach to optimize the placement of Distributed Generation (DG) units in a distribution network.
3. **Use** the ACO algorithm to determine the optimal routing of power in a transmission network to minimize losses.
4. **Develop** a MATLAB code to simulate the Bat Algorithm for solving a unit commitment problem.
5. **Evaluate** the effectiveness of the Shuffled Frog Leaping Algorithm in solving a multi-objective optimization problem in power systems.

L4: Analyze / Compare

1. **Analyze** the convergence rates of GA, PSO, and ABC algorithms in solving a benchmark optimization problem.
2. **Compare** the robustness of ACO and Bat Algorithm in handling dynamic changes in power system parameters.
3. **Assess** the impact of algorithm parameters (like population size and mutation rate) on the performance of GA in solving ELD problems.
4. **Examine** the scalability of ABC and PSO algorithms when applied to large-scale power system optimization problems.
5. **Critique** the suitability of using multi-objective optimization techniques in real-time power system operations.

L5: Evaluate / Design / Create

1. **Design** a hybrid optimization algorithm combining GA and PSO to solve a complex power system optimization problem.
2. **Develop** a comprehensive framework for implementing ABC algorithms in smart grid applications.
3. **Propose** a methodology for integrating multi-objective evolutionary algorithms into the decision-making process for power system planning.
4. **Create** a simulation model to compare the performance of different evolutionary algorithms in solving a unit commitment problem with valve-point effects.
5. **Evaluate** the feasibility of using Bat Algorithm for real-time optimization in power system operations, considering computational constraints.

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MTEP12041 Data Science Applications In Power Engineering 3 0 0 3
(Program Elective-IV.1)

Course Objectives:

- To introduce the fundamental concepts of data science and machine learning.
- To understand the process of data preparation and analysis for engineering problems.
- To learn various machine learning algorithms and their applications.
- To apply machine learning techniques to real-world problems in the power generation industry.
- To analyze specific case studies related to power system forecasting and maintenance

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Differentiate between data science, machine learning, and AI concepts and their relevance to engineering disciplines.	3	2	2	3	2	L1
CO2	Analyze and prepare datasets for use in machine learning models, including handling outliers and performing feature engineering.	2	3	2	1	2	L2
CO3	Apply various machine learning algorithms to solve regression and classification problems.	3	3	3	2	3	L2, L3,L4
CO4	Understand and articulate the practical applications of machine learning within the power generation industry.	3	2	2	1	3	L3, L4
CO5	Develop and evaluate forecasting models for specific power system challenges, such as electrical consumption and wind power failures.	2	3	2	2	3	L3,L4, L5

Unit I - Introduction to Data Science **11 Hours**

Introduction to data science, introduction to machine learning, overview of the power generation industry, artificial intelligence in the power generation industry, climate change and the power industry, machine learning for industry transition, mitigation of problems using machine learning.

Unit II - Data Science, Statistics, and Time Series **12 Hours**

Preparing a clean dataset, measuring and storing data in control systems, data uncertainty, time-series analysis, data correlation, mathematical representation and modeling, data representation and significance, outlier removal, model goodness, feature engineering, dimensionality reduction, practical checklist for dataset preparation.

Unit III - Machine Learning **10 Hours**

Introduction to machine learning concepts, supervised and unsupervised learning, regression and classification, bias-variance trade off, model complexity, neural networks (feed-forward and recurrent), support vector machines (SVM), random forest, self- organizing maps (SOM), Bayesian networks, training a model, splitting datasets (training, testing, validation), cross-validation, assessing model performance, role of a domain expert, practical advice for a machine learning project.

Unit IV - Machine Learning in the Power Generation Industry & Electrical Consumption Forecasting **12 Hours**

Machine learning studies in power plants and for power users, predictive maintenance, forecasting supply and demand, modeling physical relationships, consumer modeling, practical applications of machine learning in the power industry, case study of electrical consumption forecasting in a medical clinic, integration with Building Management Systems, artificial neural network (ANN) implementation, multilayer perceptron ANN, backpropagation training algorithm, ANN inputs (loads, day type, time, weather), formal procedure for ANN parameter selection.

Unit V - Forecasting Wind Power Plant Failures Topic **10 Hours**

Wind power plant damage mechanisms, impact on lifetime cost and power production, vibration spectra analysis for damage detection, predictive maintenance, forecasting failures on turbine blades, rotors, and generators

TEXTBOOKS:

1. Machine Learning and Data Science in the Power Generation Industry: Best Practices, Tools, and Case Studies, edited by Patrick Bangert, Elsevier, ISBN: 9780128197424.
2. Machine Learning for Energy Systems, edited by Denis N. Sidorov, MDPI Books, Publication Date: December 2020, ISBN (Hardback): 978-3-03943-382-7, ISBN (PDF): 978-3-03943-383-4.
3. Data Science for Engineers, by Raghunathan Rengaswamy and Resmi Suresh, CRC Press, Publication Date: December 16, 2022, ISBN (Hardback): 9780367754266, ISBN (eBook): 9781003353584.

REFERENCES:

1. Application of Machine Learning and Deep Learning Methods to Power System Problems, edited by Morteza Nazari- Heris, Somayeh Asadi, Behnam Mohammadi-Ivatloo, Moloud Abdar, Houtan Jebelli, and Milad Sadat-Mohammadi, Springer International Publishing, 2021.
2. Real-World Applications of Artificial Intelligence and Machine Learning in Power Systems: A Code Approach, by T. Mariprasath and V. Kirubakaran, Nova Science Publishers, 2025.

Internal Assessment Pattern

Cognitive Level	**Internal Assessment #1(%)**	**Internal Assessment #2(%)**
L1	20%	15%
L2	30%	25%
L3	35%	40%
L4	10%	15%
L5	5%	5%
Total (%)	**100%**	**100%**

L1: Recall / Define

1. **Define** the term "machine learning" and explain its relevance to power engineering.
2. **List** the common types of machine learning algorithms used in power system analysis.
3. **Describe** the concept of "feature engineering" in the context of preparing datasets for machine learning models.
4. **Identify** the key differences between supervised and unsupervised learning.
5. **Explain** the role of data preprocessing in building effective machine learning models

L2: Understand / Explain

1. **Explain** how outliers can affect the performance of machine learning models in power system applications.
2. **Discuss** the importance of data normalization and scaling in machine learning workflows.
3. **Illustrate** how decision trees can be used for classification tasks in power system fault detection.
4. **Compare** the advantages and limitations of using linear regression versus support vector machines for load forecasting.
5. **Analyze** the impact of missing data on the accuracy of machine learning models in power system analysis.

L3: Apply / Solve

1. **Apply** a k-means clustering algorithm to segment a dataset of power consumption patterns into distinct groups.
2. **Implement** a decision tree classifier to predict equipment failure based on historical maintenance data.
3. **Utilize** a neural network to model and predict short-term electrical load in a regional power grid.
4. **Develop** a regression model to estimate wind power generation based on meteorological data inputs.
5. **Construct** a confusion matrix to evaluate the performance of a classification model predicting transformer faults.

L4: Analyze / Compare

1. **Analyze** the performance of a random forest model versus a gradient boosting machine in predicting power system anomalies.
2. **Compare** the effectiveness of different feature selection techniques in improving model accuracy for load forecasting.
3. **Evaluate** the trade-offs between model complexity and interpretability in machine learning models used in power systems.
4. **Assess** the impact of data imbalance on the performance of classification models in fault detection tasks.
5. **Investigate** the potential benefits and challenges of integrating real-time data streams into machine learning models for dynamic power system monitoring.

L5: Evaluate / Design / Create

1. **Design** a machine learning pipeline for predictive maintenance of power transformers, including data collection, preprocessing, model selection, and deployment.
2. **Develop** a hybrid model combining machine learning and traditional power system analysis techniques for enhanced fault detection.
3. **Propose** a methodology for evaluating the scalability and robustness of machine learning models in large-scale power grid applications.
4. **Create** a dashboard that visualizes the predictions of a machine learning model for real-time monitoring of power system health.
5. **Critique** an existing machine learning model applied to power system load forecasting, identifying potential improvements and justifying your recommendations.

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MTEP12042 Electric Vehicle Charging Techniques 3 0 0 3
(Program Elective-IV.2)

Prerequisite: Electric and Hybrid Vehicles, Power Electronics, Smart Grid Technologies

Course Objectives:

- To understand the charging infrastructure for EV's
- To understand Location Planning And Land Allocation
- To Learn methods of arranging for power supply for charging infrastructure.
- To explore the working of grid connected with EV's.
- To understand an implementation model for EV charging infrastructure and identifies three models in India.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Understand the planning and operational issues related to EV's charging.	3	3	2	1	2	L1
CO2	Acquire knowledge about EV's charging implementation models.	3	3	2	2	1	L1,L2

UNIT-I: **10 Hours**

AN OVERVIEW OF EV CHARGING INFRASTRUCTURE:

Orients the reader to EV charging infrastructure, providing a brief introduction to technical concepts of electric vehicle supply equipment, AC and DC charging, power ratings, and charging standards.

UNIT-II: **12 Hours**

LOCATION PLANNING AND LAND ALLOCATION:

Covers the location and site planning aspects for EV charging, by framing the principles of location planning and demonstrating a methodology for spatial allocation of charging demand, and identifies enabling processes and policies to integrate public charging in urban planning.

UNIT-III: **11 Hours**

CONNECTING EVs TO THE ELECTRICITY GRID:

Focuses on supply of electricity for charging infrastructure, familiarizing readers with the regulations that govern electricity supply for EV charging, the role of DISCOMs in provision of EV charging connections, and the three methods of arranging for power supply for charging infrastructure.

UNIT-IV: **10 Hours**

ACHIEVING EFFECTIVE EV-GRID INTEGRATION:

Zooms out from site-level considerations for supply of electricity to assess grid-level impacts, and then highlights the need for smart charging to minimize adverse impacts of EV charging loads on the grid.

UNIT-V: **10 Hours**

MODELS OF EV CHARGING IMPLEMENTATION

Defines the typical roles within an implementation model for EV charging infrastructure and identifies three models in India – the government-driven model, the consumer-driven model and the charge point operator-driven model – for charging infrastructure implementation.

TEXTBOOKS:

Sulabh Sachan, P. Sanjeevikumar, Sanchari Deb, "Smart Charging Solutions for Hybrid and Electric Vehicles",Wiley Publications, March 2022.

Handbook of Electric Vehicle Charging Infrastructure Implementation Version-1

REFERENCES:
Vahid Vahidinasab, Behnam Mohammadi-Ivatloo, “Electric Vehicle Integration via Smart Charging, Springer, 2022.
Alam, Mohammad Saad, Pillai, Reji Kumar, Murugesan, N, “Developing Charging Infrastructure and Technologies for Electric Vehicles”, IGI Global

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	20%	15%
L2	30%	25%
L3	35%	40%
L4	10%	15%
L5	5%	5%
Total (%)	**100%**	**100%**

L1: Recall / Define

1. **Define** the term "Electric Vehicle Supply Equipment (EVSE)" and list its main components.
2. **Explain** the concept of "Vehicle-to-Grid (V2G)" integration in the context of electric vehicles.
3. **Identify** the different types of electric vehicle charging connectors and their standards.
4. **List** the key factors to consider when planning the location of EV charging stations
5. **Describe** the role of the Battery Management System (BMS) in EV charging infrastructure

L2: Understand / Explain

1. **Explain** the differences between Level 1, Level 2, and DC Fast Charging in terms of charging speed and infrastructure requirements.
2. **Discuss** the challenges associated with integrating EV charging stations into existing power grids.
3. **Describe** the impact of charging infrastructure on the adoption rate of electric vehicles
4. **Analyze** the importance of load forecasting in the planning of EV charging networks.
5. **Illustrate** the concept of "smart charging" and its benefits for both users and utilities.

L3: Apply / Solve

1. **Calculate** the required capacity of an EV charging station serving 50 vehicles daily, each requiring an average of 2 hours of charging.
2. **Design** a basic layout for an EV charging station considering factors like accessibility, safety, and grid connection
3. **Implement** a scheduling algorithm for optimizing the charging times of multiple EVs to reduce peak load on the grid.
4. **Simulate** the impact of adding a new EV charging station on the local power distribution network.
5. **Evaluate** the feasibility of using renewable energy sources (e.g., solar panels) to power an EV charging station.

L4: Analyze / Compare

1. **Compare** the efficiency and cost-effectiveness of AC charging versus DC fast charging for electric vehicles.
2. **Analyze** the environmental impact of widespread EV adoption on urban air quality.
3. **Assess** the potential economic benefits of establishing a public-private partnership for EV charging infrastructure development
4. **Investigate** the regulatory challenges faced by EV charging infrastructure providers in different regions
5. **Examine** the role of data analytics in managing and optimizing EV charging networks

L5: Evaluate / Design / Create

1. Design a comprehensive EV charging infrastructure plan for a mid-sized city, considering factors like population density, existing power infrastructure, and future growth.
2. Develop a policy framework for incentivizing the installation of EV charging stations in residential and commercial areas.
3. Create a business model for an EV charging station that includes pricing strategies, maintenance plans, and customer engagement approaches.
4. Propose a solution for integrating EV charging stations with renewable energy sources to achieve a sustainable charging ecosystem.
5. Critique an existing EV charging infrastructure project and suggest improvements based on current technological advancements and user needs.

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MTEP12043 **Digital Control Systems** **3 0 3 0**

(Program Elective-IV.3)

Prerequisite: Control Systems

Course Objectives:

- To introduce the fundamentals of digital control systems, sampling process, and quantization effects in discrete-time systems.
- To develop proficiency in applying Z-transform techniques to solve discrete-time system equations.
- To analyze digital control systems using z-plane methods, pulse transfer functions, and stability criteria.
- To familiarize students with state-space modeling, analysis, and design concepts for discrete-time systems.
- To explore discrete optimal control techniques, including Linear Quadratic Regulator (LQR) design and steady-state optimal control.

Course Outcomes: After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Explain the principles of sampling, quantization, and their impact on digital control system performance.	2	2	3	3	1	L1,L2
CO2	Apply Z-transform techniques to analyze and solve difference equations in discrete-time control systems.	3	3	1	1	2	L2
CO3	Analyze the stability and dynamic response of digital control systems using z-plane methods and pulse transfer functions.	2	2	3	2	3	L3,L4
CO4	Design and evaluate discrete-time state-space models, ensuring controllability, observability, and stability using Lyapunov analysis.	3	2	3	2	1	L2,L3, L4
CO5	Design discrete optimal controllers using LQR techniques to achieve desired performance in digital control systems.	3	3	2	2	3	L4,L5

UNIT-I: **10 Hours**

INTRODUCTION:

Continuous and Discrete time system-Digital control systems - Quantizing and quantization error, Sampling theorem.

UNIT-II: **8 Hours**

Z-TRANSFORMS:

Z-transforms of elementary functions, important properties and theorems, Inverse Z transform, Z-transform method of solving difference equations.

UNIT-III: **10 Hours**

Z-PLANE ANALYSIS OF DISCRETE-TIME CONTROL SYSTEMS:

Impulse sampling and data hold, Pulse transfer function, Realization of digital controllers and digital filters, Mapping between s-plane and z-plane, Stability analysis of closed loop systems in z-plane, Transient and steady state analyses.

UNIT-IV: **10 Hours**

STATE SPACE ANALYSIS OF DIGITAL CONTROL SYSTEMS:

Solution of discrete time state space equations, Discretization of continuous time state space equations, Lyapunov stability analysis for Discrete linear system, Controllability, Observability, Pole Placement and Observer Design.

UNIT-V: **8 Hours**

DISCRETE OPTIMAL CONTROL SYSTEMS:

Linear Quadratic Regulator (LQR) Design via pole placement, Steady state quadratic optimal control.

TEXTBOOKS:

K. Ogata, Discrete time control systems, Pearson Education India, 2015, 2nd Edition.
M. Gopal, Digital Control and State Variable Methods, McGraw Hill Education, 2017, 4th Edition.

REFERENCES:

C.L. Phillips, H.T. Nagle, A. Chakrabortty, Digital Control System Analysis and Design, Pearson, 2014, 4th Edition.
B.C. Kuo, Digital Control Systems, Oxford University Press, 2012, 2nd Edition.

C.A. Rabbath, N. Lechevin, Discrete-Time Control System Design with Applications, Springer-Verlag New York Inc, 2014, 1st Edition.

Internal Assessment Pattern

Cognitive Level	**Internal Assessment #1(%)**	**Internal Assessment #2(%)**
L1	20%	15%
L2	30%	25%
L3	35%	40%
L4	10%	15%
L5	5%	5%
Total (%)	100%	100%

L1 (Recall / Define / List)

1. Define the zero-order hold (ZOH).
2. What is quantization error in a sampled-data system?
3. State the difference between continuous-time and discrete-time systems.

4. What is the pulse transfer function?
5. Define controllability in discrete-time systems.

L2 (Understanding / Explain / Describe)

1. Explain the effect of sampling period on aliasing in digital control.
2. Describe how Z-transform converts a difference equation into algebraic form.
3. Explain the relationship between s-domain poles and z-domain poles (i.e. z=esTz = e^{sT}z=esT).
4. Describe how the choice of quantizer step size affects system performance.
5. Explain why a system being controllable is important for state-feedback design.

L3 (Application / Solve)

1. For the difference equation
2. y[k]−0.5 y[k−1]=2 u[k−1],y[k] - 0.5\,y[k-1] = 2\,u[k-1],y[k]−0.5y[k−1]=2u[k−1],
3. derive the pulse transfer function G(z)=Y(z)U(z)G(z) = \frac{Y(z)}{U(z)}G(z)=U(z)Y(z).
4. Given the continuous plant G(s)=3s+1G(s) = \frac{3}{s + 1}G(s)=s+13 and sampling period T=0.2T = 0.2T=0.2 s, find the equivalent discrete transfer function via zero-order hold.
5. Consider the discrete system

L4 (Analysis / Compare / Critique)

1. Given the closed-loop transfer function
2. Y(z)R(z)=0.4z+0.1z2−1.2z+0.32, \frac{Y(z)}{R(z)} = \frac{0.4 z + 0.1}{z^2 − 1.2 z + 0.32},R(z)Y(z)=z2−1.2z+0.320.4z+0.1

locate poles & zeros in the z-plane, analyze stability, and comment on transient behavior.

3. Compare the effects of choosing a very small sampling period versus a large sampling period on system stability and response.
4. Given two candidate state-feedback gains K1K_1K1 and K2K_2K2, analyze which gives better trade-off between speed and control effort for the same discrete system.
5. For a system subject to quantization noise, analyze how the noise feeds into the closed-loop and suggest possible mitigation (filtering, dithering etc.)
6. A design yields closed-loop poles at 0.5±0.3j0.5 \pm 0.3j0.5±0.3j. Analyze whether the system is well-damped or oscillatory, and estimate damping ratio or possible overshoot.

L5 (Synthesis / Design / Evaluate)

1. Design an LQR state-feedback controller for the discrete system
2. x[k+1]=(10.101)x[k]+(00.1)u[k]x[k+1] = \begin{pmatrix}1 & 0.1 \\ 0 & 1\end{pmatrix} x[k] + \begin{pmatrix}0 \\ 0.1\end{pmatrix} u[k]x[k+1]=(100.11)x[k]+(00.1)u[k]
3. with weighting matrices Q=IQ = IQ=I, R=0.01R = 0.01R=0.01. Compute KKK.
4. Propose a digital control architecture (SCADA + RTU + controller) for real-time control of a power system frequency regulation task, and justify your design decisions.

5. Given a discretized model of a system with delay, design a compensation controller (predictive or Smith predictor) and explain its realization in z-domain.

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MTEP12044 **Real-Time Control Of Power Systems** 3 0 0 3

Course Objectives:

- To introduce the fundamentals of state estimation in power systems and its role in real-time monitoring and control.
- To develop knowledge of power system security analysis and real-time control strategies under normal and contingency conditions.
- To familiarize students with the architecture, functions, and applications of SCADA in power system operation.
- To explain communication standards, SCADA protocols, and the functional hierarchy of load dispatch centers for system coordination.
- To provide insights into computer control of power systems, software tools, and their applications for monitoring, prediction, and optimization.

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Apply weighted least squares (WLS) methods for power system state estimation, analyze observability, and incorporate PMU data for accurate monitoring.	3	3	2	2	2	L1,L2
CO2	Evaluate power system security using contingency analysis and sensitivity factors, and explain real- time control strategies for different operating states.	3	3	2	1	2	L2
CO3	Demonstrate the architecture and operation of SCADA systems, including data acquisition, HMI, and communication between field devices and control centers.	2	3	3	2	3	L3,L4
CO4	Compare SCADA protocols (Modbus, DNP, IEC standards) and explain the functional roles of various load dispatch centers in system operation.	3	2	2	1	3	L2,L3, L4
CO5	Design computer-aided control strategies integrating state estimation, generation and load control, and security analysis for reliable grid operation.	3	3	2	2	3	L3,L4, L5

UNIT-I: STATE ESTIMATION OF POWER SYSTEM **12 Hours**

Introduction to State Estimation (SE) in Power Systems: Weighted Least Square Estimation (WLS-SE). SE of AC networks: Types of measurements, Linear WLS–SE theory, DC Load flow based WLS–SE, Linearized model of WLS–SE of Non–linear AC power systems, typical results of SE on an AC network. Detection and Identification of bad measurements, Network Observability and Pseudo–measurements, optimal meter placement. Incorporation of PMU data in WLS-SE.

UNIT-II: 10 Hours

SECURITY ANALYSIS AND REAL-TIME CONTROL OF POWER SYSTEMS SECURITY ANALYSIS OF POWER SYSTEMS:

Concept of security, Security analysis and monitoring, Contingency Analysis for Generator and Line Outages by Fast Decoupled Inverse Lemma based approach, Network Sensitivity factors.

REAL-TIME CONTROL OF POWER SYSTEMS:

Introduction, operating states of a Power System.

UNIT-III: SCADA FUNCTIONS 13 Hours

Introduction to SCADA: Grid Operation & Control, advantages of SCADA operation. Lay out of substation, Main Equipment's in Sub Station, Instrument Transformers, and necessary parameters for Grid operation - Analog Points, Status Points, Alarms, Transducers & their connectivity.

Data Acquisition, Monitoring and Event Processing, Control Functions, Time tagged data, Disturbance data collection and analysis, Reports and Calculations.

Human – Machine Interface (HMI): Operator's Console, VDU Display, Operator Dialogs, Mimic Diagram Functions. Remote Terminal Unit (RTU), Phase angle Measurement unit (PMU) & Communication Practices.

Major Components: RTU Panel, Interface Panel, D20M Main Processor, Analog Card, Status Card, Control Card, Modems. Types of Communications - Power Line Carrier Communications, Microwave, Optical fiber, VSAT Communications. Types of Network - Elements in LAN & WAN. Process of Data Communication.

UNIT-IV: 10 Hours

SCADA PROTOCOLS, COMMUNICATION STANDARDS AND LOAD DISPATCH CENTERS

INTRODUCTION TO SCADA PROTOCOLOS AND COMMUNICATION STANDARDS

Evolution of Protocol for Communication, Protocols -Modbus, Distributed Network Protocol (DNP), IEC 870-5 and 60870 series, IEC 61850, Benefits from IEC (International Electro technical Commission) communication Standards LOAD DISPATCH CENTERS

Hierarchy of LDCs, Data Flow. Equipment in LDC: Workstations, FEPS, Routers, Functionalities of Sub LDC-Real time software, Functionalities and operations carried out by Sub LDC, State LDC, Regional LDC and National LDC.

UNIT-V: 9 Hours

COMPUTER CONTROL OF ELECTRICAL POWER SYSTEMS

Evolution of System Control, time scale of system control, online computer control, and Software Elements: State Estimation, Monitoring & Prediction, Generation & Load Control, Security Analysis; Software Coordination & Systems Simulation.

TEXTBOOKS:

Allen J. Wood, Bruce Wollenberg and Gerald B, Power System Generation, Operation and Control, Sheble, John Wiley and Sons, 2013, 3rd Edition.

Mini S. Thomas and John D. McDonald, Power System SCADA and Smart GridsCRC Press, 2015, 1st Edition.

REFERENCES:

John J. Grainger and William D Stevenson Jr,Power System Analysis, McGraw Hill, 2017, ISE.

Torsten Cegrell, Prentice ,Power System control – Technology, Hall International series in Systems and control Engineering, Prentice Hall International Ltd., 1986.

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	20%	15%
L2	30%	25%
L3	35%	40%
L4	10%	15%
L5	5%	5%
Total (%)	**100%**	**100%**

Level 1: Recall / Definition / Conceptual

1. Define state estimation in a power system context.
2. What is meant by observability in power system state estimation?
3. List the main components of a SCADA system (e.g. RTU, MTU, HMI).
4. What are the key differences between Modbus, DNP3, and IEC 60870-5-104 protocols?
5. What is the meaning of “normal mode”, “alert mode”, and “contingency mode” in system operation?

Level 2: Basic Application / Short Problem

1. Given a simple 3–bus system, with measured real and reactive power injections and line flows, set up the measurement equation z=h(x)+ez = h(x) + ez=h(x)+e.
2. For the same 3-bus system, linearize the nonlinear measurement function around an operating point and derive the Jacobian matrix.
3. Given a set of measurement residuals and measurement variances, compute the weighted least squares (WLS) objective and derive the normal equations.
4. Given a single line contingency, compute the LODF or PTDF for a selected line.
5. For a 5-bus system, check whether a given set of measurements yields full observability (topological test).

Level 3: Analysis / Intermediate Problems

1. In a 14-bus IEEE test system, perform contingency analysis: for all single line outages, compute the post-contingency line flows and check which ones violate limits. Rank the contingencies by severity.
2. Derive how a topology error (e.g. a breaker misreported open/close status) affects state estimation residuals. Propose a method to detect such a topology error.
3. Given a set of PMU measurements synchronized, formulate a hybrid estimator combining SCADA and PMU data. Show how the augmented Jacobian is built.
4. For a dynamic state estimation (DSE) problem, derive the basic Kalman filter equations for a simplified linear time-varying model of the grid.
5. Analyze the tradeoffs between preventive and corrective control actions in a small network under load increase scenario.

Level 4: Synthesis / Design Problems

1. Design a computer-aided real-time control scheme for a 30-bus network that integrates (a) hybrid state estimation, (b) contingency analysis, and (c) corrective dispatch. Describe data flows, algorithms, and control logic.
2. Propose and simulate a bad data robust estimator (e.g. least absolute value, Huber loss, or robust regression) for a test system, and compare its performance vs classical WLS under multiple bad data injections.
3. Propose an optimal PMU placement strategy for a 57-bus system to maximize observability under dynamics. Use an optimization criterion (e.g. maximize determinant of observability Gramian).
4. Develop a cyberattack scenario where false data is injected into SCADA measurements; propose detection and mitigation strategies in the state estimator / control logic.
5. Design a communication network (topology, bandwidth, latency) for real-time SCADA/EMS links among area/regional dispatch centers. Analyze how protocol choices and delays affect control.

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MTEP1206 Power Systems Computation Lab-II 0 0 4 2

Prerequisite: Power Systems and Artificial Neural Networks

Course Objectives:

- To know Neural network tool box
- To know the various Evolutionary Algorithms
- To apply various Evolutionary Algorithms to power system problems

After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Understood Neural network and fuzzy logic tool box	3	2	1	3	2	L1,L2
CO2	Understood various Evolutionary Algorithms	2	3	2	1	2	L2,L3
CO3	Solve power system problems by applying various Evolutionary Algorithms	3	2	3	2	1	L4,L5

List of Experiments:

1. Load Flow analysis using Neural Network
2. State Estimation using Neural Network
3. Contingency Analysis using Neural Network
4. Power system Security using Neural Network
5. Fuzzy Logic based AGC – Single area system – Two area system
6. Fuzzy Logic based small signal stability analysis
7. Economic Dispatch of Thermal Units using ANN
8. Economic Dispatch of Thermal Units using GA
9. Unit commitment problem by using GA
10. Unit commitment problem by using PSO
11. Optimal location and sizing of capacitor in distribution system using PSO
12. Security constrained optimal power dispatch using GA
13. Optimal Reactive power dispatch using PSO.

L1 / L2 Tasks (Understanding & Basic Use of Toolboxes)

1. Use the Neural Network Toolbox in MATLAB / Python to build a simple feedforward neural network to approximate a given nonlinear function (e.g. mapping voltage to load)
2. Explore the fuzzy logic toolbox: define membership functions, rules, and simulate a fuzzy controller for a small system
3. Run a built-in PSO or GA solver on a standard test function (e.g. sphere, Rastrigin) to understand convergence characteristics
4. Compare different evolutionary algorithm variants (GA vs PSO) on same benchmark function and plot convergence
5. Change algorithm parameters (population size, mutation rate, inertia weight, etc.) and observe effects on convergence / quality of solution

L3 / L4 Tasks (Applying to Simple Power System Problems)

1. Solve an Economic Dispatch problem using GA or PSO on a small 3-unit system; compare results with classical methods
2. Use ABC (Artificial Bee Colony) algorithm to optimize reactive power dispatch or capacitor placement in a small distribution network
3. Implement a hybrid GA-PSO algorithm to minimize line loss in a small transmission network
4. Use fuzzy logic + evolutionary algorithm to set parameters for a controller in a power system stability problem
5. Apply ACO (Ant Colony Optimization) to route power flow or minimize loss in a simple network graph

L5 Tasks (Complex / Design / Research Level Projects)

1. Develop a multi-objective evolutionary algorithm (e.g. NSGA-II) to optimize trade-offs in power system (e.g. cost vs emissions vs losses)
2. Design and implement a real-time (simulated) adaptive algorithm that reoptimizes dispatch using changing load / generation data
3. Compare classical methods vs evolutionary algorithms vs hybrid approaches on a real dataset (if available) and evaluate performance metrics (convergence, computational time, robustness)
4. Integrate neural network forecasting of load or renewable generation with evolutionary optimization of dispatch or control
5. Build a software tool (GUI or script) that allows selection of a power system optimization problem and solves using different algorithms, shows comparisons

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MTEP1207 **Power System Protection Lab** 0 0 4 2

Prerequisite: Power System Protection

Course Objectives:

- To understand practically different types of Faults occurring in power systems
- To study the characteristics of different types of relays
- To apply different protection schemes and understand the principle of operation

Course Outcomes: After completion of the course, students will be able to:

CO code	Course outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO3	PSO1	PSO2	
CO1	Calculate various faults	2	3	1	3	2	L1,L2
CO2	Analyze the various time-current characteristics of protective relays	3	3	2	1	2	L2
CO3	Know the Performance and Testing of various electrical models and systems	3	2	3	2	3	L3,L4

List of Experiments:

1. Characteristics of Electromechanical Non-Directional over current relay
2. Characteristics of Electromechanical Directional Over Current Relay
3. Characteristics of Electromechanical differential protection relay
4. Characteristics of Numerical Distance relay
5. Characteristics of Integrated Numerical under Voltage Relay
6. Characteristics of Numerical over current Relay
7. Zones protection characteristics of distance Relay
8. Differential protection on Single Phase Transformer
9. Performance and Testing of Feeder Protection System
10. Performance and Testing of Generator Protection System.

L1 / L2 (Understanding & Basic Tests)

1. Carry out **symmetrical (three-phase)** and **unsymmetrical (SLG, LL, DLG)** fault tests using fault analyser kit; record currents, voltages, etc.
2. Study **Over-Current Relay (IDMT / definite time / instantaneous)**: vary settings & plot time-current characteristics.
3. Perform **Undervoltage / Overvoltage Relay** tests: see how relay trips when voltage goes below or above thresholds.
4. Test **Directional Overcurrent Relay**: observe behavior when fault occurs in forward vs reverse direction.
5. Use simulation software (e.g. ETAP, MATLAB / Simulink) to model a relay's trip characteristic vs fault current.

L3 / L4 (Analysis / Application / Testing)

1. Perform **Transformer Differential Protection** test: inject currents on primary & secondary side, simulate internal fault, check relay response.
2. Test **Percentage Biased Differential Relay** (for transformer) and observe stability under external faults / inrush conditions.
3. Test **Auto-Recloser / Circuit Breaker Failure Relay** behavior: see how backup / failure logic works.
4. Use software to coordinate relay settings in a small network (e.g. set TCC curves for multiple relays to achieve selectivity).
5. Carry out **Residual / Earth Fault** relay tests on a three-phase system, measuring zero-sequence current, setting sensitivity.

L5 (Design / Integration / Advanced Projects)

1. Design and implement a complete protection scheme for a small network: selection and placement of relays, CTs, settings, coordination and test it.
2. Simulate and test **relay performance under CT saturation / transient phenomena** (e.g. during magnetizing inrush) and study relay mis-operation conditions.
3. Use software + hardware integration to test the performance of numerical relays (e.g. microprocessor relays) in various fault scenarios.
4. Develop a graphical interface or tool to help students set relay parameters and simulate the resulting behavior.
5. Compare the performance of conventional analog / electromechanical relay vs digital / numerical relay under same fault conditions, analyze response times, stability, selectivity.

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MTAC1108 Constitution of India 2 0 0 0

Course Objectives: Students will be able to:

1. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
2. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Course Outcomes: Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3. Discuss the passage of the Hindu Code Bill of 1956.

SYLLABUS

UNIT-I:

History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working), Philosophy of the Indian Constitution: Preamble, Salient Features.

UNIT-II:

Contours of Constitutional Rights & Duties: Fundamental Rights Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT-III:

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualification, Powers and Functions.

UNIT-IV:

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT-V:

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

TEXT BOOKS/ REFERENCES:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014. 4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Next

MTAC1109 **Pedagogy Studies** **2 0 0 0**

Course Objectives: Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

Course Outcomes: Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

SYLLABUS

UNIT-I:

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions. Overview of methodology and Searching.

UNIT-II:

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

UNIT-III:

Evidence on the effectiveness of pedagogical practices, Methodology for the indepth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the scho curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT-IV:

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community. Curriculum and assessment, Barriers to learning: limited resources and large class sizes.

UNIT-V:

Research gaps and future directions: Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

TEXT BOOKS/ REFERENCES:

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.

2. Agrawal M (2004) curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.

3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.

4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.

5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.

6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.

7. www.pratham.org/images/resource%20working%20paper%202.pdf.