ANNAMACHARYA INSTITUTE OF TECHNOLOGY AND SCIENCES: TIRUPATI
(AUTONOMOUS)

Course structure for Two Year Regular M .Tech. Degree

(Effective from the batches admitted from 2025-26)
POWER SYSTEMS (EEE)
SEMESTER – I

S. No.	Course codes	Course Name	Category	Hours per week			Credits	CIE	SEE	TOTAL
				L	T	P				
1.	25DPC8201	Advanced Power System Protection	PC	3	0	0	3	40	60	100
2.	25DPC8202	Power System Security and State Estimation	PC	3	0	0	3	40	60	100
3.	**Program Elective – I**		PE	3	0	0	3	40	60	100
	25DPE8201	Energy Auditing and Management								
	25DPE8202	Modelling and Analysis of HVDC Systems								
	25DPE8203	Power System Optimization								
4.	**Program Elective – II**		PE	3	0	0	3	40	60	100
	25DPE8204	Solar & Wind Energy Conversion Systems								
	25DPE8205	Smart Grid Technologies								
	25DPE8206	E-Mobility								
5.	25DPC8203	Power System Analysis and Protection Lab	PC	0	0	4	2	40	60	100
6.	25DPC8204	Power Systems Simulation Lab	PC	0	0	4	2	40	60	100
7.	25DMC0110	**Research Methodology and IPR**	MC	2	0	0	2	40	60	100
8.	25DSE8201	**Skill Enhancement Course** AI Techniques in Electrical Engineering	SE	0	1	2	2	40	60	100
9.	**Audit Course – I**		AC	2	0	0	2	40	-	40
	25DMC2001	English for Research Paper Writing								
	25DMC2002	Disaster Management								
	25DMC2003	Essence of Indian Traditional Knowledge								
Total							**20**	**360**	**480**	**840**

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Course structure for Two Year Regular M .Tech. Degree

(Effective from the batches admitted from 2025-26)
POWER SYSTEMS (EEE)
SEMESTER – II

S.No.	Course codes	Course Name	Category	Hours			Credits	CIE	SEE	TOTAL
				L	T	P				
1.	25DPC8205	Power System Stability and Control	PC	3	0	0	3	40	60	100
2.	25DPC8206	FACTS Controllers	PC	3	0	0	3	40	60	100
3.	**Program Elective – III**		PE	3	0	0	3	40	60	100
	25DPE8207	Reactive power Compensation & Management								
	25DPE8208	Modern Control Theory								
	25DPE8209	Evolutionary Algorithms Applications in Power Engineering								
4.	**Program Elective – IV**		PE	3	0	0	3	40	60	100
	25DPE8210	Power Quality								
	25DPE8211	EV Charging Infrastructure & Technology								
	25DPE8212	EHVAC Transmission systems								
5.	25DPC8207	Renewable Energy Sources Lab	PC	0	0	4	2	40	60	100
6.	25DPC8208	FACTS Devices Simulation Lab	PC	0	0	4	2	40	60	100
7.	25DMC5801	**Quantum Technologies And Applications**	MC	2	0	0	2	40	-	40
8.	25DPC8207	**Comprehensive Viva Voce**	PC	0	0	0	2	100	-	100
9.	25DMC2004	**Audit Course – II**	AC	2	0	0	0	40	-	40
Total							**20**	**420**	**360**	**780**

****Students have to undergo an Industry Internship after I Year II Semester for a duration of 6 to 8 weeks**

ANNAMACHARYA INSTITUTE OF TECHNOLOGY AND SCIENCES: TIRUPATI
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Course structure for Two Year Regular M .Tech. Degree

(Effective from the batches admitted from 2025-26)
POWER SYSTEMS (EEE)
SEMSTER – III

S.No.	Course codes	Course Name	Category	Hours per			Credits	CIE	SEE	TOTAL
				L	T	P				
1.	**Program Elective – V**		PE	3	0	0	3	40	60	100
	25DPE8213	Restructured Power								
	25DPE8214	Machine Learning Applications in Power								
	25DPE8215	Distributed Generation and Micro grid Control								
2.	**Open Elective-I**		OE	3	0	0	3	40	60	100
	25DOE8201	**PHOTOVOLTAIC SYSTEMS**								
3.	25DPR8201	**Dissertation Phase – I**	PR	0	0	20	10	100	-	100
4.	25DPR8202	**Industry Internship**	PR	0	0	0	2	100	-	100
5.	25DPR8203	**Co- Curricular**	PR	0	0	0	1	-	-	-
Total							**19**	**280**	**120**	**400**

Open Elective-I

1.PHOTOVOLTAIC SYSTEMS

SEMESTER – IV

S.No.	Course codes	Course Name	Category	Hours per week			Credits	CIE	SEE	TOTAL
				L	T	P				
1.	25DPR8204	**Dissertation Phase – II**	PR	0	0	32	16	100	100	200
Total							**16**	**100**	**100**	**200**

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Course structure for Two Year Regular M .Tech. Degree

(Effective from the batches admitted from 2025-26)
POWER SYSTEMS (EEE)
SEMESTER – I

S. No.	Course codes	Course Name	Category	Hours per week			Credits	CIE	SEE	TOTAL
				L	T	P				
1.	25DPC8201	Advanced Power System Protection	PC	3	0	0	3	40	60	100
2.	25DPC8202	Power System Security and State Estimation	PC	3	0	0	3	40	60	100
3.	**Program Elective – I**		PE	3	0	0	3	40	60	100
	25DPE8201	Energy Auditing and Management								
	25DPE8202	Modelling and Analysis of HVDC Systems								
	25DPE8203	Power System Optimization								
4.	**Program Elective – II**		PE	3	0	0	3	40	60	100
	25DPE8204	Solar & Wind Energy Conversion Systems								
	25DPE8205	Smart Grid Technologies								
	25DPE8206	E-Mobility								
5.	25DPC8203	Power System Analysis and Protection Lab	PC	0	0	4	2	40	60	100
6.	25DPC8204	Power Systems Simulation Lab	PC	0	0	4	2	40	60	100
7.	25MBA0110	**Research Methodology and IPR**	MC	2	0	0	2	40	60	**100**
8.	25DSE8201	**Skill Enhancement Course** AI Techniques in Electrical Engineering	SE	0	1	2	2	40	60	100
9.	**Audit Course – I**		AC	2	0	0	2	40	-	40
	25DMC2001	English for Research Paper Writing								
	25DMC2002	Disaster Management								
	25DMC2003	Essence of Indian Traditional Knowledge								
Total							**20**	**360**	**480**	**840**

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POWER SYSTEMS (EEE)

Course Code	ADVANCED POWER SYSTEM PROTECTION	L	T	P	C
25DPC8201		3	0	0	3
	Semester	**I**			

Course Objectives: To make the student

- To know construction of static relays, the operation of microprocessor based protective relays and Artificial Intelligence based numerical protection.
- To understand the operation of amplitude and phase comparators.
- To comprehend the concepts of Static over current, static differential and static distance relays.
- To understand multi-input comparators and concept of power swings on the distance relays.

Course Outcomes (CO):
Student will be able to

	CO Statements:
CO1	Understand the working and key differences between amplitude comparators, phase comparators, and multi-input comparator schemes.
CO2	Apply static relay principles to determine appropriate relay settings for overcurrent and differential protection in a given power system scenario.
CO3	Analyze static distance relays and power swings.
CO4	Analyze the microprocessor based protective relays and their characteristics.
CO5	Analyze AI-based protection scheme integrating ANN or wavelet-based logic for specific fault detection and classification.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	Amplitude comparators, phase comparators, and multi-input comparator schemes.			L2
CO2	Apply	Relay settings for overcurrent and differential protection in a given power system scenario			L3
CO3	Analyze	Static distance relays and power swings.			L4
CO4	Analyze	Microprocessor based protective relays and their characteristics			L4
CO5	Analyze	AI-based protection scheme integrating ANN or wavelet-based logic for specific fault detection and classification.			L4

UNIT – I	**STATIC RELAYS & COMPARATORS**	Lecture Hrs: 8

Introduction to Static relays – Basic construction of Static relays – Level detectors – Replica Impedance– Basic Introduction to Numerical Threshold Logic used in Static Comparators – General equation for two input Phase and Amplitude Comparators – Duality between Amplitude and Phase Comparator.

Comparators: Types of Amplitude Comparators and Phase Comparators, Multi –Input Comparators: Conic section characteristics Three input amplitude comparator – Hybrid comparator – Switched distance schemes – Polyphase distance schemes– Phase fault scheme – Three phase scheme – Combined and ground fault scheme.

UNIT - II	**STATIC OVER CURRENT AND DIFFERENTIAL RELAYS**	Lecture Hrs:9

Introduction– Instantaneous over current relay – Time over current relays – Definite time and Inverse definite time over current relays– Directional over current relays – Static Differential Relays– Analysis of static differential relays– Static relay schemes– Dual bias transformer differential protection – Harmonic restraint relay.

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Course structure for Two Year Regular M .Tech. Degree

(Effective from the batches admitted from 2025-26)

POWER SYSTEMS (EEE)

UNIT - III	**STATIC DISTANCE RELAYS AND POWER SWINGS**	Lecture Hrs: 9
Static Distance Relays: Static Impedance – Reactance – MHO and Angle Impedance relay Sampling comparator – Realization of reactance and MHO relay using a sampling comparator. Power Swings: Effect of power swings on the performance of Distance relays– Power swing analysis – Principle of out of step tripping and blocking relays – Effect of line length and source impedance on distance relays.		
UNIT - IV	**MICROPROCESSOR BASED PROTECTIVE RELAYS**	Lecture Hrs: 12
Over current relays – Impedance relays – Directional relay – Reactance relay (Block diagram and flow chart approach only). Generalized mathematical expression for Distance relays– Measurement of R and X – MHO and offset MHO relays – Realization of MHO characteristics – Realization of Offset MHO characteristics (Block diagram and flow chart approach only) – Quadrilateral Relay –Basic principle of Digital computer relaying.		
UNIT - V	**ARTIFICIAL INTELLIGENCE BASED NUMERICAL PROTECTION**	Lecture Hrs: 10
Application of Artificial Intelligence to Power System Protection – Application of ANN to Overcurrent Protection – Application of ANN to Transmission Line Protection – Neural Network Based Directional Relay – ANN Modular Approach for Fault Detection, Classification and Location – Wavelet Fuzzy Combined Approach for Fault Classification – Application of ANN to Power Transformer – Power Transformer Protection Based on Neural Network and Fuzzy Logic – Power Transformer Protection Based Upon Combined Wavelet Transform and Neural Network – Application of ANN to Generator Protection.		
Textbooks:		
1. T.S. Madhava Rao, Power system Protection static relay, Tata McGrawHill Publishing Company limited, 2nd Edition, 2004. 2. Badri Ram and D.N. Vishwakarma, Power system Protection and Switchgear, Tata McGraw Hill Publication Company limited, 2nd Edition, 2013.		
Reference Books:		
1. Bhavesh Bhalja, R. P. Maheshwari, N. G. Chothani, Protection and Switchgear, Oxford University Press, 2nd Edition, New Delhi, India, 2018. 2. Oza, B. A., N. C. Nair, R. P. Mehta, et al., Power System Protection & Switchgear, Tata McGraw Hill, New Delhi, 1st Edition, 2011.		
Online Learning Resources:		
1. https://nptel.ac.in/courses/108105167 2. http://www.digimat.in/nptel/courses/video/108107167/L03.html		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	2	1	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High)

ANNAMACHARYA INSTITUTE OF TECHNOLOGY AND SCIENCES: TIRUPATI
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Course structure for Two Year Regular M .Tech. Degree

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POWER SYSTEMS (EEE)

Course Code	POWER SYSTEM SECURITY AND STATE ESTIMATION	L	T	P	C
22DPC8202		3	0	0	3
	Semester	**I**			

Course Objectives: To make the student

- Understand the basic concepts of network matrices, power flow methods, state estimation, and applications of power system state estimation and structure of deregulated power system.
- Analyze about admittance/impedance matrices, factors influencing power system security, network problems and power wheeling transactions.
- Implement the methods for determining the bus matrices, optimal ordering, DC power flow, AC power flow, estimating a value and Available Transfer Capability (ATC).
- Develop the algorithm for orthogonal matrix, method to identify network problems and congestion management methods and electricity sector structure.

Course Outcomes (CO):
Student will be able to

	CO Statements:
CO1	Understand the formation of bus admittance matrices and bus impedance matrices.
CO2	Understand the concept of power system security and its influencing factors.
CO3	Apply power flow methods, including DC power flow, to analyze power systems.
CO4	Analyze contingency analysis results to detect network problems and select contingencies.
CO5	Analyze strategies for managing congestion and ensuring system security in a deregulated power system environment.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	Bus Admittance Matrices And Bus Impedance Matrices.			L2
CO2	Understand	Power System Security And Its Influencing Factors.			L2
CO3	Apply	Power Flow Methods, Including Dc Power Flow, To Analyze Power Systems.			L3
CO4	Analyze	Contingency Analysis Results To Detect Network Problems And Select Contingencies.			L4
CO5	Analyze	Managing Congestion And Ensuring System Security		In A Deregulated Power System Environment.	L4

UNIT - I	**POWER SYSTEM NETWORK MATRICES**	Lecture Hrs: 10

Formation of bus admittance matrices by direct inspection method and singular transformation method – Algorithm for formation of Bus impedance matrix: addition of a branch and addition of a link, removal element in Bus impedance matrix– Sparsity programming and Optimal Ordering – Numerical problems – ∏-representation of off-nominal tap transformers.

UNIT - II	**POWER SYSTEM SECURITY-I**	Lecture Hrs: 9

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Course structure for Two Year Regular M .Tech. Degree

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POWER SYSTEMS (EEE)

Review of power flow methods (qualitative treatment only)– DC power flow method- Introduction to power system security – Factors influencing power system security.		
UNIT - III	**POWER SYSTEM SECURITY-II**	Lecture Hrs: 10
Introduction to contingency analysis – Contingency analysis: Detection of Network problems, linear sensitivity factors –AC power flow methods– Contingency selection.		
UNIT - IV	**STATE ESTIMATION IN POWER SYSTEM**	Lecture Hrs: 10
Power system state estimation – SCADA –EMS center, Methods of state estimation – Method of least squares, Orthogonal matrix–Properties– Givens rotation–Orthogonal decomposition–Bad data detection, Pseudo measurements and applications of power system state estimation – Simple problems.		
UNIT - V	**SECURITY IN DEREGULATED ENVIRONMENT**	Lecture Hrs: 9
Need and conditions for deregulation–Electricity sector structure model – Power wheeling transactions – Congestion management methods– Available Transfer Capability (ATC) – System security in deregulation.		
Textbooks:		
1. Allen J. Wood and Wollenberg B.F., Power Generation Operation and control, John Wiley & Sons, 3rd edition, 2013. 2. P. Venkatesh, B.V. Manikandan, S. Charles Raja and A. Srinivasan, Electrical power systems analysis, security, and deregulation, PHI learning private limited, Delhi, 1st edition 2014.		
Reference Books:		
1. Nagrath I.J. and Kothari D.P., Modern Power System Analysis, TMH, New Delhi, 3rd Edition, 2004. 2. John J. Grainger and William D. Stevenson, Power System Analysis, Tata McGraw-Hill, 1st edition, 2003.		
Online Learning Resources:		
1. https://nptel.ac.in/content/storage2/courses/108106022/LECTURE%205.pdf 2. https://nptel.ac.in/content/storage2/courses/108101040/download/Lec-26.pdf		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	2	1	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course structure for Two Year Regular M .Tech. Degree

(Effective from the batches admitted from 2025-26)
POWER SYSTEMS (EEE)

Course Code	ENERGY AUDITING AND MANAGEMENT	L	T	P	C
22DPE8201	(PE-I)	3	0	0	3
	Semester	I			

Course Objectives: To make the student

- To understand the current energy scenario and importance of energy conservation.
- To acquire the knowledge about different energy efficient devices.
- To measure thermal efficiency and other renewable resources.
- To design suitable energy monitoring system to analyze and optimize the energy consumption in an electrical system.

Course Outcomes (CO):
Student will be able to

	CO Statements:
CO1	Understand energy audit and demand side management concepts in power utilities.
CO2	Apply energy audit techniques to identify energy conserving opportunities.
CO3	Analyze energy consumption patterns using instrumentation techniques.
CO4	Analyze energy conservation measures in various systems.
CO5	Analyze economic evaluation plans for energy conservation measures.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	Energy Audit And Demand Side Management Concepts In Power Utilities.			L2
CO2	Apply	Energy Audit Techniques To Identify Energy Conserving Opportunities.			L3
CO3	Analyze	Energy Consumption Patterns Using Instrumentation Techniques.			L4
CO4	Analyze	Energy Conservation Measures In Various Systems.			L4
CO5	Analyze	Economic Evaluation Plans For Energy Conservation Measures.			L4

UNIT - I	ENERGY AUDIT AND DEMAND SIDE MANAGEMENT (DSM) IN POWER UTILITIES	Lecture Hrs: 10

Energy Scenario & Conservation -Demand Forecasting Techniques- Integrated Optimal Strategy for Reduction of T&D Losses - DSM Techniques and Methodologies- Loss Reduction in Primary and Secondary Distribution system and capacitors - Energy Management — Role of Energy Managers – Energy Audit-Metering.

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UNIT - II	ENERGY AUDIT	Lecture Hrs: 9

Energy audit concepts - Basic elements and measurements - Mass and energy balances - Scope of energy auditing in industries - Evaluation of energy conserving opportunities and environmental management - Preparation and presentation of energy audit reports - case studies and potential energy savings.

UNIT - III	INSTRUMENTATION	Lecture Hrs: 10

General Audit Instrumentation –Measuring building losses – Applications of IR thermo graphy – Measurement of electrical system performance – Measurement of heating, ventilation, air conditioning system performance – Measurement of combustion systems.

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UNIT - IV	**ENERGY CONSERVATION**	Lecture Hrs:10
Energy conservation in HVAC systems and thermal power plants, Solar systems, Fan and Lighting Systems - Different light sources and luminous efficiency		
UNIT - V	**ECONOMIC EVALUATION OF ENERGY CONSERVATION**	Lecture Hrs:9
Energy conservation in electrical devices and systems - Economic evaluation of energy conservation measures - Electric motors and transformers - Inverters and UPS - Voltage stabilizers.		

Textbooks:

1. Frank kreith and D. Yogi goswamy/ Editors, "Energy Management and conservation handbook". NewYork,2008.
2. WC Turner: Energy Management Handbook, Seventh Edition, (Fairmont Press Inc., 2007)
3. YP Abbi and Shashank Jain: Handbook on Energy Audit and Environment Management, (TERIPress, 2006)

Reference Books:

1. Albert Thumann, and William J. Younger, "Handbook of Energy Audits", Marcel Dekker, Inc., Newyork, 6th edition, 2003.
2. D.A.Reay, Industrial Energy Conservation-Pergamon Press, 1980.
3. T.L.Boten, LiptakB.G.,(Ed)Instrument Engineers Handbook, Chinton Book Company, 2004.
4. Hodge B.K, Analysis and Design of Energy Systems, Prentice Hall, 2002.
5. Larry C.Witte, Schmidt & Brown, Industrial energy management and utilization. Hemisphere publishing, Co.NewYork,1988.

Online Learning Resources:

1. https://onlinecourses.swayam2.ac.in/nou23_es05/preview
2. https://onlinecourses.nptel.ac.in/noc25_ar10/preview

Mapping of course outcomes with program outcomes

CO/PO	**PO1**	**PO2**	**PO3**
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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POWER SYSTEMS (EEE)

Course Code	MODELLING AND ANALYSIS OF HVDC SYSTEMS (PE-I)	L	T	P	C
22DPE8202		3	0	0	3
	Semester	**I**			

Course Objectives: To make the student

- To understand the concept, planning of DC power transmission.
- To analyze HVDC converters, Transient and Dynamic Stability.
- To apply modeling of power flow analysis.
- To design digital dynamic simulation of converters and DC systems.

CourseOutcomes(CO): Student will be able to

	CO Statements:
CO1	Understand the fundamental concepts of HVDC converters and system control.
CO2	Understand the modeling techniques for power flow analysis of AC/DC systems.
CO3	Analyze the transient and dynamic stability of AC/DC systems.
CO4	Evaluate the impact of harmonic and torsional interactions on HVDC systems.
CO5	Analyze digital dynamic simulations of HVDC systems for performance analysis.

CO	**Action Verb**	**Knowledge Statement**	**Condition**	**Criteria**	**Blooms level**
CO1	Understand	Fundamental concepts of HVDC converters and system control.			L2
CO2	Understand	Modeling techniques for power flow analysis of AC/DC systems.			L2
CO3	Analyze	Transient and dynamic stability of AC/DC systems.			L4
CO4	Evaluate	Impact of harmonic and torsional interactions on HVDC systems.			L5
CO5	Analyze	Digital dynamic simulations of HVDC systems for performance analysis.			L4

UNIT – I	**HVDC CONVERTERS AND SYSTEM CONTROL**	Lecture Hrs: 10

Analysis of HVDC Converters: Pulse number – choice of converter configuration – simplified analysis of Graetz circuit – converter bridge characteristics. Converter and HVDC system control: Principles of DC link control – converter control characteristics – system control hierarchy – firing angle control – current and extinction angle control – starting and stopping of DC link power control.

UNIT – II	**MODELING FOR POWER FLOW ANALYSIS OF AC/DC SYSTEMS**	Lecture Hrs: 9

Modeling of HVDC Components: HVDC Converter model - Converter control - Modeling of DC network - Modeling of AC Network.

Power flow analysis in AC/DC systems: Modeling of DC links –Multi terminal DC links- Solution of DC load flow –per unit system for DC qualities – Solution of AC/DC power flow.

UNIT - III	**TRANSIENT AND DYNAMIC STABILITY ANALYSIS**	Lecture Hrs: 10

Transient stability Analysis – Converter model – Converter control models – DC network models – solution methodology – Direct methods for stability Evaluation.

Dynamic Stability and power modulation - Power modulation for damping low frequency oscillations – Basic principles – practical consideration in the application of power modulation controllers – Introduction to Converter-Based Stability Enhancement Techniques (FACTS/HVDC Light – basic concept only)– power modulation in MTDC system – voltage stability in AC/DC system.

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UNIT – IV	**HARMONIC AND TORSIONAL INTERACTIONS**	Lecture Hrs: 10
Harmonic and Torsional Interactions: Harmonic Interactions - Torsion Interactions – Torsional interactions with in HVDC systems – counter measures to torsion interactions with DC systems. Simulation of HVDC systems: System simulation – philosophy & Tools – HVDC system simulation – modeling of HVDC systems Digital dynamic simulation.		
UNIT – V	**MODELING OF HVDC SYSTEMS**	Lecture Hrs: 9
Digital dynamic simulation of converters and DC systems: Valve model, Gate pulse generation – generation of control voltage – transformer model – converter model – transient simulation of DC and AC systems. HVDC Breakers, Monopolar Operation.		
Textbooks:		
1. K.R. Padiyar, HVDC Power Transmission Systems – Technology & System Interactions, New Age International Publishers, 3rd Edition, 2017 2. S Kamakshaiah and V Kamaraju, HVDC Transmission, Tata Mc Graw Hill, New Delhi, 2nd Edition, 2021.		
Reference Books:		
1. E.W. Kimbark, Direct current transmission, Wiely Inter Science – New York, 1st Edition, 1971 2. J. Arillaga, HVDC Transmission, Peter Peregrinus Ltd., London UK 2nd Edition, 1998 3. E. Uhlman, Power transmission by direct current, Springer Verlag, Berlin Helberg, 1st Edition, 1985		
Online Learning Resources:		
1. https://www.youtube.com/watch?v=yP7OACmLP48		

Mapping of course outcomes with program outcomes

CO/PO	**PO1**	**PO2**	**PO3**
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

ANNAMACHARYA INSTITUTE OF TECHNOLOGY AND SCIENCES: TIRUPATI
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Course structure for Two Year Regular M .Tech. Degree

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POWER SYSTEMS (EEE)

Course Code	POWER SYSTEM OPTIMIZATION	L	T	P	C
25DPE8203	(PE-I)	3	0	0	3
	Semester	I			

Course Objectives: To make the student

- Understand the fundamental concepts of Optimization Techniques.
- Analyze the importance of optimizations in real life scenarios.
- Apply the concepts of various classical and modern methods for constrained and unconstrained problems in both single and multivariable.
- Design the algorithms for different optimizations techniques

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand conventional optimization techniques.
CO2	Understand particle swarm optimization (PSO) techniques and their evolution.
CO3	Analyze ant colony search algorithms and their characteristics.
CO4	Analyze the tabu search approach and algorithms
CO5	Analyze optimization solutions for power system applications.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	Conventional Optimization Techniques			L2
CO2	Understand	Particle Swarm Optimization (PSO) Techniques and their evolution.			L2
CO3	Analyze	Ant colony search algorithms and their characteristics.			L4
CO4	Analyze	Tabu search approach and algorithms			L4
CO5	Analyze	Optimization Solutions For Power System Applications.			L4

UNIT – I	CONVENTIONAL OPTIMIZATION TECHNIQUES	Lecture Hrs: 10

Concepts & Terms related to Optimization -Quadratic optimization problem - Karush - Kuhn - Tucker (KKT) necessary and sufficient conditions for quadratic programming problem- Interior point method for convex optimization - linear programming.

UNIT – II	FUNDAMENTALS OF PARTICLE SWARM OPTIMIZATION (PSO) TECHNIQUE	Lecture Hrs: 9

Background of PSO – Original PSO – Variation of PSO – Discrete PSO – PSO for MINLPs – Constriction Factor Approach (CFA) – Hybrid PSO (HPSO) – L bestModel – Adaptive PSO (APSO) Evolutionary PSO (EPSO) – Applications. Problem formulation of VVC, VVC using PSO

UNIT - III	FUNDAMENTALS OF ANT COLONY SEARCH ALGORITHMS	Lecture Hrs: 10

Ant Colony Search Algorithm – Behavior of Real Ants – Ant Colony Algorithms – The Ant System – The Ant Colony System – The Max-Min Ant System – Major Characteristics of Ant Colony Search Algorithm – Distributed Computation: Avoid Premature Convergence – Positive Feedback: Rapid Discovery of Good Solution – Use of Greedy Search and Constructive Heuristic Information: Find Acceptable Solutions in the Early Stage of the Process.

UNIT – IV	FUNDAMENTALS OF TABU SEARCH	Lecture Hrs: 10

Overview of the Tabu Search Approach – Problem Formulation – Coding and Representation – Neighborhood Structure – Characterization of the Neighborhood – Functions and Strategies in Tabu Search – Recency- Based Tabu Search – Basic Tabu Search Algorithm – Candidate List Strategies – Tabu tenure – Aspiration Criteria –

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The Use of Long Term Memory in Tabu Search – Frequency-Based Memory – Intensification – Diversification – Other TS Strategies – Path Relinking – Strategic Oscillation – Applications of Tabu Search.		
UNIT – V	**APPLICATION TO POWER SYSTEMS**	Lecture Hrs: 9
Introduction to power system applications – Model identifications – Dynamic load modeling – Short term load forecasting – Distribution system applications – Network reconfiguration for loss reduction – Optimal protection and switching devices placements – Examples.		
Textbooks:		
1. A Ravindran, K.M. Ragsdell, and G.V. Reklaitis, "Engineering optimization : Methods and applications", Wiley India Edition. 2. Kwang Y. Lee and Mohamed A. EI- Sharkawi "Modern Heuristic Optimization Techniques Theory and Applications to Power Systems", A John Wiley & Sons. INC. Publication, 1st edition, 2020 3. D. P. Kothari and J. S. Dhillon, "Power System Optimization", PHI Learning Private Limited, 2nd Edition, 2011.		
Reference Books:		
1. Jizhong Zhu, "Optimization of power system operation", IEEE Press, John *Wiley* & Sons, Inc., *Publication, 2nd edition, 2015*. 2. Joshua adam Taylor, "Convex optimization of power systems'', Cambridge University Press, 1st edition, 2015.		
Online Learning Resources:		
https://nptel.ac.in/courses/112/106/112106064/		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	SOLAR & WIND ENERGY CONVERSION SYSTEM	L	T	P	C
25DPE8204	(PE-II)	3	0	0	3
	Semester	I			

Course Objectives: To make the student

- To introduce photovoltaic systems and principle of wind turbines.
- To deal with various technologies of solar PV cells.
- To understand details about manufacture, sizing and operating techniques in solar energy conversion systems.
- Understand the concepts of fixed speed and variable speed, wind energy conversion systems, knowledge of design considerations and analyze grid integration issues.

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand solar and wind energy fundamentals.
CO2	Analyze solar PV module design and integration to wind energy.
CO3	Analyze solar PV module their applications
CO4	Analyze wind turbine control systems and site analysis.
CO5	Understand the wind generation systems with variable speed turbines.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	solar and wind energy fundamentals.			L2
CO2	Analyze	solar PV module design and integration to wind energy.			L4
CO3	Analyze	solar PV module their applications			L4
CO4	Analyze	wind turbine control systems and site analysis.			L4
CO5	Understand	the wind generation systems with variable speed turbines.			L2

UNIT – I	**SOLAR & WIND FUNDAMENTALS**	Lecture Hrs: 10

Need for sustainable energy sources – solar radiation – the sun and earth movement – angle of sunrays on solar collectors – sun tracking – estimating solar radiation – measurement of solar radiation. Types of wind energy conversion devices – definition - solidity, tip speed ratio, power coefficient, wind turbine ratings and specifications - aerodynamics of wind rotors - design of the wind turbine rotor – Issues due to integration of solar and wind energy systems.

UNIT – II	**SOLAR PHOTOVOLTAIC MODULES**	Lecture Hrs: 9

Solar PV Modules from solar cells – model of a solar cell, effect of series and shunt resistanceon efficiency, effect of solar radiation on efficiency - series and parallel connection of cells – mismatch in module – mismatch in series connection – hot spots in the module, bypass diode – mismatching in parallel diode – design and structure of PV modules – number of solar cells in a module, wattage of modules, Basic Concept of PV Module Degradation Mechanisms (LID/LeTID)– PV module power output.

UNIT - III	**PV SYSTEM DESIGN AND APPLICATIONS**	Lecture Hrs: 09

Introduction to solar PV systems – standalone PV system configuration – design methodology ofPV systems – design of PV powered DC fan without battery, standalone system with DC load using MPPT, design of PV powered DC pump, design of standalone system with battery and AC/DC load – wire sizing in PV system – precise sizing of PV systems – Hybrid PV systems – grid connected PV systems.

UNIT – IV	**WIND TURBINE CONTROL SYSTEMS & SITE ANALYSIS**	Lecture Hrs: 10

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Wind Turbine - Torque speed characteristics – Modelling of wind turbines, Pitch angle control – stall control – power electronic control – Yaw control – Control strategy – Wind speed measurements – Wind speed statistics – Site and turbine selection. Constant voltage & constant frequency- single output system –double output system with current converter & voltage source inverter – equivalent circuits – reactive power and harmonics - reactive power compensation – variable voltage, variable frequency – the self-excitation process – circuit model for the self-excited induction generator – analysis of steady state operation – the excitation requirement – effect of a wind generator on the network.

UNIT – V	**WIND GENERATION WITH VARIABLE SPEED TURBINES AND APPLICATIONS**	Lecture Hrs: 10

Classification of schemes – operating area – induction generators – doubly fed induction generator – wound field synchronous generator – the permanent magnet generator – Merits and limitations of wind energy conversion systems – application in hybrid energy systems – diesel generator and photovoltaic systems – wind and photovoltaic systems.

Textbooks:

1. "Solar Photovoltaics Fundamentals, Technologies and Applications" by Chetan Singh Solanki, PHI publications, 3rd edition, 2015
2. S.N.Bhadra, D.Kastha, S.Banerjee, " wind electrical systems" Oxford University Press, 1st edition, 2013
3. Banshi D. Shukla, "Engineering of Wind Energy", Jain Brothers, 1st edition, 2018

Reference Books:

1. H.P. Garg, J. Prakash, Solar Energy Fundamentals and applications Tata McGraw- Hill publishers 1st edition, 2000
2. S.Rao & B.B.Parulekar, Energy Technology, Khanna publishers, 4th edition, 2005.
3. N.K.Bansal, M. Kleemann,Michael Meliss, Renewable Energy sources & Conversion Technology, Tata Mcgraw Hill Publishers & Co., 1st edition, 1990

Online Learning Resources:

1. https://www.youtube.com/watch?v=yKgKW4K9ILU
2. http://www.digimat.in/nptel/courses/video/103103206/L37.html

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
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POWER SYSTEMS (EEE)

Course Code	SMART GRID TECHNOLOGIES	L	T	P	C
25DPE8205	(PE-II)	3	0	0	3
	Semester	I			

Course Objectives: To make the student

- To know the importance of smart grid technology functions over the present grid.
- To get the knowledge about the measurement system and communication technology of Smart grid.
- To enhance the quality, efficiency and security of power supply.
- To impart an understanding of economics, policies and technical regulations for DG integration.

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand smart grid concepts and technologies.
CO2	Apply transmission and distribution management techniques for wide area applications.
CO3	Analyze smart metering and demand side integration systems.
CO4	Analyze the communication technologies for smart grids.
CO5	Analyze secure smart grid systems with encryption and authentication.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	Smart Grid Concepts And Technologies.			L2
CO2	Apply	Transmission And Distribution Management Techniques for wide area applications.			L3
CO3	Analyze	Smart Metering And Demand Side Integration Systems.			L4
CO4	Analyze	Communication Technologies For Smart Grids.			L4
CO5	Analyze	Secure Smart Grid Systems With Encryption And Authentication.			L4

UNIT – I	**SMART GRIDS**	Lecture Hrs: 08

Smart grid overview- ageing assets and lack of circuit capacity- thermal constraints, operational constraints, security of supply- national initiatives- early smart grid initiatives- active distribution networks- virtual power plant- other initiatives and demonstrations- overview of the technologies required for the smart grid.

UNIT – II	**TRANSMISSION AND DISTRIBUTION MANAGEMENT**	Lecture Hrs: 10

Data Sources- Energy Management System-Wide Area Applications, Visualization Techniques- Data Sources and Associated External Systems- SCADA- Customer Information System- Modeling and Analysis Tools, Distribution System Modeling- Topology Analysis- Load Forecasting- Power Flow Analysis- Fault Calculations- State Estimation- Applications-System Monitoring- Operation- Management- Outage Management System- Overview of energy storage technologies.

UNIT - III	**SMART METERING AND DEMAND SIDE INTEGRATION**	Lecture Hrs: 10

Overview- Smart metering – Evolution of electricity metering- key components of smart metering- smart meters: an overview of the hardware used – signal acquisition- signal conditioning-analogue to digital conversion-computation-input/output and communication. Communication infrastructure and protocols for smart metering - Home area network, Neighborhood Area Network- Data Concentrator- meter data management system- Protocols for communication. Demand Side Integration- Services Provided by DSI-Implementation of DSI- Hardware Support- Flexibility Delivered by consumers from the Demand Side- System Support from DSI.

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UNIT – IV	**COMMUNICATION TECHNOLOGIES FOR THE SMART GRID**	Lecture Hrs: 10
Data Communications: Dedicated and Shared Communication Channels, Switching Techniques, Circuit Switching, Message Switching, Packet Switching- Communication Channels, Introduction to TCP/IP. Communication Technologies: IEEE 802 Series- Mobile Communications- Multi-Protocol Label Switching- Power line Communication.		
UNIT – V	**INFORMATION SECURITY FOR THE SMART GRID**	Lecture Hrs: 10
Overview- Encryption and Decryption, Symmetric Key Encryption- Public Key Encryption- Authentication- Authentication Based on Shared Secret Key- Authentication Based on Key Distribution Center- Digital Signatures- Secret Key Signature-Public Key Signature- Message Digest.		
Textbooks:		
1. Janaka Ekanayake, Kithsiri Liyanage, et.al., Smart Grid Technology and Applications, Wiley Publications, 1st edition, 2012. 2. James Momoh, Smart Grid: Fundamentals of Design and Analysis, Wiley, IEEE Press, 1st edition, 2012. 3. Bharat Modi, Anuprakash, Yogesh Kumar, Fundamentals of Smart Grid Technology, S.K Kataria& Sons, 1st edition, 2019.		
Reference Books:		
1. Eric D. Knapp, Raj Samani, Applied Cyber Security and the Smart Grid-Implementing Security Controls into the Modern Power Infrastructure, Syngress Publishers, 1st edition, 2013. 2. Nouredine Hadjsaid, Jean Claude Sabonnadiere, Smart Grids, Wiley Blackwell Publications, 1st edition, 2012. 3. Peter-Fox Penner, Smart Power: Climate Changes, the Smart Grid and the future of electric utilities, Island Press, 1st edition, 2010.		
Online Learning Resources:		
www.indiasmartgrid.org		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
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(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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POWER SYSTEMS (EEE)

Course Code	E-MOBILITY	L	T	P	C
25DPE8206	(PE-II)	3	0	0	3
	Semester	I			

Course Objectives: To make the student

- Remember and Understand the differences between conventional Vehicle and Electric Vehicles, electro mobility and environmental issues of EVs.
- Analyze various EV configurations, parameters of EV systems and Electric vehicle dynamics.
- Analyze the basic construction, operation and characteristics of fuel cells and battery charging techniques in HEV systems.
- Design and analyze the various control structures for Electric vehicle

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand the fundamentals of electric vehicle systems, energy sources, and environmental impact.
CO2	Analyze electric propulsion systems and dynamics in electric vehicles.
CO3	Analyze fuel cell technology and its application in electric vehicles.
CO4	Analyze battery charging and control systems for electric vehicles.
CO5	Analyze energy storage systems for electric vehicles, including hybrid energy storage systems and energy management strategies.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	Fundamentals Of Electric Vehicle Systems, Energy Sources, And Environmental Impact.			L2
CO2	Analyze	Electric Propulsion Systems And Dynamics In Electric Vehicles.			L4
CO3	Analyze	Fuel Cell Technology And Its Application In Electric Vehicles.			L4
CO4	Analyze	Battery Charging And Control Systems For Electric Vehicles.			L4
CO5	Analyze	Energy Storage Systems For Electric Vehicles, Including Hybrid Energy Storage Systems And Energy Management Strategies.			L4

UNIT – I	**INTRODUCTION TO EV SYSTEMS AND ENERGY SOURCES**	Lecture Hrs: 10

Past, Present and Future of EV - EV Concept- EV Technology- State-of-the Art of EVs- EV configuration- EV system- Fixed and Variable gearing- Single and multiple motor drive- In-wheel drives- EV parameters: Weight, size, force and energy, performance parameters.
Electro mobility and the environment- History of Electric power trains- Carbon emissions from fuels- Green houses and pollutants- Comparison of conventional, battery, hybrid and fuel cell electric systems.

UNIT – II	**EV PROPULSION AND DYNAMICS**	Lecture Hrs: 08

Choice of electric propulsion system- Block diagram- Concept of EV Motors- Single and multi-motor configurations- Fixed and variable geared transmission- In-wheel motor configuration- Classification-

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Electric motors used in current vehicle applications- Recent EV Motors- Linear Induction Motors Vehicle load factors- Vehicle acceleration.		
UNIT - III	**FUEL CELLS**	Lecture Hrs: 10
Introduction of fuel cells- Basic operation- Model - Voltage, power and efficiency- Power plant system – Characteristics- Sizing - Example of fuel cell electric vehicle. Introduction to HEV- Brake specific fuel consumption - Comparison of Series-Parallel hybrid systems- Examples.		
UNIT – IV	**BATTERY CHARGING AND CONTROL**	Lecture Hrs: 10
Battery charging: Basic requirements- Charger architecture- Charger functions- Wireless charging- Power factor correction. **Control:** Introduction- Modeling of electro mechanical system- Feedback controller design approach- PI controllers designing- Torque-loop, Speed control loop compensation- Acceleration of battery electric vehicle.		
UNIT – V	**ENERGY STORAGE TECHNOLOGIES**	Lecture Hrs: 10
Role of Energy Storage Systems- Thermal- Mechanical-Chemical- Electrochemical- Electrical - Efficiency of energy storage systems- Super capacitors-Superconducting Magnetic Energy Storage (SMES)- SoC- SoH -fuel cells - G2V- V2G- Energy storage in Micro-grid and Smart grid- Energy Management with storage systems- Hybrid energy storage systems -Battery SCADA.		
Textbooks:		
1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001,1st Edition 2. Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt," Energy Storage in Power Systems" Wiley Publication, ISBN: 978-1-118-97130-7, Mar 2016,1st Edition		
Reference Books:		
1. Electric and Hybrid Vehicles Design Fundamentals, Iqbal Husain, CRC Press 2021,3rd Edition. 2. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2015,1st Edition 3. A.G.Ter-Gazarian, "Energy Storage for Power Systems", the Institution of Engineering and Technology (IET) Publication, UK, (ISBN – 978-1-84919-219-4), Second Edition, 2011. 3. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, "Modern Elelctric, Hybrid Elelctric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2004,1st Edition 4. James Larminie, John Lowry, "Electric Vehicle Technology Explained", Wiley, 2003,2nd Edition.		
Online Learning Resources:		
1. https://nptel.ac.in/courses/108/102/108102121/ 2. https://nptel.ac.in/syllabus/108103009		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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POWER SYSTEMS (EEE)

Course Code	POWER SYSTEM ANALYSIS AND PROTECTION LAB	L	T	P	C
25DPC8203		0	0	4	2
	Semester	I			

Course Objectives: To make the student

- Understand the experiments ensuring the safety of equipment and personnel.
- Analyze the power system data fault studies.
- Interpret the experimental results and correlating them with the practical power system.
- Design the relays for power system protection purpose.

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand synchronous machines and power system components with modeling.
CO2	Apply fault analysis techniques in power systems.
CO3	Analyze protective relay characteristics.
CO4	Understand microprocessor-based relay performance.
CO5	Analyze the test procedures for protective relays.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	Synchronous Machines And Power System Components.			L2
CO2	Apply	Fault Analysis Techniques In Power Systems.			L3
CO3	Analyze	Protective Relay Characteristics.			L4
CO4	Understand	Microprocessor-Based Relay Performance.			L2
CO5	Analyze	Test procedures for protective relays.			L4

List of Experiments:

EXP NO	Experiment Name	CO
1	Determination of Subtransient Reactance and Time Constant of a Salient Pole Machine	CO1
2	Fault Analysis i)LG Fault, ii)LL Fault ,iii)LLG Fault, iv)LLLG Fault	CO2
3	Determination of Sequence Impedances of a Cylindrical Rotor Synchronous Machine	CO1
4	Equivalent Circuit of a Three Winding Transformer	CO1
5	Separation of No Load losses of a Three Phase Squirrel Cage Induction Motor	CO1
6	Power Angle Characteristics of a Salient Pole Synchronous Machine	CO1
7	Characteristics of Static/Numeric Over Current Relay	CO3
8	Characteristics of Static Negative Sequence Relay	CO3
9	Characteristics of Static/Numeric Percentage Biased Differential Relay	CO3
10	Characteristics of Static/Numeric Over Voltage Relay	CO3
11	Testing of Buchholz Relay	CO5
12	Testing of Frequency Relay	CO5
13	Dynamic Stability Analysis of a Single Machine–Infinite Bus (SMIB) System Using MATLAB/Simulink	CO1
14	Testing of Earth fault Relay	CO5

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15	Microprocessor Based Relay	CO4

Web Sources: https://www.vlab.co.in

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

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POWER SYSTEMS (EEE)

Course Code	POWER SYSTEMS SIMULATION LAB	L	T	P	C
25DPC8204		0	0	4	2
	Semester	I			

Course Objectives: To make the student

- Understand how to write the coding in simulation.
- Analyze the data related to load flows, economic dispatch problem and transient stability analysis.
- Apply the computational results in real life power system problems.
- Have the capabilities to develop new software's to optimize the results.

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand power system analysis techniques.
CO2	Apply numerical methods for load flow analysis.
CO3	Analyze power system performance and power quality issues.
CO4	Evaluate available transfer capabilities and contingency analysis.
CO5	Create filter designs to mitigate harmonics and simulate power system scenarios.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	Power System Analysis Techniques.			L2
CO2	Apply	Load Flow Analysis.			L3
CO3	Analyze	Power System Performance And Power Quality Issues			L4
CO4	Evaluate	Transfer Capabilities And Contingency Analysis.			L5
CO5	Create	Filter Designs To Mitigate Harmonics And Simulate Power System Scenarios.			L6

List of Experiments:

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EXP NO	Experiment Name	CO
1	Y - Bus Formation	CO1
2	Z- Bus Formation	CO1
3	Gauss – Seidel Load Flow Analysis	CO2
4	Newton-Raphson Method for Load Flow Analysis	CO2
5	Fast Decoupled Load Flow Analysis	CO2
6	Fast Decoupled Load Flow Analysis for Distribution Systems	CO2
7	Point by Point Method	CO4
8	Computation of Available Transfer Capabilities	CO4
9	Contingency analysis	CO3
10	State estimation using Weighted Least Square, linear and non-linear methods	CO3
11	Simulation of power quality problems (Sag/Swell, interruption, transients, harmonics, flickers etc.)	CO3
12	Harmonic analysis and Single tuned filter design to mitigate harmonics	CO5
13	Harmonic analysis and Double tuned filter design to mitigate harmonics	CO5

Web Sources: https://www.vlab.co.in

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
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POWER SYSTEMS (EEE)

Course Code	AI TECHNIQUES IN ELECTRICAL ENGINEERING (SE)	L	T	P	C
25DSE8201		0	1	2	2
	Semester	**I**			

Course Objectives: To make the student

- To locate soft commanding methodologies, such as artificial neural networks, Fuzzy logic and genetic Algorithms.
- To observe the concepts of feed forward neural networks and about feedback neural networks.
- To practice the concept of fuzziness involved in various systems and comprehensive knowledge of fuzzy logic control and to design the fuzzy control.
- To analyze genetic algorithm, genetic operations and genetic mutations.

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand artificial neural networks and their learning techniques.
CO2	Analyze the Artificial Neural Network paradigm algorithms.
CO3	Analyze the fuzzy logic and defuzzfication techniques
CO4	Analyze genetic algorithms and their operators.
CO5	Analyze intelligent solutions for power systems using AI.

CO	**Action Verb**	**Knowledge Statement**	**Condition**	**Criteria**	**Blooms level**
CO1	Understand	artificial neural networks and their learning techniques			L2
CO2	Analyze	Artificial Neural Network paradigm algorithms			L4
CO3	Analyze	fuzzy logic and defuzzfication techniques			L4
CO4	Analyze	genetic algorithms and their operators			L4
CO5	Analyze	Intelligent Solutions For Power Systems Using Ai			L4

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POWER SYSTEMS (EEE)

UNIT - I	**ARTIFICIAL NEURAL NETWORKS**	Lec Hrs: 10
Introduction-Models of Neural Network - Architectures – Knowledge representation – Artificial Intelligence and Neural networks – Learning process – Error correction learning – Hebbian learning – Competitive learning – Boltzmann learning – Supervised learning –Unsupervised learning – Reinforcement learning -learning tasks.		
UNIT - II	**ANN PARADIGMS**	Lec Hrs: 9
Multi – layer perceptron using Back propagation Algorithm-Self – organizing Map –Radial Basis Function Network– Functional link network– Hopfield Network.		
UNIT - III	**FUZZYLOGIC**	Lec Hrs: 9
Introduction – Fuzzy versus crisp – Fuzzy sets - Membership function – Basic Fuzzy set operations –Properties of Fuzzy sets – Fuzzy Cartesian Product – Operations on Fuzzy relations – Fuzzy logic – Fuzzy Quantifiers-Fuzzy Inference- Fuzzy Rule based system– Defuzzification methods.		
UNIT - IV	**GENETIC ALGORITHMS**	Lec Hrs: 10
Introduction-Encoding– Fitness Function-Reproduction operators–Genetic Modeling –Genetic operators- Crossover-Single–site crossover –Two-point crossover–Multi point crossover-Uniform crossover–Matrix crossover-Crossover Rate-Inversion & Deletion–Mutation operator–Mutation–Mutation Rate-Bit-wise operators-Generational cycle-convergence of Genetic Algorithm.		
UNIT - V	**APPLICATIONS OF AI TECHNIQUES**	Lec Hrs: 10
Load forecasting – Load flow studies – Economic load dispatch –Load frequency control – Single area system and two area system – Small Signal Stability (Dynamic stability)- Reactive power control – speed control of DC and AC Motors.		
Textbooks:		
1.S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic & Genetic Algorithms" PHI,New Delhi, 2nd edition,2017. 2.Sudarshan K. Valluru and T. Nageswara Rao, "introduction to Neural Networks, Fuzzy Logic & Genetic Algorithms", Jaico Publishing House, 1st edition, 2010.		
Reference Books:		
1. P.D.Wasserman, VanNostrand Reinhold," NeuralComputingTheory&Practice",NewYork,1st . Eddition ,1989 2. Bart Kosko,"Neural Network & Fuzzy System", Prentice Hall,1992. 3. G.J.Klir and T.A.Folger, "Fuzzy sets, Uncertainty and Information", Pearson, 1st edition, 2015. 4. D.E.Goldberg, "Genetic Algorithms", Pearson Education India, 1st edition, 2008.		
Online Learning Resources:		
1. https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview **2. https://onlinecourses.nptel.ac.in/noc23_ge36/preview** **3. https://onlinecourses.nptel.ac.in/noc22_hs59/preview**		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
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CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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SEMESTER – II

S.No.	Course codes	Course Name	Category	Hours			Credits	CIE	SEE	TOTAL
				L	T	P				
1.	25DPC8205	Power System Stability and Control	PC	3	0	0	3	40	60	100
2.	25DPC8206	FACTS Controllers	PC	3	0	0	3	40	60	100
3.	**Program Elective – III**		PE	3	0	0	3	40	60	100
	25DPE8207	Reactive power Compensation & Management								
	25DPE8208	Modern Control Theory								
	25DPE8209	Evolutionary Algorithms Applications in Power Engineering								
4.	**Program Elective – IV**		PE	3	0	0	3	40	60	100
	25DPE8210	Power Quality								
	25DPE8211	EV Charging Infrastructure & Technology								
	25DPE8212	EHVAC Transmission systems								
5.	25DPC8207	Renewable Energy Sources Lab	PC	0	0	4	2	40	60	100
6.	25DPC8208	FACTS Devices Simulation Lab	PC	0	0	4	2	40	60	100
7.	25DMC5801	**Quantum Technologies And Applications**	MC	2	0	0	2	40	-	40
8.	25DMC2002	**Comprehensive Viva Voce**	PC	0	0	0	2	100	-	100
9.	25DMC2003	**Audit Course – II**	AC	2	0	0	0	40	-	40

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Total	**20**	**420**	**360**	**780**

****Students have to undergo an Industry Internship after I Year II Semester for a duration of 6 to 8 weeks**

Course Code	**POWER SYSTEM STABILITY AND CONTROL**	**L**	**T**	**P**	**C**
25DPC8205		**3**	**0**	**0**	**3**
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand power system stability problems and classifications.
CO2	Apply modeling techniques for power system components.
CO3	Analyze small signal stability and transient stability.
CO4	Analyze methods for improving power system stability.
CO5	Apply strategies to prevent voltage collapse.

CO	**Action Verb**	**Knowledge Statement**	**Condition**	**Criteria**	**Blooms level**
CO1	Understand	Power System Stability Problems And Classifications.			L2
CO2	Apply	Power System Components.			L3
CO3	Analyse	Small Signal Stability And Transient Stability.			L4
CO4	Analyse	Methods For Improving Power System Stability			L4
CO5	Apply	strategies to prevent voltage collapse.			L3

UNIT - I	**INTRODUCTION TO POWER SYSTEM STABILITY PROBLEMS**	Lec Hrs: 10

Definition of stability, classification of stability, Rotor angle stability, frequency stability, voltage stability, mid-term and longterm stability, classical representation of synchronous machine in a single machine infinite bus system (SMIB), equal area criterion to asses stability of a SMIB system, limitations of classical model of synchronous machines.

UNIT - II	**MODELING OF POWER SYSTEM COMPONENTS FOR STABILITY ANALYSIS**	Lec Hrs: 9

Synchronous machine modeling: sub-transient model, two axis model, one axis (flux decay) model, classical model. Excitation systems modeling: DC excitation, AC excitation and static excitation. Prime mover and energy supply systems modeling. Transmission line modeling, load modeling. Methods of representing synchronous machines in stability analysis.

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UNIT - III	**SMALL SIGNAL STABILITY**	Lec Hrs: 9
Fundamental concepts, state space representation, Modal analysis: eigen properties, participation factors, stability assessment. Effects of excitation system on stability, power system stabilizer and its design, Angle and voltage stability of multi-machine power systems and phenomenon of sub synchronous resonance.		
UNIT - IV	**TRANSIENT STABILITY**	Lec Hrs: 10
Fundamentals of transient stability, numerical solutions: simultaneous implicit and partitioned explicit methods, simulation of dynamic response, analysis of unbalanced faults, direct method of transient stability, transient energy function method, Methods of improving transient stability.		
UNIT - V	**VOLTAGE STABILITY**	Lec Hrs: 10
Classification of voltage stability, modeling requirements, voltage stability analysis: static and dynamic, sensitivity analysis, modal analysis, voltage collapse, prevention of voltage collapse.		
Textbooks:		
1. R. Ramanujam, 'Power System Dynamics: Analysis and Simulation', PHI Learning Private Ltd., 2009. 2. P. M. Anderson and A. A. Fouad, "Power System Control and Stability, Wiley Interscience, John Wiley & Sons. 3. K.R. Padiyar: Power System Dynamics Stability and Control, BS Publications, 2nd edition, 2002		
Reference Books:		
1. IEEE TF report, "Proposed terms and definitions for power system stability," IEEE Trans. on Power Appart. and Syst.,, Vol. PAS-101, pp.1894-1897, July 1982. 2. IEEE/CIGRE Joint Task Force on Stability Terms and Definitions, "Definition and Classification of Power System Stability", IEEE Trans. on Power Syst., Vol. 19, No. 2, pp. 1387-1400, May 2004.		
Online Learning Resources:		
https://nptel.ac.in/courses/108106026		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	FACTS CONTROLLERS	L	T	P	C
25DPC8206		3	0	0	3
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand the basic types of FACTS devices.
CO2	Analyze voltage and current sourced converters.
CO3	Analyze the operation of shunt FACTS devices.
CO4	Analyze the operation of series FACTS devices
CO5	Understand the operation of different power types of flow controllers.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	basic types of FACTS devices.			L2
CO2	Analyse	voltage and current sourced converters			L3
CO3	Analyse	shunt FACTS devices.			L4
CO4	Analyse	series FACTS devices			L5
CO5	Understand	Different Power Flow Controllers			L6

UNIT - I	**CONCEPTS OF FLEXIBLE AC TRANSMISSIONSYSTEMS**	Lec Hrs: 10

Transmission line Interconnections, Power flow in parallel lines, Mesh systems, Stability considerations, Relative importance of controllable parameters, Basic types of FACTS controllers, Shunt controllers, Series controllers, Combined shunt and series controllers, Benefits of FACTS

UNIT - II	**VOLTAGE AND CURRENT SOURCED CONVERTER**	Lec Hrs: 9

Single Phase Full Wave Bridge Converter, Three Phase Full Wave Bridge Converter, Transformer Connections for 12-Pulse Operation, 24 and 48-Pulse Operation, Three Level Voltage Sourced Converter, Pulse Width Modulation (PWM) Converter, Converter Rating, Concept of Current Sourced Converters, Thyristor based converters, Current Sourced Converter with Turn off Devices, Comparison of Current Sourced and Voltage Sourced Converters.

UNIT - III	**STATIC SHUNT COMPENSATORS**	Lec Hrs: 9

Objectives of Shunt Compensation, Midpoint Voltage Regulation for Line Segmentation, End of Line VoltageSupporttoPreventVoltageInstability,ImprovementofTransientStability, Power Oscillation Damping, Methods of Controllable VAR Generation, Variable Impedance Type Static VAR Generators, Switching

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Converter Type VAR Generators, Hybrid VAR Generators, SVC and STATCOM, Transient Stability Enhancement and Power Oscillation Damping, Comparison Between STATCOM and SVC, V-I, V-Q Characteristics, Response Time.		
UNIT - IV	**STATIC SERIES COMPENSATORS**	Lec Hrs: 10
Objectives of Series Compensation, Voltage Stability, Improvement of Transient Stability, Power Oscillation Damping, Sub-synchronous Oscillation Damping, Variable Impedance Type Series Compensators, GTO Thyristor Controlled Type Series Capacitor (GCSC), Thyristor Switched Series Capacitor (TSSC), Thyristor-Controlled Series Capacitor(TCSC), Basic Operating Control Schemes for GCSC, TSSC, and TCSC, Switching Converter Type Series Compensators, The Static Synchronous Series Capacitor(SSSC),TransmittedPowerVersusTransmissionAngleCharacteristic, ControlRange and VA Rating Capability to Provide Real Power Compensation.		
UNIT - V	**POWER FLOW CONTROLLERS**	Lec Hrs: 10
The Unified Power Flow Controller-Basic Operating Principles, Conventional Transmission Control Capabilities, Independent Real and Reactive Power Flow Control. Control Structure, Basic Control System for P and Q Control, Dynamic Performance, the Interline Power Flow Controller(IPFC), Basic Operating Principles and Characteristics, Generalized and Multifunctional FACTS Controllers.		
Textbooks:		
1. UnderstandingFACTS– ConceptsandtechnologyofFlexibleACTransmissionsystems,NarainG. Hingorani, Laszlo Gyugyi, IEEE Press, WILEY, 1st Edition, 2000, Reprint 2015. 2. FACTSControllersinPowerTransmissionandDistribution,PadiyarK.R.,NewAgeInte rnational Publishers, 1st Edition, 2007.		
Reference Books:		
1. Flexible AC Transmission Systems: Modelling and Control, Xiao –Ping Zhang, Christian Rehtanz, Bikash Pal, Springer, 2012, First Indian Reprint, 2015. 2. FACTS–Modelling and Simulation in Power Networks, Enrigue Acha, Claudio R.Fuerte –Esquival, Huge Ambriz – perez, Cesar Angeles – Camacho, WILEY India Private Ltd., 2004, Reprint 2012		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	2	1	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	REACTIVE POWER COMPENSATION & MANAGEMENT (PE-III)	L	T	P	C
25DPE8207		3	0	0	3
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand load compensation and reactive power characteristics.
CO2	Apply reactive power compensation techniques in transmission systems.
CO3	Analyze reactive power coordination and demand side management.
CO4	Analyze distribution and user-side reactive power management methods.
CO5	Apply reactive power management plans for traction systems and arc furnaces.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO 1	Understand	Load Compensation And Reactive Power Characteristics.			L2
CO 2	Apply	Reactive Power Compensation Techniques In Transmission Systems.			L3
CO 3	Analyze	Reactive Power Coordination And Demand Side Management.			L4
CO 4	Analyze	Distribution And User-Side Reactive Power Management Methods.			L4
CO 5	Apply	Reactive Power Management Plans For Traction Systems And Arc Furnaces.			L3

UNIT - I	LOAD COMPENSATION	Lec Hrs: 10

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.

UNIT - II	STEADY STATE AND TRANSIENT STATE REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM	Lec Hrs: 9

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Uncompensated line – Types of compensation – Passive shunt and series and dynamic shunt compensation – Characteristic time periods – Passive shunt compensation – Static compensation - Series capacitor compensation – Compensation using synchronous condensers – Examples.		
UNIT - III	**REACTIVE POWER COORDINATION & DEMAND SIDE MANAGEMENT**	Lec Hrs: 9
Objective – Mathematical modeling – Operation planning – Transmission benefits – Basic concepts of quality of power supply – Disturbances - Steady – state variations – Effects of under Voltages – Frequency – Harmonics, radio frequency and electromagnetic interferences. Load patterns – Basic methods - load shaping – Power tariffs - KVAR based tariffs - penalties for voltage flickers and Harmonic voltage levels.		
UNIT - IV	**DISTRIBUTION & USER SIDE REACTIVE POWER MANAGEMENT**	Lec Hrs: 10
System losses – Loss reduction methods – Examples – Reactive power planning – Objectives – Economics - Planning capacitor placement – Retrofitting of capacitor banks - KVAR requirements for domestic appliances – Purpose of using capacitors – Selection of capacitors – Deciding factors – Types of capacitors, characteristics and Limitations		
UNIT - V	**REACTIVE POWER MANAGEMENT IN ELECTRIC TRACTION SYSTEM AND ARC FURNACES**	Lec Hrs: 10
Typical layout of traction systems – Reactive power control requirements – Distribution transformers - Electric arc furnaces – Furnaces transformer – Filter requirements – Remedial measures – Power factor of an arc furnace		
Textbooks:		
1. J.E.Miller, Reactive Power Control in Electric Power Systems, John Wiley and Sons, 1982 (Units I to IV). 2. D.M.Tagare, Reactive power Management, Tata McGraw Hill, 2004 (Units V toVIII).		
Reference Books:		
1. M.A.Pai, Power System Stability-Analysis by the direct method of Lyapunov, North HollandPublishing Company, New York, 1981.		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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POWER SYSTEMS (EEE)

Course Code	MODERN CONTROL THEORY (PE-III)	L	T	P	C
25DPE8208		3	0	0	3
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand state variable analysis and mathematical preliminaries.
CO2	Apply controllability and observability concepts.
CO3	Analyze state feedback control and observer design.
CO4	Analyze nonlinear system stability using describing functions.
CO5	Apply Lyapunov functions for stability analysis.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO 1	Understand	State Variable Analysis And Mathematical Preliminaries.			L2
CO 2	Apply	Controllability And Observability Concepts.			L3
CO 3	Analyze	State Feedback Control And Observer Design.			L4
CO 4	Analyze	Nonlinear System Stability Using Describing Functions.			L4
CO 5	Apply	Lyapunov Functions For Stability Analysis.			L3

UNIT - I	MATHEMATICAL PRELIMINARIES AND STATE VARIABLE ANALYSIS	Lec Hrs: 10

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

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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.		
UNIT - II	**CONTROLLABILITY AND OBSERVABILITY**	Lec Hrs: 9
General concept of controllability – Controllability tests, different state transformations such as diagnolization, 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.		
UNIT - III	**STATE FEEDBACK CONTROLLERS AND OBSERVERS**	Lec Hrs: 9
State feedback controller design through Pole Assignment, using Ackkermans formula– State observers: Full order and Reduced order observers.		
UNIT - IV	**NON-LINEAR SYSTEMS**	Lec Hrs: 10
Introduction – 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.		
UNIT - V	**STABILITY ANALYSIS**	Lec Hrs: 10
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.		
Textbooks:		
1. M. Gopal, Modern Control System Theory by – New Age International - 1984 2. Ogata. K, Modern Control Engineering by– Prentice Hall - 1997 3. N K Sinha, Control Systems– New Age International – 3 rd edition.		
Reference Books:		
1. Donald E. Kirk, Optimal Control Theory an Introduction, Prentice - Hall Network series - First edition.		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	EVOLUTIONARY ALGORITHMS APPLICATIONS IN POWER ENGINEERING (PE-III)	L	T	P	C
25DPE8209		3	0	0	3
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand optimization concepts and principles of multi objective optimization.
CO2	Understand multi-objective optimization techniques.
CO3	Apply evolutionary algorithms in NFL theorem.
CO4	Analyze evolutionary strategies and programming.
CO5	Analyze solutions using multi-objective evolutionary algorithms.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO 1	Understand	Optimization Concepts And Principle of multi objective optimization..			L2
CO 2	Understand	Multi-Objective Optimization Techniques.			L2
CO 3	Apply	Evolutionary Algorithms.			L3
CO 4	Analyze	Evolutionary Strategies And Programming.			L4
CO 5	Analyze	Solutions Using Multi-Objective Evolutionary Algorithms.			L4

UNIT - I	INTRODUCTION TO OPTIMIZATION	Lec Hrs: 10

Introduction to optimization – single and multi objective optimization – Evolutionary algorithms – principles of multi objective optimization.

UNIT - II	MULTI OBJECTIVE OPTIMIZATION	Lec Hrs: 9

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`Convex programming, Karush-Kuhn-Tucker conditions, Direct functional evaluation and derivative based optimization techniques		
UNIT - III	**EVOLUTIONARY ALGORITHMS**	Lec Hrs: 9
Simulated annealing, Tabu search; NFL theorem; Biological principles of evolution, General scheme of EAs, Representation, Selection schemes, Population evaluation, Variation operators; Constraint handling; Schema theorem; Binary coded genetic algorithm, Real coded genetic algorithm.		
UNIT - IV	**EVOLUTIONARY STRATEGIES AND EVOLUTIONARY PROGRAMMING**	Lec Hrs: 10
Evolutionary strategies, Evolutionary programming, genetic programming, Differential evolution, Particle swarm optimization		
UNIT - V	**APPLICATIONS OF MULTI-OBJECTIVE EVOLUTIONARY ALGORITHMS**	Lec Hrs: 10
Pareto-optimality, Multi-objective evolutionary algorithms; Statistical analysis of EC techniques; Customization in EAs; Applications of multi-objective evolutionary algorithms – Mechanical component design – Truss-structure design – Other applications.		
Textbooks:		
1. Back, T., Fogal, D. B. and Michalewicz, Z., "Handbook of Evolutionary Computation", Oxford University Press, 1997. 2. Clerc, M.,"Particle Swarm Optimization", ISTE, 2006. 3. Deb, K., "Multi-objective Optimization using Evolutionary Algorithms", Wiley, 2001.		
Reference Books:		
1. Fogel, D. B., "Evolutionary Computation, The Fossil Record", IEEE Press, 2003. 2. Goldberg, D., "Genetic Algorithms in Search, Optimization, and Machine Learning", Addison Wesley, 1989. 3. Price, K. , Storn, R. M. , and Lampinen, J. A. ,"Differential Evolution: A Practical Approach to Global Optimization", Springer, 2005. Read more articles		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	2	1	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	POWER QUALITY (PE-IV)	L	T	P	C
25DPE8210		3	0	0	3
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Analyze the Transient Voltages and Symptoms of poor power quality
CO2	Analyze performance of Flickers
CO3	Analyze the various Sag and Wave Form Distortions.
CO4	Understand the Power Quality Monitoring
CO5	Understand interruptions, Wave Form Distortion

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO 1	Analyze	Transient Voltages and Symptoms of poor power quality			L4
CO 2	Analyze	Flickers			L4
CO 3	Analyze	Sag and Wave Form Distortions			L4
CO 4	Understand	Power Quality Monitorin			L2
CO 5	Understand	Interruptions, Wave Form Distortion			L2

UNIT - I	INTRODUCTION	Lec Hrs: 10

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

UNIT - II	FLICKERS AND TRANSIENT VOLTAGES	Lec Hrs: 9

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

UNIT - III	**VOLTAGE SAG, SWELLS AND INTERRUPTIONS**	Lec Hrs: 9

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

UNIT - IV	**WAVEFORM DISTORTION**	Lec Hrs: 10

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

UNIT - V	**POWER QUALITY MONITORING**	Lec Hrs: 10

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

Textbooks:

1. M. H. J. Bollen (2000), Understanding Power Quality Problems, voltage sag and interruptions, 1st edition,IEEE Press, New Delhi.
2. Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H. Wayne Beaty (2008), Electrical Power SystemsQuality, 2 ndedition, Tata McGraw Hill Publications, New Delhi.

Reference Books:

1. J. Arrillaga, M. R. Watson, S. Chan (2007), Power system quality assessment, 1st edition, John Wiley and sons, New Delhi.

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	2	1	3
CO5	2	1	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	EV CHARGING INFRASTRUCTURE & TECHNOLOGY	L	T	P	C
25DPE8211	(PE-IV)	3	0	0	3
	Semester	II			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand EV charger classification, standards, and architectures.
CO2	Understand PFC converters and their working principles in EV chargers.
CO3	Apply DC-DC converters in EV chargers for efficient power conversion.
CO4	Analyze communication protocols and standards for EV charging systems.
CO5	Evaluate EMI/EMC considerations and design filters for EV chargers.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO 1	Understand	EV charger classification, standards, and architectures.			L2
CO 2	Understand	PFC converters and their working principles in EV chargers.			L2
CO 3	Apply	DC-DC converters in EV chargers for efficient power conversion.			L3
CO 4	Analyze	communication protocols and standards for EV charging systems.			L4
CO 5	Evaluate	EMI/EMC considerations and design filters for EV chargers.			L5

UNIT - I	CLASSIFICATION OF EV CHARGERS AND STANDARDS	Lec Hrs: 10

classification of chargers based on charging levels, modes, plug types; architecture and specifications of Bharat AC001 and DC001 chargers; standards related to: connectors, communication, supply equipment, EMI/EMC.

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UNIT - II	**PFC CONVERTERS**	Lec Hrs: 9
Role of front-end power-factor-correction (PFC) converters in EV chargers; types of AC-DC converters; working principles, modulation, design, and closed loop control of PFC converters s u c h a s : Boost type PFC, Totem-pole PFC, active front-end converter, three-phase PFCs; working principles, modulation, design, and closed loop control of singlestage AC-DC PFC converters; G2V, V2X modes of operation.		
UNIT - III	**DC-DC CONVERTERS IN EV CHARGERS**	Lec Hrs: 9
Types of DC-DC converter used for EV chargers; working principles, modulation, design, modelling and closed loop control of: dual active bridge (DAB), LLC converter, buck-boost converter; high frequency magnetics; soft-switching criteria.		
UNIT - IV	**PROTOCOLS AND COMMUNICATION**	Lec Hrs: 10
Open charge point protocol (OCPP); Open System Interconnection-Layer-Model (OSI); adapted PWM signal based low level communication; PLC based high level communication; CAN Communication; testing methodology for EV battery chargers and EVSE.		
UNIT - V	**EMI/EMC CONSIDERATIONS**	Lec Hrs: 10
sources of EMI in battery chargers; differential mode noise; common mode noise; LISN; measuring of EMI/EMC spectrum; design of DM filters and CM filters.		
Textbooks:		
1.Per Enge, Nick Enge and Stephen Zoepf , Electric Vehicle Engineering, Mc Graw Hill (2020). Roger. C. Dugan, Mark. F. McGranagham, Surya Santoso, H. Wayne Beaty (2008), Electrical Power SystemsQuality, 2.Iqbal Husain, Electric and Hybrid Vehicles: Design 18 Fundamentals, CRC Press (2021).		
Reference Books:		
1. Robert W. Erickson, and Dragan Maksimovic Fundamentals of Power Electronics, 3 rd E d ., Springer (2020). 2. Christoph Marscholik and Peter Subke, Road Vehicles - Diagnostic Communication, University Science Press (2009).		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	EHVAC TRANSMISSION	L	T	P	C
25DPE8212	(PE-IV)	3	0	0	3
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand EHV AC transmission systems, parameters, and electrostatic fields.
CO2	Understand voltage gradients, corona effects, and electromagnetic interference.
CO3	Apply concepts of traveling waves and electrostatic fields to EHV lines.
CO4	Analyze voltage control methods and reactive power compensation techniques.
CO5	Evaluate performance of EHV transmission systems, including corona effects and voltage control.

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO 1	Understand	EHV AC transmission systems, parameters, and electrostatic fields.			L2
CO 2	Understand	Voltage Gradients, Corona Effects, And Electromagnetic Interference.			L2
CO 3	Apply	Traveling waves and electrostatic fields to EHV lines.			L3
CO 4	Analyze	Voltage Control Methods And Reactive Power Compensation Techniques.			L4
CO 5	Evaluate	Performance of EHV transmission systems, including corona effects and voltage control.			L5

UNIT - I	**EHV AC Transmission Systems and Parameters**	Lec Hrs: 10

Preliminaries Necessity of EHV AC transmission – advantages and problems–power handling capacity and line losses- mechanical considerations — bundle conductor systems. Line inductance and capacitances – sequence inductances and capacitances – modes of propagation

UNIT - II	**ELECTROSTATIC FIELDS AND VOLTAGE GRADIENTS**	Lec Hrs: 9

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Voltage gradients of conductors Electrostatics – field of sphere gap – field of line changes and properties – charge – potential relations for multi-conductors – surface voltage gradient on conductors – distribution of voltage gradient on sub-conductors of bundle – Examples.		
UNIT - III	**CORONA EFFECTS AND INTERFERENCE**	Lec Hrs: 9
Corona Effects Corona in E.H.V. lines – Corona loss formulae- attention of traveling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits. Measurements of audio noise radio interference due to Corona - properties of radio noise – frequency spectrum of RI fields – Measurements of R and RIV.		
UNIT - IV	**ELECTROSTATIC FIELDS AND TRAVELING WAVES**	Lec Hrs: 10
Electro Static Field Electrostatic field: calculation of electrostatic field of EHV/AC lines – effect on humans, animals and plants – electrostatic induction in unenergised circuit of double-circuit line – electromagnetic interference-Examples. Traveling wave expression and solution- source of excitation-terminal conditionsopen circuited and short-circuited end- reflection and refraction coefficients-Lumped parameters of distributed lines-generalized constants-No load voltage conditions and charging current.		
UNIT - V	**VOLTAGE CONTROL AND REACTIVE POWER COMPENSATION**	Lec Hrs: 10
Voltage control Power circle diagram and its use – voltage control using synchronous condensers – cascade connection of shunt and series compensation – sub synchronous resonance in series capacitor – compensated lines – static VAR compensating system.		
Textbooks:		
1. R. D. Begamudre, ―EHVAC Transmission Engineering‖, New Age International (p) Ltd, 3rd Edition, 2006. 2. S.Rao, ―EHVAC and HVDC Transmission Engineering and Practice‖, Khanna Publishers, 2015(Reprint). Reference		
Reference Books:		
1. E Rakesh Das Begamudre, ―Extra High Voltage AC Transmission Engineering‖, Wiley Eastern LTD., New Delhi, 1987. 2. Edison,‖EHV Transmission line‖, Electric Institution - (GEC 1968).		

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	2	1	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	**RENEWABLE ENERGY SOURCES LAB**	**L**	**T**	**P**	**C**
25DPC8207		**0**	**0**	**4**	**2**
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand principles and characteristics of solar PV, wind, and hybrid power systems.
CO2	Understand the performance and efficiency of solar PV systems, including shadowing effects.
CO3	Apply simulation tools to design and analyze solar, wind, and hybrid power systems.
CO4	Analyze the performance of grid-connected, standalone, and hybrid power systems.
CO5	Evaluate the performance and efficiency of various renewable energy systems, including solar, wind, and fuel cells.

CO	**Action Verb**	**Knowledge Statement**	**Condition**	**Criteria**	**Blooms level**
CO1	Understand	characteristics of solar PV, wind, and hybrid power systems.			
CO2	Understand	performance and efficiency of solar PV systems, including shadowing effects.			
CO3	Apply	simulation tools to design and analyze solar, wind, and hybrid power systems.			
CO4	Analyze	performance of grid-connected, standalone, and hybrid power systems.			
CO5	Evaluate	performance and efficiency of various renewable energy systems, including solar, wind, and fuel cells.			

List of Experiments:

EXP NO	Experiment Name	CO

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1	Simulation study on Solar PV Energy System.	CO1
2	Experiment on "VI-Characteristics and Efficiency of 1kWp Solar PV System".	CO2
3	Experiment on "Shadowing effect & diode based solution in1kWp Solar PV system".	CO2
4	Experiment on Performance assessment of Grid connected and Standalone 1kWp Solar Power System.	CO3
5	Simulation study on Wind Energy Generator.	CO3
6	Experiment on Performance assessment of micro Wind Energy Generator.	CO3
7	Simulation study on Hybrid (Solar-Wind) Power System.	CO3
8	Experiment on Performance Assessment of Hybrid (Solar-Wind) Power System.	CO4
9	Simulation study on Hydel Power. Experiment on Performance Assessment of 100W Fuel.	CO5

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	2	1	3
CO3	3	2	3
CO4	3	2	3
CO5	3	2	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High

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Course Code	FACTS DEVICES SIMULATION LAB	L	T	P	C
25DPC8208		0	0	4	2
	Semester	**II**			

Course Outcomes (CO): Student will be able to

	CO Statements:
CO1	Understand the basic principles and operation of FACTS devices
CO2	Create simulation models using software tools to evaluate the effectiveness of FACTS controllers.
CO3	Analyze the performance of FACTS devices in power systems
CO4	Analyze the impact of FACTS devices on power system stability and reliability
CO5	Analyze and simulate FACTS devices for power system applications

CO	Action Verb	Knowledge Statement	Condition	Criteria	Blooms level
CO1	Understand	basic principles and operation of FACTS devices			L2
CO2	Apply	simulation models using software tools	to evaluate the effectiveness of FACTS controllers.		L3
CO3	Analyze	Performance of FACTS devices in power systems			L4
CO4	Analyze	Impact of FACTS devices on power system stability and reliability			L4
CO5	Analyze	FACTS devices for power system applications			L4

List of Experiments:

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EXP NO	Experiment Name	CO
1	Simulation of SVC (Static Var Compensator) for Voltage Regulation	CO1
2	Simulation of STATCOM (Static Synchronous Compensator) for Power Factor Correction	CO1
3	Simulation of TCSC (Thyristor-Controlled Series Capacitor) for Power Flow Control	CO1
4	Simulation of UPFC (Unified Power Flow Controller) for Power System Stability Enhancement	CO2
5	Design and Simulation of a FACTS Controller for Power System Damping	CO3
6	Simulation of IPFC (Interline Power Flow Controller) for Power Flow Control	CO4
7	Simulation of SSSC (Static Synchronous Series Compensator) for Power System Stability Enhancement	CO4
8	Hardware Implementation of a FACTS Controller	CO5

Mapping of course outcomes with program outcomes

CO/PO	PO1	PO2	PO3
CO1	2	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	3	3

(Levels of Correlation, viz., 1.Low, 2.Moderate, 3.High