(Autonomous Institute VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute Affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction, Evaluation and Course Contents)

For
Two-Year Postgraduate Program

Leading to Master of Technology

(M. Tech.) Degree in

Electrical Engineering with specialization in
Integrated Power Systems (IPS)

Implemented from the batch admitted in the
Academic Year 2025-26

Program Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems in Integrated Power Systems.

PO2: An ability to write and present a substantial technical report/document in the area of Integrated Power Systems

PO3: Students should be able to demonstrate a degree of mastery, higher than the requirements in the bachelor program in the area of Integrated Power Systems.

CREDIT STRUCTURE

SEM I - IV			
Abbr.	**Description**	**No of Courses**	**Credits**
PSMC	Program Specific Math Course	1	1*3=3
PCC	Program Core Course	2*3+2*4	14
PSC	Program Specific Course	2*3+2*4	14
MLC	Mandatory Learning Course	2 (1 non-credit)	1*3=3
LC	Laboratory Course	6	6*1=6
IOC	Interdisciplinary Open Course	2	2*3=6
LLC	Liberal Learning Course	2	2*1=2
SLC	Self-Learning Course	2	2*1=2
SBC	Skill-Based Course	4	10+12=22
Total		**27**	**72**

No. of Credits (semester-wise)					
	SEM I	**SEM II**	**SEM III**	**SEM IV**	**Total**
PSMC	3	-	-	-	3
PCC	7	7	-	-	14
PSC	7	7	-	-	14
MLC	-	3	-	-	3
LC	3	3	-	-	6
IOC	3	3	-	-	6
LLC	1	1	-	-	2
SLC	-	-	2	-	2
SBC	-	-	10	12	22
Total	**24**	**24**	**12**	**12**	**72**

SEMESTER I

Scheme of Instruction				Scheme of Evaluation				
Sr. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**TA**	**MST**	**ESE**	**ESE hours**
1 (PSMC-1)	EEIPS5001S	Computational Methods	3-0-0	3	20	30	50	3
2 (PCC-1)	EEIPS5011T	Linear Control Theory: Analysis and Design	3-0-0	3	20	30	50	3
3 (PCC-2)	EEIPS5012T	Modelling and Analysis of Integrated Power Systems	3-1-0	4	20	30	50	3
4 (PSC-1)	EEIPS5021S/ EEIPS5022S	Program Elective I	3-1-0	4	20	30	50	3
5 (PSC-2)	EEIPS5031T/ EEIPS5032T	Program Elective II	3-0-0	3	20	30	50	3
6 (IOC-1)		Open Elective I	3-0-0	3	20	30	50	3
7 (LC-1)	EEIPS5011P	Linear Control Theory: Analysis and Design Lab	0-0-2	1	60 CIE		40	-
8 (LC-2)	EEIPS5012P	MAIPS Lab	0-0-2	1	60 CIE		40	-
9 (LC-3)	EEIPS5031P/ EEIPS5032P	High-Voltage Engineering Lab/ Modeling of Machines Lab	0-0-2	1	60 CIE		40	-
10 (LLC-1)		Liberal Learning	0-0-2	1	100% CIE			-
Total			**28**	**24**				

Abbreviations:

- **L** : Lecture
- **T** : Tutorial
- **P** : Practical
- **TA** : Teacher Assessment / Term Work Assessment
- **MST** : Mid Semester Test
- **ESE** : End Semester Written Examination
- **CIE** : Continuous In-semester Evaluation

SEMESTER II

Scheme of Instruction					Scheme of Evaluation			
Sr. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	**TA**	**MST**	**ESE**	**ESE hours**
1 (MLC-1)	EEIPS5002S	Research Methodology & IPR	3-0-0	3	20	30	50	3
2 (PCC-3)	EEIPS5013S	Wide Area Monitoring For Power System Protection	3-0-0	3	20	30	50	3
3 (PCC-4)	EEIPS5014T	Dynamics And Control of Integrated Power Systems	3-1-0	4	20	30	50	3
4 (PSC-3)	EEIPS5041S/ EEIPS5042S	Program Elective III	3-1-0	4	20	30	50	3
5 (PSC-4)	EEIPS5051T/ EEIPS5052T	Program Elective IV	3-0-0	3	20	30	50	3
6 (IOC-2)		Open Elective II	3-0-0	3	20	30	50	3
7 (LC-4)	EEIPS5014P	DCIPS Lab	0-0-2	1	60% CIE		40	-
8 (LC-5)	EEIPS5051P/ EEIPS5052P	Machine Learning Applications to Power Systems Lab/ High Performance Drives Lab	0-0-2	1	60% CIE		40	-
9 (LC-6)	EEIPS5076L	Technical Writing and Seminar	0-0-2	1	60% CIE		40	-
10 (LLC-2)		Liberal Learning	0-0-2	1	100% CIE			-
			28	**24**				

Abbreviations:

L	:	Lecture
T	:	Tutorial
P	:	Practical
TA	:	Teacher Assessment / Term work Assessment
MST	:	Mid Semester Test
ESE	:	End Semester Written Examination
CIE	:	Continuous In-semester Evaluation

List of Program Elective I

Sr. No.	Course Code	Course Title
T1.1	EEIPS5021S	Economic Operation of Power Systems
T2.1	EEIPS5022S	Cyber-Physical Systems

List of Program Elective II

Sr. No.	Course Code	Course Name
T3.1	EEIPS5031T	High Voltage Engineering
T4.1	EEIPS5032T	Modeling of Machines

List of Program Elective III

Sr. No.	Course Code	Course Title
T1.2	EEIPS5041S	Restructured Power Systems
T2.2	EEIPS5042S	Electric Vehicles: Dynamics and Architectures

List of Program Elective IV

Sr. No.	Course Code	Course Name
T3.2	EEIPS5051T	Machine Learning Applications to Power Systems
T4.2	EEIPS5052T	High Performance Electric Drives

List of Open Elective I

Sr. No.	Course Code	Course Title
1		
2.		

List of Open Elective II

Sr. No.	Course Code	Course Title
1		
2.		

List of Liberal Learning Course

Sr. No.	Course Code	Course Title
1		
2.		

SEMESTER III

Scheme of Instruction					Scheme of Evaluation
Sr. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	
1 (SBC-1)	EEIPS5091D	Skill Based Course (Project Stage -I)	---	5	100% CIE
2 (SBC-2)	EEIPS5092D	Skill Based Course (Project Stage -II)	---	5	100% CIE
3 (SLC-1)	EEIPS5101S	Self-Learning Course - 1	1-0-0	1	100% ESE of 3 hours or credit transfer
4 (SBC-2)	EEIPS5201S	Self-Learning Course - 2	1-0-0	1	100% ESE of 3 hours or credit transfer
5 (MLC-2)	EEIPS5301S	Mandatory Non-Credit Course	2-0-0	0	100% ESE of 3 hours or credit transfer
				12	

SEMESTER IV

Scheme of Instruction					Scheme of Evaluation
Sr. No	**Course Code**	**Course Title**	**L-T-P**	**Credits**	
1 (SBC-3)	EEIPS5093D	Skill Based Course (Project Stage -III)	---	5	100% CIE
2 (SBC-4)	EEIPS5094D	Skill Based Course (Project Stage -IV)	---	7	100% CIE
				12	

Abbreviations:

L : Lecture
T : Tutorial
P : Practical
CIE : Continuous In-semester Evaluation

SEMESTER I

<table>
<tr><td></td><td>M. TECH. IN
ELECTRICAL ENGINEERING
with specialization in
INTEGRATED POWER SYSTEMS (IPS)</td><td>FIRST YEAR
SEM - I</td></tr>
</table>

<table>
<tr><td rowspan="3">COURSE CODE</td><td rowspan="3">[EEIPS5001S]
(PSMC-1)</td><td colspan="5">CREDITS ASSIGNED</td></tr>
<tr><td>THEORY</td><td>TUTORIAL</td><td>LAB</td><td>TOTAL HRS</td><td>TOTAL CREDITS</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">COMPUTATIONAL METHODS (CM)</td><td colspan="5">EVALUATION SCHEME</td></tr>
<tr><td>TA</td><td>MST</td><td>ESE</td><td colspan="2">TOTAL MARKS</td></tr>
<tr><td>20</td><td>30</td><td>50</td><td colspan="2">100</td></tr>
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Prerequisite: Undergraduate Engineering Mathematics, Basic integrals and ODEs, Matrix operations, Maxima and minima of a function, Solution to algebraic linear and nonlinear equations and ODEs

Course Outcomes:

CO1:	Analyze linear algebra concepts and apply them to engineering problem-solving.
CO2:	Analyze and implement unconstrained and constrained optimization methods, for both linear and nonlinear objectives
CO3:	Apply fundamental principles of probability theory to model and analyze uncertain events
CO4:	Develop and analyze time series models and apply them for effective forecasting of temporal data in practical applications.

Course Contents

Module 1: Linear Algebra

Scalars, Vectors, Vector spaces, Subspaces, Span, Linear Independence, Basis and Dimension, Matrices and Linear transformations, Rank and Determinant, Eigenvalues and Eigenvectors, Singular Value Decomposition, Inner product spaces and Orthogonality, Gram-Schmidth Orthonormalization

Module 2: Optimization

Unconstrained optimization: gradient descent, steepest descent, line search methods, conjugate gradient methods

Constrained optimization: Linear programming- equality constraints, Lagrange multiplier, inequality constraints, KKT conditions. Primal-dual dynamics, Solving using simplex method, interior-point method

Module 3: Probability Theory

Probability: Introduction, Probability axioms, Random variables, Jointly Distributed Random variables, Conditional probabilities & Expectations, Bayes theorem, Stirling's approximation

Discrete Distributions: Binomial, Poisson

Continuous Distributions: Normal, t-distribution, Central Limit theorem
Module 4: Time Series Analysis Introduction and Basics, Autoregressive processes, Moving average processes, Mixed processes, Forecasting
Books Recommended: (1) Gilbert Strang, *Introduction to Linear Algebra*, Wellesley Cambridge press, 6th ed., 2023. (2) Jorge Nocedal, Stephen J. Wright, *Numerical Optimization*, 2nd Ed., Springer Science 2006. (3) Michael J Panik, *Statistical Inference,* Wiley Publications, 2012. (4) K Hoffman & R Kunze, *Linear Algebra*, PHI, 1971 (5) A. Papoulis, *Probability, Random Variables & Stochastic Processes,* 3rd edition, McGraw Hill, 1991. (6) Gebhard Kirchgässner & Jürgen Wolters, *Introduction to Modern Time Series Analysis,* Springer, 2008 (7) S C Gupta, V K Kapoor, *Fundamentals of Mathematical Statistics*. S. Chand & Sons, January 2014

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)				**FIRST YEAR SEM - I**	
COURSE CODE	**[EEIPS5011T] (PCC-1)**	**CREDITS ASSIGNED**				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
		3	**0**	**0**	**3**	**3**
COURSE TITLE	**LINEAR CONTROL THEORY: ANALYSIS AND DESIGN (LCTAD)**	**EVALUATION SCHEME**				
		TA	**MST**	**ESE**	**TOTAL MARKS**	
		20	**30**	**50**	**100**	

Pre-requisites: Feedback systems, Transfer function modelling, Block diagram algebra, Stability concepts (Routh-Hurwitz, root-locus, frequency response), Laplace transforms, Review of basic stability, Steady-state and transient response of second order system to various inputs, steady state error, Root-locus method, Bode method, State Space Modelling

Course Outcomes:

CO1:	Design controllers using PID, Lead/Lag, state feedback, and observers.
CO2:	Evaluate the observability of linear time-invariant systems.
CO3:	Analyze the controllability and stabilizability of linear time-invariant systems.
CO4:	Apply robust and optimal control techniques like H-infinity and LQR.

Course Contents

Module 1: Compensator Design

Need for compensator, Lead/Lag compensator design using Root locus technique, Full state feedback control design, PID controller design, Observer design, Internal Model Control.

Module 2: Controllability and State Feedback

Controllable and reachable subspaces, Controllable systems, Controllable decompositions, stabilizability

Module 3: Observability and Output Feedback

Observability, Output feedback, minimal realizations, Linearization principles for observability, Observers and Detectability

Module 4: Advanced Topics in Control

Robust Control: System uncertainties, robust stability, small gain theorem, Sensitivity and Complementary sensitivity function, H-infinity control, Loop shaping.

Optimal Control: Formulation of optimal control problem, Linear Quadratic Regulator (LQR), Riccati equations for control design

Books Recommended:

(1) Norman S. Nise, *Control System Engineering*, 8th Edition, John Wiley & Sons Inc, 2019
(2) Morari and Zafiriou, *Robust Process Control*, Prentice Hall, Englewood Cliffs, New Jersey
(3) Kemin Zhou, *Essentials of Robust and Optimal Control*, Prentice Hall, 1998
(4) Jo˜ao P. Hespanha, *Linear Systems Theory,* PowerEn, 2010.
(5) Graham C. Goodwin, Stefan F. Graebe, and Mario E. Salgado, *Control System Design*, Prentice Hall, 2001
(6) Dale E. Seborg, Thomas F. Edgar, Duncan A. Mellichamp, and Francis J. Doyle, *Process Dynamics and Control*, 4th edition, Wiley, 2017

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)						FIRST YEAR SEM - I
COURSE CODE	**[EEIPS5012T] (PCC-2)**	**CREDITS ASSIGNED**					
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**	
		3	**1**	**0**	**4**	**4**	
COURSE TITLE	**MODELLING AND ANALYSIS OF INTEGRATED POWER SYSTEMS (MAIPS)**	**EVALUATION SCHEME**					
		TA	**MST**	**ESE**	**TOTAL MARKS**		
		20	**30**	**50**	**100**		

Pre-requisites: Primitive and network matrices, Zbus and Ybus building algorithms, Modeling of Generators, transmission lines, and transformers using equivalent circuit models, Symmetrical and Unsymmetrical fault analysis, Working principles of generators, inverters, and their control in grid-connected or standalone modes, Operation of solar PV and wind energy systems, interfacing with the grid

Course Outcomes:

CO1:	Analyze and evaluate traditional and integrated power systems, and perform load flow analysis using deterministic and probabilistic methods.
CO2:	Explain the concept, structure, operation modes, and control strategies of microgrids with inverter-based distributed generation.
CO3:	Model and analyze the dynamics of microgrids under different operation modes.
CO4:	Analyze the structure and control of microgrids as a system of systems (SoS)

Course Contents

Module 1: Introduction to Integrated Power Systems

Overview of power systems, Review of formation of Ybus, Zbus, Load flow analysis using iterative methods, Concept of integrated Power systems, Renewable power generation, Issues in renewable energy integration. Distribution system Load Flow methods, Vector based load flow method, Backward-Forward Sweep method and Current injection method, Introduction to Probabilistic Load Flow Methods

Module 2: Microgrids: Concept, Structure and Operation Modes

Microgrids - Concept and structure, Operation modes, Control mechanism of connected distributed generators in microgrid- control of inverter based distributed generators, control structure in grid connected mode, control structure in islanded mode, Microgrid control strategies: Centralized, decentralized, hierarchical control.

Module 3: Microgrid Dynamics and Modeling

Distribution network (main grid) and connection modeling, Overall Representation of the Grid-Connected Microgrid, Microgrid Components Dynamics and Modeling, Simplified Microgrid Frequency Response Model, A Detailed State-Space Dynamic Mode, Microgrid Dynamic Modeling and Analysis as a Multivariable System

Module 4: Microgrid as a System of Systems (SoS)

SoS structure, framework, Control hierarchy, Grid synchronization in Distributed generation units, Control methods for SoS- Hierarchical, Consensus, Decentralized, Networked DC microgrid control: DC Microgrid for a Residential Area, Low-voltage Bipolar-type DC Microgrid. Stability evaluation, Voltage control approach.

Books Recommended:

(1) J. Duncan Glover et al., *Power System Analysis and Design*, Cengage Learning, 5^{th} ed, 2011.
(2) Hadi Sadat, *Power System Analysis*, McGraw Hill – International Edition – 2019
(3) James Momoh, *Smart Grid: Fundamentals of Design and Analysis*, Wiley-IEEE Press, 2012.
(4) B. M. Weedy, B. J. Cory, N. Jenkins, G. Strbac, M. Ekanayake, *Electric Power Systems*, Wiley, 2012.
(5) W. H. Kersting, *Distribution System Modeling and Analysis*, 4^{th} ed, CRC Press, 2017.
(6) Hassan Bevrani, Bruno François, Toshifumi Ise, *Microgrid Dynamics and Control*, Wiley, 1^{st} Ed., 2017
(7) Peng Zhang, *Networked Microgrids*, Cambridge University Press, 1^{st} Ed., 2021
(8) Magdi S. Mahmoud, Fouad M. AL-Sunni, *Control and Optimization of Distributed Generation Systems*, Springer Nature, 2015.
(9) Magdi S. Mahmoud, *Microgrid: Advanced Control Methods and Renewable Energy System Integration*, Elsevier, 2017.

Program Elective-I

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)					FIRST YEAR SEM - I
COURSE CODE	**[EEIPS5021S] (PSC-1)**	**CREDITS ASSIGNED**				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
		3	**1**	**0**	**4**	**4**
COURSE TITLE	**ECONOMIC OPERATION OF POWER SYSTEMS (EOPS)**	**EVALUATION SCHEME**				
		TA	**MST**	**ESE**	**TOTAL MARKS**	
		20	**30**	**50**	**100**	

Pre-requisites: Operating characteristics of thermal and hydro power plants, optimization techniques, load flow analysis, control systems, Models of generator, load, prime-mover, governor, tie-line

Course Outcomes:

CO1:	Apply optimization techniques for Economic Dispatch (ED) and hydro-thermal scheduling
CO2:	Analyze and solve Optimal Power Flow (OPF) and Unit Commitment (UC) problems
CO3:	Model and analyze Load Frequency Control and Automatic Generation Control systems
CO4:	Formulate and solve ED, UC, and OPF problems under uncertainty using probabilistic and stochastic approaches

Course Contents

Module 1: Economic Dispatch of Thermal and Hydro Units

Economic dispatch (ED) problem and methods of solutions, Optimization methods used in Economic Dispatch. Characteristics of steam units, ED of Thermal Units and methods of solutions – with and without considering transmission losses.

Multi-area Economic Dispatch: Economy of Multi-area interconnection- solving using Nonlinear convex Network Flow programming, Wheeling, Total transfer capability computation in multi areas

Hydro-thermal Coordination – Hydroelectric plant models – short term hydro thermal scheduling problem – gradient approach – Hydro units in series – pumped storage hydro plants – hydro- scheduling using Dynamic programming and linear programming.

Module 2: Optimal Power Flow and Unit Commitment

Optimal Power Flow- Introduction-Solution of OPF –gradient method, Newton's method- Linear Sensitivity analysis -linear programming method- Security Constrained OPF- Interior Point OPF- Bus Incremental Costs.

Unit Commitment – Definition – Constraints in Unit Commitment – Unit Commitment solution methods – Priority – List Methods – Dynamic Programming Solution, Lagrange Relaxation method

Module 3: Power Generation Control

Generator control- P-f and Q-V controllers-interactions, Single area control, Requirements of Control strategy, Load frequency Control of two-area system (uncontrolled and controlled case), Load frequency and Economic Dispatch controls, Design of AGC control using Kalman method, Tie-line bias control and PID controllers in AGC

Module 4: Uncertainty Analysis in Power Systems

Economic Dispatch with uncertainties, Unit Commitment with uncertainties, Probabilistic OPF

Books Recommended:

(1) Allen J. Wood and Bruce. F. Wollenberg, *Power Generation Operation and Control*, John Wiley & Sons, 2nd edition, New York, 2016.
(2) Jizhong Zhu, *Optimization of Power system Operation*, 2nd edition, Wiley publications, 2015
(3) Alireza Soroudi, *Power system Optimization modelling in GAMS*, Springer 2017.
(4) Robert H. Miller, James H. Malinowski, *Power System Operation*, Tata McGraw Hill, 2009.

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)	FIRST YEAR SEM - I

COURSE CODE	**[EEIPS5022S] (PSC-1)**	**CREDITS ASSIGNED**				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
		3	**1**	**0**	**4**	**4**
COURSE TITLE	**CYBER-PHYSICAL SYSTEMS (CPS)**	**EVALUATION SCHEME**				
		TA	**MST**	**ESE**	**TOTAL MARKS**	
		20	**30**	**50**	**100**	

Pre-requisites: Probability and Statistics, Computer Networks and Communication Protocols, Machine Learning Fundamentals, Embedded Systems / Real-Time Systems (Introductory Level)

Course Outcomes:

CO1:	Understand the fundamentals of CPS, including system classification, decision-making, and communication networks.
CO2:	Explain the layered architecture of CPS and analyze the role of network protocols
CO3:	Apply Machine learning and Decentralized technologies and evaluate their potential in future communication paradigms.
CO4:	Apply CPS concepts to real-world systems like smart grids, healthcare, and traffic management.

Course Contents

Module 1: Introduction to Cyber Physical systems (CPS)

Classification of systems, uncertainty and Probability theory, Mathematical Information and Communication, CAN bus, Network types, Processes on networks and applications, From Big data to Mathematical abstractions, Forms of decision making, Game theory, Optimization, Rule-based decisions.

Module 2: Layers of CPS

Three layers of CPS, Dynamics of CPS Data Networks and Wireless Communications, Network Layers and Their Protocols, Network: Edge and Core, IoT, Machine-Type Communications, and 5G.

Module 3: ICT Technologies

Machine Learning: Data, Model, and Loss Function, Formalizing and Solving a ML Problem, ML Methods, Decentralized Computing and Distributed Ledger Technology, Federated Learning and Decentralized Machine Learning, Blockchain and Distributed Ledger Technology Future Technologies: A Look at the Unknown Future, Quantum Internet

Module 4: Applications

Power grid, public health surveillance system, Real-time Traffic Routing

Books Recommended:

(1) Pedro H. J. Nardelli, *Cyber-Physical Systems: Theory, Methodology and Applications*, Wiley, 2022.
(2) Walid M. Taha, et-al, *Cyber-Physical Systems: A Model-Based Approach*, Springer, 2021
(3) Rajkumar, de Niz & Klein, *Cyber-Physical Systems*, Pearson, 2017

Program Elective -II

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)	FIRST YEAR SEM - I

COURSE CODE	[EEIPS5031T] (PSC-2)	CREDITS ASSIGNED				
		THEORY	TUTORIAL	LAB	TOTAL HRS	TOTAL CREDITS
		3	0	0	3	3
COURSE TITLE	HIGH VOLTAGE ENGINEERING (HVE)	EVALUATION SCHEME				
		TA	MST	ESE	TOTAL MARKS	
		20	30	50	100	

Pre-requisites: Revision of various laws of electromagnetics, The impact of various electrode shapes and electric field line distribution, The role of frequency on insulating material and their properties, Basics of AC/DC systems and magnetic circuits, Transformer and machine modelling fundamentals.

Course Outcomes:

CO1:	Analyze breakdown mechanisms in gases, liquids, and solid insulators under various field conditions.
CO2:	Describe high voltage generation methods and analyze measurement techniques for high voltages and currents.
CO3:	Analyze partial discharge phenomena, detection methods, and evaluate insulation performance and fault diagnosis techniques in high voltage cables and equipment.
CO4:	Develop 2D finite element models for electromagnetic components in high voltage systems.

Course Contents

Module 1: Breakdown Of Gases, Liquids, Solid Insulators

Introduction to solid, liquid and gaseous insulators, Ageing of insulation materials. Breakdown of gaseous dielectric- The Townsend's theory, Streamer theory of breakdown, The Paschen's law, Schumann's formula, Breakdown of air/ SF6 under uniform field at NTP. Breakdown under extremely non-uniform fields.
Various types of insulating liquids, filtration and purification of oil. Breakdown of oil. Breakdown of solids. Breakdown under Vacuum condition.

Module 2: Generation of High Voltage, Measurement of High Voltage and High Currents

Cascaded transformer, resonance transformer, Cockroft Walton circuit, Impulse voltage generator
Precautions in measurements, Role of CT PT in measurement of High Voltage and High Current. Resistance voltage divider, Capacitance voltage divider, Shunts, Rogowskii coil. Sources of errors in HV measurements, Compensations used in dividers. Measurement of Impulse waveforms.

Module 3: Partial Discharge and High Voltage Cables

Partial discharge, Causes, Effects. Measurement Methods of PD, Testing for partial discharge in transformers, Generators, and insulators. Importance of impedance matching

PD detectors and their principle of working. Insulating materials for cables, Essential properties required for insulating materials, Faults in underground cables, and testing in cables.

Module 4: Introduction to Finite Element Methods

Methods based on Finite Differences and Integral Formulations, the Finite Element Method, 2D - Finite element modeling of single-phase transformer, Solenoid, Inductor, Capacitors, wire wound Resistor & Toroid

Books Recommended:

(1) M. S. Naidu and V. Kamaraju, *High Voltage Engineering*, Tata McGraw-Hill Education, 2004.
(2) C. L. Wadhwa, *High Voltage Engineering*, 3rd edition, New Age Publication, 2012.

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)	**FIRST YEAR SEM - I**

		CREDITS ASSIGNED				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
COURSE CODE	**[EEIPS5032T] (PSC-2)**	**3**	**0**	**0**	**3**	**3**

		EVALUATION SCHEME			
		TA	**MST**	**ESE**	**TOTAL MARKS**
COURSE TITLE	**MODELING OF MACHINES (MoM)**	**20**	**30**	**50**	**100**

Pre-requisites: Electrical Machines (DC, induction, synchronous), Electromechanical Energy Conversion and Dynamics, Modeling of Electromechanical Systems, State-Space Analysis and Control Basics, Torque–Speed Characteristics of Machines, Basics of Special Electric Machines (PM motors, SRM, BLDC, PMSM).

Course Outcomes:

CO1:	Develop mathematical models of electrical machines by analyzing electromagnetic and mechanical subsystems
CO2:	Model and analyze DC machines using equivalent circuits, state-space representations, and transfer function methods for predicting steady-state and dynamic performance.
CO3:	Develop and implement mathematical models of AC machines, applying space-phasor techniques to analyze and simulate their steady-state and transient behaviour.
CO4:	Evaluate and design modeling and control strategies for special electrical machines, with practical applications in high-performance electric drives and electric vehicles.

Course Contents

Module 1: Fundamentals of Modeling

Need for modeling, Problems of modeling, Neglected phenomena, Power of Electrical sources, Electromotive force, Voltage balance equation, Leakage flux, Energy of the coupling field, Power of electromechanical conversion, torque expression, mechanical subsystem, model of mechanical subsystem, Equations of Mathematical model.

Module 2: DC Machine Modeling

Theory of operation, induced EMF, equivalent circuit, electromagnetic torque production, electromechanical and state-space modeling, transfer function representation and block diagrams, field excitation effects, and modeling of Permanent Magnet Brushless DC (PMBLDC) motors.

Module 3: AC Machine Modeling

Induction machines: principle of operation, equivalent circuit, steady-state and dynamic modeling, space-phasor model, stator and rotor voltage and flux linkage equations, dq0 transformation, and control principles. Synchronous machines with permanent magnets (PMSM): dynamic modeling, voltage, and flux linkage equations, sub-transient and transient reactances, and torque expressions

Module 4: Special Machines

Square wave and sine wave permanent magnet motors: modeling and control techniques. Switched reluctance motors (SRM): voltage and torque equations, inductance modeling, and control strategies. Applications in high-performance electric drives and electric vehicles.

Books Recommended:

(1) S. Vukosavic, *Electrical Machines*, Springer, Reprinted 2018.
(2) R. Krishnan, *Electric Motor Drives: Modeling, Analysis, and Control*, Pearson, 2017.
(3) P. C. Krause, O. Wasynczuk, S. D. Sudhoff, A. K. Pekarek, *Analysis of Electric Machinery and Drive Systems*, 3rd edition, Wiley, 2022.
(4) P. Kundur, *Power System Stability and Control*, Mc Graw Hill, 2006

Laboratory Courses

<table>
<tr><td rowspan="1"></td><td colspan="5">M. TECH. IN
ELECTRICAL ENGINEERING
with specialization in
INTEGRATED POWER SYSTEMS (IPS)</td><td colspan="2">FIRST YEAR
SEM - I</td></tr>
<tr><td rowspan="3">COURSE CODE</td><td rowspan="3">[EEIPS5011P]
(LC-1)</td><td colspan="6">CREDITS ASSIGNED</td></tr>
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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">LINEAR CONTROL THEORY: ANALYSIS AND DESIGN LAB (LCTADL)</td><td colspan="6">EVALUATION SCHEME</td></tr>
<tr><td colspan="2">CIE</td><td>ESE</td><td colspan="3">TOTAL MARKS</td></tr>
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</table>

Prerequisite: Fundamentals of Control Systems, Root Locus Method, Feedback Controller Design, State-Space Concepts, Basic MATLAB/Simulink Skills (if using simulation tools)

Lab Outcomes:

LO1:	Design and analyze classical and modern control systems by applying root locus, PID, and state-space techniques to meet desired time-domain and frequency-domain specifications.
LO2:	Develop and analyze state-space-based controllers and observers-including LQR, Luenberger observer, internal model control, and output feedback-to achieve robust control and state estimation.

List of Experiments

(1) Transform a system to controllable canonical form and analyze decompositions.

(2) Design an output feedback controller (e.g., observer-based feedback).

(3) Cascade lead compensator and cascade lag compensator design using Root locus.

(4) To obtain values of the proportional, integral and derivative gains of a PID controller so as to meet the desired specifications

(5) Design a full state feedback controller using pole placement so as to meet desired specifications

(6) Design a Luenberger observer for a given state-space model.

(7) Implement internal model-based controller for set-point tracking and disturbance rejection.

(8) Design a controller using loop-shaping principles and evaluate performance.

(9) Design a Linear Quadratic Regulator for a system and simulate its response.

(10) Hardware experiments based on the syllabus

<table>
<tr><td></td><td colspan="3">M. TECH. IN
ELECTRICAL ENGINEERING
with specialization in
INTEGRATED POWER SYSTEMS (IPS)</td><td colspan="3">FIRST YEAR
SEM - I</td></tr>
<tr><td rowspan="3">COURSE CODE</td><td rowspan="3">[EEIPS5012P]
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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">MODELLING AND ANALYSIS OF INTEGRATED POWER SYSTEMS LAB (MAIPSL)</td><td colspan="5">EVALUATION SCHEME</td></tr>
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</table>

Prerequisite: Power System Analysis using any software- DIgSILENT, ETAP, MATLAB

Lab Outcomes:

LO1:	Analyze and evaluate voltage profile and load flow characteristics of conventional and integrated power systems using MATLAB and professional simulation tools.
LO2:	Model and simulate advanced power electronic interfaces such as three-stage Solid-State Transformers and grid-connected inverters for microgrid applications.

List of Experiments

(1) Voltage profile control of power system (using MATLAB and / or professional software)

(2) Load flow of power system

(3) Forward backward load flow

(4) Load flow of integrated power system using software

(5) Modeling of 3-stage SST for microgrid

(6) Modeling grid connected inverter

<table>
<tr><td></td><td colspan="2">M. TECH. IN
ELECTRICAL ENGINEERING
with specialization in
INTEGRATED POWER SYSTEMS (IPS)</td><td colspan="4">FIRST YEAR
SEM - I</td></tr>
<tr><td rowspan="3">COURSE CODE</td><td rowspan="3">[EEIPS5031P]
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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">HIGH VOLTAGE ENGINEERING LAB (HVEL)</td><td colspan="5">EVALUATION SCHEME</td></tr>
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<tr><td colspan="2">60</td><td>40</td><td colspan="2">100</td></tr>
</table>

Prerequisite: Understanding Breakdown Mechanism for Solid, Liquid, and Gaseous Insulators, Partial Discharge Test and Significance, Safety Measures in Testing of High Voltage

Lab Outcomes:

LO1:	Demonstrate an understanding of high voltage testing standards, procedures, and equipment through hands-on evaluation of type tests, routine tests, partial discharge tests, and insulation breakdown tests on electrical components and safety gear.
LO2:	Apply knowledge of high voltage generation methods, earthing systems, and laboratory safety protocols to conduct and analyze safe and effective testing of CTs, PTs, generator coils, and insulating materials under various operating conditions.

List of Experiments

(1) Study of different standards used for testing.

(2) Introduction to type tests and routine test, Destructive tests

(3) Study of various equipment used for testing.

(4) Understanding difference between breakdown mechanism for solid liquid and gaseous insulators.

(5) Partial discharge test and significance.

(6) Testing of CT and PT

(7) Testing of various samples like safety shoes, hand gloves, generator coils

(8) Performance of oil breakdown test

(9) Study of earthing system and requirement in high voltage lab

(10) Various methods of generation of high Voltage and high current

(11) Safety measures in testing of high voltage

<table>
<tr><td rowspan="1"></td><td colspan="5">M. TECH. IN
ELECTRICAL ENGINEERING
with specialization in
INTEGRATED POWER SYSTEMS (IPS)</td><td colspan="2">FIRST YEAR
SEM - I</td></tr>
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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">MODELLING OF MACHINES LAB (MoML)</td><td colspan="6">EVALUATION SCHEME</td></tr>
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<tr><td colspan="2">60</td><td>40</td><td colspan="3">100</td></tr>
</table>

Prerequisite: Modeling of Electromechanical Systems, Electromechanical Energy Conversion and Dynamics, Working principles of DC, induction, and synchronous machines, Torque-speed characteristics

Lab Outcomes:

LO1:	Develop and analyze dynamic models of electrical machines using transformation techniques and data-driven approaches to evaluate machine behavior under varying operating conditions.
LO2:	Design, simulate, and validate advanced control strategies and fault detection mechanisms for electrical machines using real-time simulation tools and signal analysis techniques.

List of Experiments

(1) Dynamic modeling of DC Machines

(2) d-q Axis modeling of Synchronous Machines

(3) Induction machine modeling using Space Vector Theory

(4) Field-Oriented Control (FOC) of Induction Machines

(5) Use offline tests (no-load, blocked rotor) to estimate parameters of IM and synchronous machines.

(6) Use real-time simulators (like dSPACE/OPAL-RT) to test control strategies on modelled machines.

(7) Any other hardware/simulation experiment

SEMESTER II

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)					FIRST YEAR SEM - II
COURSE CODE	**[EEIPS5002S] (MLC-1)**	**CREDITS ASSIGNED**				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
		3	**0**	**0**	**3**	**3**
COURSE TITLE	**RESEARCH METHODOLOGY & IPR (RM&I)**	**EVALUATION SCHEME**				
		TA	**MST**	**ESE**	**TOTAL MARKS**	
		20	**30**	**50**	**100**	

Pre-requisites: Basics of probability, Probability Axioms, Conditional Probability and Marginal Probability, Mean, median, mode, variance, standard deviation, Familiarity with technical report writing or seminar presentations

Course Outcomes:

CO1:	Apply descriptive and inferential statistical methods to summarize and draw valid conclusions from data
CO2:	Prepare, clean, and analyze datasets using correlation, regression, and multivariate techniques.
CO3:	Design and communicate a complete research study
CO4:	Understand Intellectual Property Rights and Patent processes.

Course Contents

Module 1: Core Statistical Methods: From Description to Inference

Descriptive Statistics - Mean, Median, Mode, Range, Variance, Standard Deviation, Skewness, Kurtosis

Data visualization: Histograms, Boxplots, Bar charts

Sampling- Sampling techniques (random, stratified, etc.), sampling error, sample size estimation

Inferential Statistics - Hypothesis Testing (z-test, t-test, ANOVA, chi-square), Confidence Intervals, Type I and Type II errors

Module 2: Data Preparation and Advanced Analysis

Data Processing and Cleaning- Handling missing data, outliers, Data transformation and standardization

Correlation and Regression- Pearson and Spearman correlation, Simple and Multiple Linear Regression

Multivariate Techniques- Overview of PCA, Factor Analysis, and Cluster Analysis

Module 3: Research Design and Reporting

Formulating a research problem, conceptualizing a research design, data collection, selecting a sample, writing a research proposal, processing and displaying data, writing a research report

Module 4: IPR and Patents

Intellectual Property – The concept of IPR, IPR development process, Trade secrets, utility models, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

Books Recommended:

(1) Ranjit Kumar, *Research Methodology: A Step-by-Step Guide for Beginners,* Sage Publications, 2024.
(2) Michael J Panik, *Statistical Inference,* Wiley Publications, 2012
(3) Siva Vaidhyanathan, *Intellectual Property: A Very Short Introduction*, Oxford Publications, 2017
(4) Sheldon M. Ross, *Introductory Statistics*, 3rd edition, Academic Press, 2010
(5) A. Papoulis, *Probability, Random Variables & Stochastic Processes,* 3rd edition, McGraw Hill, 1991

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)	**FIRST YEAR SEM - II**

<table>
<tr><td rowspan="3">COURSE CODE</td><td rowspan="3">[EEIPS5013S] (PCC-3)</td><td colspan="5">CREDITS ASSIGNED</td></tr>
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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">WIDE AREA MONITORING FOR POWER SYSTEM PROTECTION (WAMPSP)</td><td colspan="5">EVALUATION SCHEME</td></tr>
<tr><td>TA</td><td>MST</td><td>ESE</td><td colspan="2">TOTAL MARKS</td></tr>
<tr><td>20</td><td>30</td><td>50</td><td colspan="2">100</td></tr>
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Pre-requisites: Sequence components, CTs and PTs, CT saturation and burden, Bias errors in CVTs, IEEE/IEC standards, types of protection of Transmission Line, transformer, generator and bus bar, adaptive relaying and relay coordination, A/D converters

Course Outcomes:

CO1:	Understand the architecture of digital relaying systems and utilize signal processing techniques for analyzing and interpreting power system signals in protection applications.
CO2:	Analyze and compute synchro-phasor measurements using estimation algorithms in both steady-state and dynamic power system conditions.
CO3:	Design and evaluate Wide Area Monitoring Systems (WAMS) architecture and communication protocols, and apply PMU data for state estimation
CO4:	Develop protection schemes using WAMS data

Course Contents

Module 1: Introduction to Computer Relaying

Computer relay architecture, Anti-aliasing filters, Substation computer hierarchy
Fourier series, Fourier transforms, Discrete Fourier transforms, Hilbert transforms, Random processes-filtering, Digital filters- windows and windowing
Transmission line relaying- Design and Implementation of Overcurrent, Pilot and Distance Protection - Relaying as parameter estimation-Algorithms

Module 2: Synchro phasors and PMUs

Synchro phasors- frequency, rate-of-change of frequency (ROCOF), Steady state and dynamic conditions in Power systems, Importance of the model: Classical phasor vs Dynamic phasor, Methods to calculate Synchro phasors based on steady-state and dynamic model, evaluation of frequency and ROCOF, Least-squares and Least-mean squares method for phasor estimation, IEEE Synchro phasor Standards C37.118.1, C37.118.2, Communication protocol-IEC 61850.

PMUs- architecture, P- type and M- type PMUs, Data Acquisition systems, Synchronization sources, Communication and Data Collector, Distributed PMU

Module 3: Wide Area Monitoring Systems

WAMS- definition, SCADA and Communication protocols, data resource, communication systems, architectures, applications, preprocessing synchronized PMU data

State Estimation (SE)- formulation of the SE problem, SE measurement model, SE classification, applications, Role and impact of PMU in SE- PMU based transmission system SE, False data injection attacks and countermeasures for WAMS

Module 4: Wide Area Monitoring Schemes for Protection

WAMS- protection and control, Adaptive Protection schemes, System Integrity Protection Schemes (SIPS), PMU assisted fault detection and localization, Wide area Differential Protection, Controlled Islanding

Books Recommended

(1) Arun G. Phadke and James S. Thorp, *Synchronized Phasor Measurements and their Applications*. Springer 2nd edition, 1 February 2017
(2) Arun G. Phadke and James S. Thorp, *Computer Relaying for Power Systems*, Wiley Publication 2nd edition, 2012
(3) Mladen Kezunovic, Jinfeng Ren, Saeed Lotfifard, *Design, Modeling and Evaluation of Protective Relays for Power Systems*, Springer, 2016.
(4) Duncan, Overbye & Sarma, *Power System Analysis & Design*, 6th edition, Cengage Learning, 2017.
(5) https://link.springer.com/article/10.1007/s40565-016-0211-x
(6) Monti, Muscas, Ponci, *PMUs and Wide Area Monitoring Systems*, 2016 Elsevier.
(7) Waldemar Rebizant, Janusz Szafran, Andrzej Wiszniewski, *DSP in Power system Protection and Control*, Springer, 2011
(8) https://ietresearch.onlinelibrary.wiley.com/doi/epdf/10.1049/iet-rpg.2018.5175

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<tr><td rowspan="1"></td><td colspan="5">M. TECH. IN
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with specialization in
INTEGRATED POWER SYSTEMS (IPS)</td><td colspan="2">FIRST YEAR
SEM - II</td></tr>
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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">DYNAMICS AND CONTROL OF INTEGRATED POWER SYSTEMS (DCIPS)</td><td colspan="6">EVALUATION SCHEME</td></tr>
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<tr><td>20</td><td>30</td><td>50</td><td colspan="3">100</td></tr>
</table>

Pre-requisites: Power system analysis, Electrical machines and Power electronics

Course Outcomes:

CO1:	Develop dynamic model of integrated power system components.
CO2:	Evaluate small-signal stability and analyze performance of integrated power system.
CO3:	Analyze large multi-machine system stability and propose suitable methods to enhance system stability under disturbances.
CO4:	Develop and analyze voltage and frequency control schemes in microgrids using inverter control techniques and power-sharing strategies.

Course Contents

Module 1: Introduction to Power System Stability

Power system operation and control, Stability problems faced by power systems, Impact on power system operation control, Concept of equilibrium, small and large Disturbance in stability

Dynamic Modeling of power system components:
Introduction: Classification and definitions of various stabilities defined in power system operation, Synchronous generator dynamic model, Multimachine dynamic modelling, Effect of machine model used, Modelling of microgrid components (Solid State transformer, i.e. SST), Power system network modelling, Load modelling and its impact.

Module 2: Small Signal Stability of Integrated Power System

Dynamic Modeling: State-space representation and Stability of a dynamic system, Linearization, Eigen properties of the state matrix, Model shape and sensitivity and participation factor, The concept of the complex frequency, Relationship between Eigen properties and transfer functions, Small-signal stability of a single machine infinite bus system (SMIB), Small signal stability of Multimachine system with renewable integrated components

Module 3: Transient Stability Analysis of Integrated Power System

Elementary view of transient stability: Equal area criteria, Simulation of power system dynamic response, Case study of transient stability of a large system

Multi-machine Large System Stability: Reference Frame theory for multimachine stability, Various dynamical models used for stability, Initial Conditions, Differential-Algebraic Model, Methods of improving stability

Module 4: Grid Connected Inverters

Dynamic model, operation, Control of voltage source inverter- design of inner and outer controllers/ PLL, PQ or PV control, V/f control.
Power sharing methods- P-w and Q-V droops, V-I droop

Books Recommended:

(1) P. Kundur, *Power System Stability and Control*, McGraw-Hill, 2022.
(2) P. Sauer and M. A. Pai, *Power System Dynamics and Control*, Prentice Hall, 2008.
(3) S.R. Wagh, *Power System Transient Stability Enhancement*, Lambert academic publishing,1st edition, 2013.
(4) Lingling Fan, *Control and Dynamics in Power Systems and Microgrids*, CRC Press, Taylor & Francis, 2017.
(5) Magdi S. Mahmoud, *Microgrid: Advanced Control Methods and Renewable Energy System Integration*, Elsevier, 2017

Program Elective -III

<table>
<tr><td rowspan="1"></td><td colspan="3">M. TECH. IN
ELECTRICAL ENGINEERING
with specialization in
INTEGRATED POWER SYSTEMS (IPS)</td><td colspan="3">FIRST YEAR
SEM - II</td></tr>
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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">RESTRUCTURED POWER SYSTEMS (RPS)</td><td colspan="5">EVALUATION SCHEME</td></tr>
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Pre-requisites: Basics of Power Systems and Power System Operation, Fundamentals of Electrical Engineering Economics, Understanding of Load Flow Analysis and Power System Stability, Basic knowledge of Market Mechanisms and Economics

Course Outcomes:

CO1:	Describe core economic principles and apply them to analyze energy markets and structures.
CO2:	Analyze the structure, operation of energy markets, and study various pricing mechanisms
CO3:	Analyze congestion management strategies and ancillary service mechanisms in deregulated power systems
CO4:	Analyze the structure and operation of electricity markets through global case studies

Course Contents

Module 1: Fundamentals of Economics and Energy Trading

Introduction, Reasons for restructuring / deregulation of power industry, Fundamentals of Economics, Restructuring Models, Role of Independent system Operator (ISO), Role of Power Exchange (PX), Essence of energy trading and framework, derivative instruments of trading, portfolio management, trading hubs, brokers in trading, green power trading.

Module 2: Energy Markets and Pricing Mechanisms

Market operations, Market power, Day-Ahead and Real-time markets -Information disclosure, Security Constrained Economic Dispatch and Security Constrained Unit commitment
Types of Energy markets- spot, forward, future, options, Classification of Energy markets based on functions, Market equilibrium and market clearing price, Calculation of Market clearing price from a stepped bid model/quadratic model, Spot market pricing mechanisms- uniform pricing, zonal pricing, Location Marginal Price (LMP), Calculation of LMP using DC load flow.

Module 3: Congestion and Ancillary Services Management

Roles of TRANSCOs, Power wheeling, Transmission Open Access, Cost components in Transmission, TTC, ATC, Pricing of Power transaction, Security management in deregulated environments, Congestion management
Classification of ancillary services, frequency regulation services, reserve service market, reactive power as ancillary service

Module 4: Case Studies

Case studies of energy markets worldwide, PJM market, Indian Scenario, Electricity Act 2003, Operation of Indian Power Exchange studies

Books Recommended:

(1) Mohammad Shahidehpour & Muwaffaq Alomoush, *Restructured Electrical Power systems: Operation, Trading and Volatility*, Marcel Dekker Inc, 2001.
(2) Mohammad Shahidehpour, H Yamin and Li, *Market operations in Electric Power Systems*, Wiley IEEE press, 2002.
(3) Daniel Kirschen, Goran Stbrac, *Fundamentals of Power System Economics*, John Wiley & Sons, 2004.
(4) Jin Zhong, *Power system Economic and Market Operations*, CRC Press, 2018.
(5) K Bhattacharya et-al, *Operation of Restructured Power Systems*, Springer, 2001.
(6) L. L. Lai, *Power System Restructuring and Regulation*, John Wiley Sons, 2001.

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)					FIRST YEAR SEM - II
COURSE CODE	**[EEIPS5042S] (PSC-3)**	**CREDITS ASSIGNED**				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
		3	**1**	**0**	**4**	**4**
COURSE TITLE	**ELECTRIC VEHICLES: DYNAMICS AND ARCHITECTURES (EVDA)**	**EVALUATION SCHEME**				
		TA	**MST**	**ESE**	**TOTAL MARKS**	
		20	**30**	**50**	**100**	

Pre-requisites: Electrical Machines, Control Systems, Power Electronics, Basics of Communication Protocols	
Course Outcomes:	
CO1:	Explain the architecture, types, and evolution of electric vehicles.
CO2:	Model the dynamic behavior of electric vehicles and apply design considerations for auxiliary systems
CO3:	Understand various motor controller strategies used in EVs.
CO4:	Design and evaluate Electric vehicle support systems.

Course Contents

Module 1: Introduction and Types of Electric Vehicles- EV architecture

Importance of EVs, History, EVs and the environment, IC Engine/ Electric Hybrid Vehicle, Fueled EVs, EVs using Supply Lines, EVs which use Flywheels or Supercapacitors, Solar-Powered Vehicles, Vehicles using Linear Motors, EVs for the Future

Module 2: Electric Vehicle Modeling and Design considerations

Tractive Effort, Modelling vehicle Acceleration, Modelling Vehicle range, Aerodynamic and rolling resistance considerations, Design of ancillary systems

Module 3: Electric Machines and Controllers

Brushed DC motor, DC regulation and Voltage conversion, Brushless motors, Motor cooling, efficiency, size and mass, Electric Machines for Hybrid vehicles

Module 4: EV Infrastructure, Auxiliaries and Battery Management Systems (BMS)

Battery Swapping and Charging, CAN Bus – protocol, and requirements, ABS, Power Steering, Regenerative braking systems.
BMS-Introduction, Battery modeling, functions of BMS, monitoring and safety, Cell-balancing

Books Recommended:

(1) Mehrdad Ehsani, *Modern Electric*, *Hybrid Electric & Fuel Cell Vehicles*, CRC Press, 2018.
(2) C.C Chan and K. T. Chau, *Modern Electric Vehicle Technology*, Oxford Press, 2001.
(3) Larminie and Lowry, *Electric Vehicle Technology Explained*, Wiley, 2012.

Program Elective -IV

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)					FIRST YEAR SEM - II
COURSE CODE	**[EEIPS5051T] (PSC-4)**	**CREDITS ASSIGNED**				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
		3	**0**	**0**	**3**	**3**
COURSE TITLE	**MACHINE LEARNING APPLICATIONS TO POWER SYSTEMS (MLAPS)**	**EVALUATION SCHEME**				
		TA	**MST**	**ESE**	**TOTAL MARKS**	
		20	**30**	**50**	**100**	

Pre-requisites: Fundamentals of power systems, Basics of renewable energy systems, Introduction to Artificial Intelligence and Machine Learning concepts, Awareness of smart grid architecture and digital technologies, Concepts of regression, classification, and time series analysis, Knowledge of data preprocessing techniques, Hands-on experience with Python/MATLAB and ML libraries

Course Outcomes:

CO1:	Use basic Machine learning and Optimization methods to solve problems and understand their applications in power systems
CO2:	Apply ML/DL techniques for load forecasting and data clustering in power systems
CO3:	Develop AI/ML-based models for grid stability and equipment health monitoring
CO4:	Investigate a particular real-world example

Course Contents

Module 1: Foundations of Machine Learning and Deep Learning for Power System Applications

Linear models for regression- Linear basis function models, Bias- Variance decomposition, Least-squares, Ridge and Lasso regression, Logistic regression

Linear models for Classification- Discriminant functions, Support vector machines.

Optimization for Machine Learning: Types of Optimization problems, First order vs Second order methods, Loss functions, Gradient-based optimization algorithms, regularization techniques

Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) in Power Systems, Review of ML/DL Applications in Power System Planning, Operation, and Control, ML Application & Challenges in Power Systems

Module 2: ML/DL Techniques for Load Forecasting and Clustering

Time Series Analysis for Short & Long-term Generation and Load Forecasting, Feature Selection, Data Preprocessing, Clustering Techniques (e.g., k-Means, DBSCAN) in Power Systems, Applications of Clustering: Load Profiling, Customer Segmentation, Event

Detection, Case Studies and Tools (Python, MATLAB, TensorFlow, etc.)

Module 3: ML/DL in Grid Stability and Equipment Health Monitoring

Voltage Stability Assessment Using ML-Based Models (e.g., ANN, SVM, Decision Trees, Ensemble Methods), Voltage Collapse Prediction, Early Warning Systems
Health Monitoring of Electrical Equipment: Transformers, Rotating Machines, Cables, etc.
Fault Detection and Diagnosis, Predictive Maintenance using DL models, Smart Sensors, Data Acquisition, and Real-time Monitoring Applications.

Module 4: Case Studies on any of the following:

LSTM-Assisted Heating Energy Demand Management in Residential Buildings, Wind Speed Forecasting Using Innovative Regression Applications of Machine Learning Techniques, Prediction of Out-of-Step Condition for Synchronous Generators Using Decision Tree Based on the Dynamic Data by WAMS/PMU, Machine Learning Approaches in a Real Power System and Power Markets, Any other relevant application

Books Recommended:

(1) Morteza Nazari-Heris et-al, *Application of Machine Learning and Deep Learning Methods to Power System Problems*, Springer 2022
(2) Stephen Haben et-al, *Core Concepts and Methods in Load Forecasting*, Springer 203
(3) Zbigniew Leonowicz et-al, *Machine Learning and Data Mining Applications in Power Systems*, MDPI, 2022

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)	**FIRST YEAR SEM - II**

COURSE CODE	**[EEIPS5052T] (PSC-4)**	**CREDITS ASSIGNED**				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
		3	**0**	**0**	**3**	**3**
COURSE TITLE	**HIGH PERFORMANCE ELECTRIC DRIVES (HPED)**	**EVALUATION SCHEME**				
		TA	**MST**	**ESE**	**TOTAL MARKS**	
		20	**30**	**50**	**100**	

Pre-requisites: Fundamentals of Electrical Machines covering DC, induction, and synchronous machines; Power Electronics including converters, inverters, and switching devices; Control Systems focusing on feedback control and PID controllers; and essential concepts of Signal Processing and Circuit Analysis relevant to drive system modeling and analysis.

Course Outcomes:

CO1:	Design and analyze DC motor drives using phase-controlled converters and chopper-based control strategies for steady-state and dynamic performance
CO2:	Evaluate and compare induction motor drives employing voltage control, slip energy recovery, and frequency control methods, focusing on efficiency and torque-speed characteristics
CO3:	Describe principles of Vector Control
CO4:	Apply and implement vector control techniques for motors to achieve high-performance operation in Industrial and Electric Vehicle applications

Course Contents

Module 1: DC Motor Drives

Speed control of DC motors using phase-controlled converters; steady-state analysis of three-phase converter-fed DC motor drives; design of controllers for performance improvement; operation and analysis of four-quadrant chopper-controlled DC motor drives; torque-speed characteristics and efficiency evaluation.

Module 2: AC Motor Drives

Phase-controlled induction motor drives: stator voltage control and slip energy recovery schemes; steady-state and dynamic performance analysis. Frequency-controlled induction motor drives: static frequency changers, voltage source inverter (VSI) fed drives, and current source inverter (CSI) fed drives; derivation of voltage and torque equations; efficiency and power factor considerations.

Module 3: Direct Control Principles

Vector control of induction motor drives: principles, direct vector control, and indirect vector control methods; speed controller design and dynamic performance analysis.

Module 4: Vector Control Strategies

Vector control strategies for permanent magnet synchronous motors (PMSM) and brushless DC (BLDC) motors; flux weakening operation, speed controller design, and sensor less control techniques. Applications in high-performance industrial drives and electric vehicles.

Books Recommended:

(1) G.K. Dubey, *Fundamentals of Electrical Drives*, 2nd Edition, Narosa (CRC Press), 2002
(2) G.K. Dubey, *Power Semiconductor Controlled Drives*, 2nd Reprint, New Age International Publishers, 2017
(3) R. Krishnan, *Electric Motor Drives: Modeling, Analysis and Control*, International Edition, Prentice Hall, 2001.
(4) Bimal K. Bose, *Modern Power Electronics and AC Drives*, Prentice Hall, 2001
(5) Mukhtar Ahmad, *High-Performance AC Drives: Modelling, Analysis and Control*, Springer, 2012.
(6) Austin Hughes & Bill Drury, *Electric Motors and Drives: Fundamentals, Types and Applications*, 5th Edition, Newnes, 2019.

Laboratory Courses

	M. TECH. IN ELECTRICAL ENGINEERING with specialization in INTEGRATED POWER SYSTEMS (IPS)					FIRST YEAR SEM - II
COURSE CODE	**[EEIPS5014P] (LC-4)**	**CREDITS ASSIGNED**				
		THEORY	**TUTORIAL**	**LAB**	**TOTAL HRS**	**TOTAL CREDITS**
		0	**0**	**2**	**2**	**1**
COURSE TITLE	**DYNAMICS AND CONTROL OF INTEGRATED POWER SYSTEMS LAB (DCIPSL)**	**EVALUATION SCHEME**				
		CIE		**ESE**	**TOTAL MARKS**	
		60		**40**	**100**	

Pre-requisites: Stability analysis using any software

Course Outcomes:

LO1:	Analyze and simulate frequency and voltage stability in power systems using dynamic models
LO2:	Design and evaluate inverter control strategies for microgrid applications

List of Experiments

(1) Simulation of Frequency Deviation in a Power System Using Swing Equation

(2) Small Signal Stability Analysis of SMIB System

(3) Inter-area Oscillation Study in a Two-Area System

(4) Equal Area Criterion for Transient Stability Assessment

(5) Lyapunov-based Stability Check

(6) Design and Simulation of Inner and Outer Control Loops of Voltage Source Inverter

(7) Droop Control Implementation for Power Sharing in Islanded Microgrid

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SEM - II</td></tr>
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<tr><td rowspan="3">COURSE CODE</td><td rowspan="3">[EEIPS5051P]
(LC-5)</td><td colspan="5">CREDITS ASSIGNED</td></tr>
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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">MACHINE LEARNING APPLICATIONS TO POWER SYSTEMS LAB (MLAPSL)</td><td colspan="5">EVALUATION SCHEME</td></tr>
<tr><td colspan="2">CIE</td><td>ESE</td><td colspan="2">TOTAL MARKS</td></tr>
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Pre-requisites: Fundamentals of Power Systems, Basics of Machine Learning and Deep Learning, Programming Knowledge (Python (NumPy, Pandas, Scikit-learn), MATLAB, familiarity with TensorFlow/Keras)

Course Outcomes:

LO1:	Apply machine learning and deep learning techniques for solving practical power system problems such as load forecasting, voltage stability, and equipment health monitoring.
LO2:	Develop and validate ML/DL models using tools like Python, MATLAB, and TensorFlow to perform clustering, fault detection, and predictive maintenance in smart grid environments.

List of Experiments

(1) Exploratory Data Analysis on Power System Dataset

(2) Short-Term Load Forecasting using ML Models

(3) Deep Learning for Long-Term Load Forecasting

(4) Load Profile Clustering using k-Means and DBSCAN

(5) Feature Engineering and Data Preprocessing for ML Applications

(6) Voltage Stability Prediction using ML Classifiers

(7) Fault Detection in Power Cables using Time-Domain Signals

(8) Predictive Maintenance for Transformers using DL Models

(9) Real-Time Monitoring with Smart Sensors and Data Acquisition

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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">HIGH PERFORMANCE DRIVES LAB
(HPEDL)</td><td colspan="6">EVALUATION SCHEME</td></tr>
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Pre-requisites: Fundamentals of Electrical Machines, Power, Control Systems, Basic Signal Processing and Circuit Analysis- simulation tools using MATLAB

Lab Outcomes:

LO1:	Demonstrate various braking techniques (rheostatic, plugging, regenerative) for both DC and AC motors through hands-on experiments and interpret their impact on motor performance
LO2:	Simulate and analyze speed control and inverter-fed operations of different electric machines (DC, stepper, BLDC, and induction motors) using MATLAB/Simulink or equivalent tools.

List of Experiments

(1) To perform rheostatic braking on three phase Induction Motor.

(2) To perform rheostatic braking on D.C. Motor.

(3) To perform plugging on three phase Induction Motor.

(4) To perform plugging on D.C. Motor

(5) To perform regenerative braking on three phase Induction Motor.

(6) To simulate the performance & control of a Stepper motor.

(7) To simulate speed control of separately excited DC motor.

(8) To simulate closed loop speed control of BLDC motor.

(9) To simulate two-level and three-level inverter with sinusoidal PWM.

(10) To simulate VSI fed Induction motor (square wave and PWM inverters).

(11) To simulate induction motor with open loop constant V/F control.

(12) To simulate induction motor with indirect vector control.

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<tr><td rowspan="3">COURSE TITLE</td><td rowspan="3">TECHNICAL WRITING AND SEMINAR
(TWS)</td><td colspan="5">EVALUATION SCHEME</td></tr>
<tr><td colspan="2">CIE</td><td>ESE</td><td colspan="2">TOTAL MARKS</td></tr>
<tr><td colspan="2">60</td><td>40</td><td colspan="2">100</td></tr>
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Pre-requisites: Basic Academic Writing Skills, Literature Review and Research Skills, Presentation and Communication Skills

Lab Outcomes:

LO1:	Demonstrate the ability to write clear, concise, and well-structured technical documents and effectively use standard components and citation styles while adhering to ethical practices in writing and avoiding plagiarism
LO2:	Plan, prepare, and deliver effective technical presentations and seminars using appropriate visual aids and communication techniques to engage and inform an audience

Course Contents

Module 1: Introduction to Technical Writing

Definition and purpose of technical writing, Characteristics of good technical writing, Common types of technical documents (research article, project reports, conference papers). Grammar, punctuation, and sentence structure, Active vs. passive voice, Clarity, conciseness, coherence

Module 2: Report Structuring and Ethics in Writing

Abstract, Introduction, Methodology, Results, Discussion, Conclusion, References, IEEE/APA citation styles, Plagiarism, and how to avoid it

Module 3: Presentation and Seminar Skills

Planning and organizing presentations, Use of visual aids (PowerPoint, charts, videos), Voice modulation, body language, and audience engagement
Literature review and selection of seminar topic, Preparation of seminar report (8–10 pages), Delivery of seminar presentation, Q&A session, and feedback

Recommended Texts and References:

(1) Kumar, Sanjay & Pushp Lata, *Communication Skills*, Oxford University Press,2011
(2) Quirk & Randolph, *A University Grammar of English*, Pearson,2006
(3) Rutherford, Andrea J., *Basic Communication Skills for Technology*, Pearson, 2007
(4) Rizvi, M Ashraf, *Effective Technical Communication*, McGraw-Hill, 2009
(5) IEEE/ACM digital libraries for accessing sample papers