K.K. Wagh Institute of Engineering Education and Research, Nashik

Department of Electrical Engineering

F.Y. M. Tech.

Electrical (Power System) Engineering

Curriculum

Pattern: 2024

W.e.f. A.Y.: 2024-25

K.K. Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

Details of Course Structure: M. Tech Electrical (Power Systems)
Semester– I F.Y. M. Tech

Course Code	Course Type	Title of Course	Teaching Scheme Hrs./week			Assessment Scheme and Marks								Credits			
			TH	TU	PR	In Sem	End Sem	CCE	TU	TW	PR	OR	Total	TH	TU	PR	Total
2406501	PCC	Computer Aided Power System Analysis	3	1	--	20	60	20	25	--	--	--	125	3	1	--	**4**
2406502	PCC	Power System Dynamics	3	1	--	20	60	20	25	--	--	--	125	3	1	--	**4**
2406503	PCC	Power Electronics Converters	4	--	--	20	60	20	--	--	--	--	100	4	--	--	**4**
2406504	PEC	Elective I A: Renewable Energy System B: Energy Storage System C: Power Sector Economics and Management	4	--	--	20	60	20	--	--	--	--	100	4	--	--	**4**
2406505	HSSM	Research Methodology and Intellectual Property Rights	3	--	--	20	60	20	--	--	--	--	100	3	--	--	**3**
2406506	PCC	Power System Lab-I	--	--	6	--	--	--	--	50	--	50	100	--	--	3	**3**
		Total	**17**	**2**	**6**	**100**	**300**	**100**	**50**	**50**	**--**	**50**	**650**	**17**	**2**	**3**	**22**

TH- Theory PR- Practical TU – Tutorial CCE – Continuous Comprehensive Evaluation TW - Term Work OR- Oral

NEP 2024 – Details of Course Structure (AY 2024 - 2025)
Semester – II F.Y. M. Tech Electrical (Power Systems)

Course Code	Course Type	Title of Course	Teaching Scheme Hrs./week			Assessment Scheme and Marks								Credits			
			TH	TU	PR	In Sem	End Sem	CCE	TU	TW	PR	OR	Total	TH	TU	PR	Total
2406511	PCC	Digital Power System Protection	3	--	--	20	60	20	--	--	--	--	100	3	--	--	**3**
2406512	PCC	Applications of Power Electronics in Power System	3	1	--	20	60	20	25	--	--	--	125	3	1	--	**4**
2406513	PCC	Power Quality Assessment and Mitigation	3	1	--	20	60	20	25	--	--	--	125	3	1	--	**4**
2406514	PEC	Elective-II A: Controllers for Electric Vehicle B: Power System Planning and Reliability C: Microgrid Operation and Control	3	--	--	20	60	20	--	--	--	--	100	3	--	--	**3**
2406515	PCC	Power System Lab-II	--	--	6	--	--	--	--	50	--	50	100	--	--	3	**3**
2406516	AEC	Seminar I	--	--	6	--	--	--	--	50	--	50	100	--	--	3	**3**
2406517	VSEC	Software in Electrical Engineering	--	--	4	--	--	--	--	50	--	--	50	--	--	2	**2**
		Total	**12**	**2**	**16**	**80**	**240**	**80**	**50**	**150**	**--**	**100**	**700**	**12**	**2**	**8**	**22**

K.K. Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

NEP 2024 – Details of Course Structure (AY 2024 - 2025)
Semester – III S.Y. M. Tech Electrical (Power Systems)

Course Code	Course Type	Title of Course	Teaching Scheme Hrs./week			Assessment Scheme and Marks								Credits			
			TH	TU	PR	In Sem	End Sem	CCE	TU	TW	PR	OR	Total	TH	TU	PR	Total
2406601	PEC	Elective III A: Smart Grid B: AI, and ML Applications C: EHV AC Transmission	3	--	--	20	60	20	--	--	--	--	100	3	--	--	**3**
2406602	VEC	Introduction to Constitution	2	--	--	--	30	20	--	--	--	--	50*****	2	--	--	**2**
2406603	PROJ	Dissertation Phase-I	--	--	20	--	--	--	--	100	--	100	200	--	--	10	**10**
2406604	OJT	Internship	--	--	10	--	--	--	--	100	--	100	200	--	--	5	**5**
		Total	**5**	**--**	**30**	**20**	**90**	**40**	**--**	**200**	**--**	**200**	**550**	**5**	**--**	**15**	**20**

*****Assessment/evaluation shall be done for 100 marks which must be converted to 50 marks as per structure.

Seminar S4 is on Industry Internship. This includes post-internship evaluation with report submission. The industry internship is for a minimum of 4 weeks.

NEP 2024 – Details of Course Structure (AY 2024 - 2025)
Semester – IV S.Y. M. Tech Electrical (Power Systems)

Course Code	Course Type	Title of Course	Teaching Scheme Hrs./week			Assessment Scheme and Marks								Credits			
			TH	TU	PR	In Sem	End Sem	CCE	TU	TW	PR	OR	Total	TH	TU	PR	Total
2406611	PROJ	Dissertation Phase-II	--	--	32	--	--	--	--	200	--	100	300	--	--	16	**16**
		Total	**--**	**--**	**32**	**--**	**--**	**--**	**--**	**200**	**--**	**100**	**300**	**--**	**--**	**16**	**16**

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: I
2406501: Computer Aided Power System Analysis

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 03 hrs./week **Tutorial: 01 hrs./week**	**TH: 03** **TU: 01**	**Continuous Comprehensive Evaluation: 20 Marks** **In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks** **Tutorial: 25 Marks**

Prerequisite Courses: Power System Analysis

Course Objectives: The course objectives are to

1. Introduce application of computer programming in power system
2. Develop computational and programming skills to analyze power system
3. Enhance technical concepts of power system analysis

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

	Course Outcomes	Bloom's Level
CO1	Formulate Y bus, Z bus, load flow and economical load dispatch problems	Understand
CO2	Calculate power flow, economic load dispatch, fault currents and voltages	Apply
CO3	Analyze practical power systems under steady state and faulty condition	Analyze
CO4	Develop algorithms and write a program to solve problems of power system analysis	Create

COURSE CONTENTS

Unit I	**Power Flow Analysis**	**09 hrs.**	**COs Mapped CO1, CO2, CO3, CO4**
Formulation of Y bus, Z bus using step-by-step method, Problem formulation of power flow and solution using: Gauss elimination method, Newton-Raphson method (Rectangular), decoupled and fast decoupled method, DC load flow			
Unit II	**Short Circuit Studies**	**09 hrs.**	**COs Mapped CO2, CO3, CO4**
System Representation, Algorithm for the formation of bus impedance matrix, Balanced fault, Sequence impedances of power system components, Unbalanced fault Analysis.			
Unit III	**Power System State Estimation**	**09 hrs.**	**COs Mapped CO3, CO4**
Power system state estimator, Method of Least Squares, Statistics, Errors and Estimates, Test for bad data, Network Topology Processing.			
Unit IV	**Optimal Power Flow Analysis**	**09 hrs.**	**COs Mapped CO1, CO2, CO3, CO4**
Optimal power flow analysis considering equality and inequality constraints, Economic dispatch with and without limits (Classical method) Gradient method, Newton's method, Newton Raphson method.			
Unit V	**Optimal Power System Operation**	**09 hrs.**	**COs Mapped CO1, CO2, CO3, CO4**

Calculation of loss coefficients, loss coefficients using sensitivity factors, power loss in a line, GSSD, Transmission loss coefficients, transmission loss formula as a function of generation and loads, economic dispatch using loss formula which is a function of real and reactive power, linear programming method.

Text Books

1. R. N. Dhar, "Computer Aided Power System Operation and Analysis," Tata McGraw Hill New Delhi, First Edition, 1982.
2. M.A. Pai, "Computer Techniques in Power System Analysis," Tata Mc-Graw Hill New Delhi, First Edition, 1979.
3. Stagg and El. Abiad, "Computer Methods in Power System Analysis," Mc-Graw Hill, First Edition, 1983.

Reference Books

1. D. P. Kothari, J. S. Dhillon, "Power System Optimization," PHI, Second Edition, 2002.
2. Hadi Saadat, "Power System Analysis," Tata McGraw Hill, Second Edition, 2002.
3. Allen Wood, "Power Generation Operation and Control," Wiley Publications, Third Edition, 2013.

List of Tutorials (Maintain separate record of all tutorial in file)

1. Problems on the determination of Y bus matrix for a three bus, four bus and five bus system.
2. Problems on the determination of Z bus matrix for a three bus, four bus and five bus system.
3. Problems on the determination of fault currents under symmetrical fault conditions.
4. Problems on the determination of fault current under unsymmetrical fault conditions.
5. Problems on power flow using the Gauss Seidel Method.
6. Problems on power flow using the Newton Raphson Method.
7. Problems on the Economic Load Dispatch excluding transmission losses.
8. Problems on the Economic Load Dispatch including transmission losses.

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	--	--	3	3	3	3
CO2	--	--	3	3	3	3
CO3	--	--	3	3	3	3
CO4	--	--	3	3	3	3

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 – (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	6 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	6 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: I
2406502: Power System Dynamics

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 03 hrs./week Tutorial: 01 hrs./week	TH: 03 TU: 01	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam:20 Marks End Sem Exam:60 Marks Tutorial: 25 Marks

Prerequisite Courses: Power System Analysis

Course Objectives: The course objectives are to

1. Introduce mathematical modeling of electrical apparatus and system
2. Demonstrate use of control system engineering in power system dynamics studies

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

	Course Outcomes	Bloom's Level
CO1	Explain concepts in the power system dynamics and stability	Understand
CO2	Model synchronous machines, excitation systems and governors	Apply
CO3	Analyze the dynamic and oscillatory behavior of power systems	Analyze
CO4	Interpret results of system stability studies	Evaluate

COURSE CONTENTS

Unit I	Power System Stability	09 hrs.	COs Mapped CO1

Power system stability states of operation and system security, system dynamics problems, system model, analysis of steady-state stability and transient stability, a simplified representation of excitation control, equal area criteria, numerical integration methods, and transient stability analysis.

Unit II	Modeling of Power System Components	10 hrs.	COs Mapped CO2

System Model, Synchronous Machine Model, Application of Model, Calculation of initial Conditions, Transmission line model, load model, Excitation System Modeling, Standard Block Diagram, System Representation by State Equations.

Unit III	Analysis of Single Machine	8 hrs.	COs Mapped CO1, CO3, CO4

Small Signal Analysis, Application of Routh-Hurwitz Criterion, Small Signal Model.

Unit IV	Design of Power System Stabilizer	09 hrs.	COs Mapped CO3, CO4

Basic Concepts of PSS, Control Signals, Structure and tuning of PSS, Field Implementation, PSS Design and Applications, Recent Development and Future Trends.

Unit V	Voltage Stability	09 hrs.	COs Mapped CO1, CO3

Definition, factors affecting voltage instability and collapse, analysis and comparison of angle and voltage stability, analysis and comparison of voltage instability and collapse, and control of voltage instability.

Text Books

1. K. R. Padiyar, "Power System Dynamics Stability and Control," B S Publication, Second Edition, 2008.
2. Prabha Kundur, "Power System Stability and Control," Tata McGraw Hill pub, Seventh reprint Edition, 2009.

Reference Books

1. A.A. Fouad, "Power System Control and Stability," John Wiley, and Sons, Second Edition, 2002.
2. P. Sauer and M. A. Pai, "Power System Dynamics and Stability," Prentice Hall, First Edition, 1997.
3. E.W. Kimbark, "Power systems Stability", Vol. I and III, Wiley publication, First Edition, 1995.

List of Tutorials (Maintain separate record of all tutorial in file)

1. Determination of power system stability using equal area criteria under sudden change in mechanical input.
2. Determination of power system stability using equal area criteria when a three-phase fault occurs at the middle point of a parallel transmission line.
3. Determination of power system stability using equal area criteria when a three-phase fault occurs at the feeder.
4. Calculation of stability using Routh-Hurwitz Criterion.
5. Mathematical modelling and simulation of an open loop single machine infinite bus system.
6. Development of power system stabilizer for a single machine infinite bus system.

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	--	--	3	3	3	3
CO2	--	--	3	3	3	3
CO3	--	--	2	2	2	2
CO4	--	--	2	2	2	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 – (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: I
2406503: Power Electronics Converters

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 04 hrs./week	TH: 04	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks

Prerequisite Courses:
1. Knowledge of basic electronics, diode, SCR, MOSFET, IGBT, and its characteristics
2. Working of Diode based rectifier, the concept of RMS and the average value

Course Objectives: The course objectives are to
1. Present advanced power electronics converters
2. Make students aware of different converter topologies

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

	Course Outcomes	Bloom's Level
CO1	Understand the use of semiconductor devices in different applications	Understand
CO2	Explain the operation of different power electronic converters	Understand
CO3	Sketch waveforms of the output signal for given input and load	Apply
CO4	Describe the design aspects of the converter	Analyze

COURSE CONTENTS

Unit I	**Power Semiconductor Devices**	**09 hrs.**	**COs Mapped-CO1**

Review of Power semiconductor devices, Gate and Base drive circuits - Preliminary design considerations, Temperature control of power devices, Heat sink design, and Design of Magnetic components.

Unit II	**DC-DC Converters**	**09 hrs.**	**COs Mapped-CO2, CO3, CO4**

Buck converter, Boost converter, Buck–Boost converter, CUK converter, Fly-back converter, Forward converter, Push–pull converter, Full bridge, and Half bridge converters, Design considerations and comparison.

Unit III	**Inverters**	**09 hrs.**	**COs Mapped-CO2, CO3**

Review of single-phase bridge inverters, 3-phase bridge inverters, Pulse width modulated inverters, 1-pulse, and multi-pulse modulation, Sinusoidal PWM, Space Vector PWM, Reduction of harmonics – Selective Harmonic Elimination Technique.

Unit IV	**Line Commutated Converters**	**09 hrs.**	**COs Mapped-CO2, CO3**

Principle of phase control, Review of single-phase converters, 3-phase half and fully controlled converters, 12–pulse converter, Dual converters.

Unit V	**AC Voltage Controllers**	**09 hrs.**	**COs Mapped-CO2, CO3**

Single phase AC voltage controllers, 3–phase AC voltage controllers.

Text Books

1. Ned Mohan, T.M Undeland and W. P Robbin, "Power Electronics: converters, Application and design" John Wiley and sons. Wiley India First Edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
3. P. S. Bimbra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003
4. P.C. Sen, "Modern Power Electronics," Wheeler Publishing Co, First Edition, New Delhi, 1998.

Reference Books

1. Abraham I. Pressman, Keith Billings &Taylor Morey: Switching Power Supply Design, McGraw Hill International, Third Edition, 2009.
2. R.W. Erickson and Dragan Maksimonic: Fundamentals of Power Electronics, Springer, Second Edition, 2001.
3. Umanand, L., Power Electronics: Essentials and Applications, John Wiley India, First Edition, 2009

Strength of CO-PO Mapping						
Course Outcomes	**Program Outcomes**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	--	--	3	2	3	--
CO2	--	--	3	2	3	1
CO3	--	--	3	2	3	1
CO4	--	--	3	2	3	3

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 – (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: I
2406504A: Renewable Energy System (Elective -I)

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 04 hrs./week	TH: 04	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objectives: The course objectives are to

1. Introduce the basic concepts of renewable energy technologies
2. Provide exposure to economic, technical, and sustainability issues involved in the integration of renewable energy systems
3. Present energy scenario and highlight the need for energy conservation

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

	Course Outcomes	Bloom's Level
CO1	Explain various terminologies related to renewable energy sources, smart grid, and grid integration	Understand
CO2	Understand various issues of grid integration	Understand
CO3	Develop a plan for the installation of wind energy and solar energy	Apply

COURSE CONTENTS

Unit I	**Solar Energy**	**09 hrs.**	**COs Mapped-CO1, CO2**

PV Characteristics, Power Electronics Interface for solar energy, Max Power Tracking algorithm, load estimation, selection of inverter, battery sizing, array sizing, wiring for SPV

Unit II	**Wind Energy**	**09 hrs.**	**COs Mapped-CO1, CO2**

Introduction, Basic principles of wind energy conversion, wind data and energy estimation, site selection considerations, types of wind generators, basic components of wind electric conversion systems, power electronics interface with wind generators, energy storage, applications of wind energy, inter-connected systems.

Unit III	**Optimization Technique**	**09 hrs.**	**COs Mapped-CO2**

Wind / Solar PV integrated systems design, Grid synchronized inverter system

Unit IV	**Grid Integration**	**09 hrs.**	**COs Mapped-CO3**

Grid-connected single-phase PV inverter schemes and control; power processing schemes based on a single string, multi-string and AC module technologies; types of grid interface; power electronic converters used in single-phase PV systems and their operation; transformer-less inverters, centralized grid-connected three-phase inverters for large PV installations.

Unit V	**Smart Grid**	**09 hrs.**	**COs Mapped-CO1**

Architecture of Smart Grid System, Standards for Smart Grid System Elements and Technologies of Smart Grid System, Distributed Generation Resources, Wide Area Monitoring Systems, Phasor Estimation, Digital relays for Smart Grid Protection

Text Books

1. R. Ramesh, "Renewable energy technologies", Narosa Publication.

2. Mittal, "Non-conventional Energy Systems", Wheelers Publication.
3. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response," CRC Press.
4. Chetan Singh Solanki, "Renewable Energy Technologies," PHI Learning Pvt. Ltd.

Reference Books

1. S.P. Sukhatme, "Solar Energy," Tata McGraw Hill.
2. Njenkins, "Wind Energy Technology," John Wiley & Sons.
3. Ali Keyhani, Mohammad N. Marwali, Min Dai, "Integration of Green and Renewable Energy in Electric Power Systems," Wiley.

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	--	--	3	--	3	2
CO2	--	--	3	--	3	2
CO3	--	--	3	--	3	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 – (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: I
2406504B: Energy Storage Systems (Elective -I)

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 04 hrs./week	TH: 04	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam:20 Marks End Sem Exam: 60 Marks

Course Objectives: The course objectives are to

1. Highlight the significance of energy storage devices
2. Introduce various energy storage technologies
3. Provide exposure to development of changing infrastructure of power system

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

	Course Outcomes	Bloom's Level
CO1	Compare various energy storage systems	Understand
CO2	Understand the requirement for installing the charging station	Understand
CO3	Mathematically model and simulate energy storage systems	Apply

COURSE CONTENTS

Unit I	**Introduction To Energy Studies**	**09 hrs.**	**COs Mapped-CO1**

Role of energy storage systems, applications, Overview of energy storage technologies: Thermal, Mechanical, Chemical, Electrochemical, Electrical, efficiency of energy storage systems.

Unit II	**Electrical Energy Storage**	**09 hrs.**	**COs Mapped-CO1, CO3**

Batteries-LTO, LFPLMO Batteries, Construction and working principle. Commercial and technical specifications, advantages, disadvantages, and applications. Study of BMS system. Manufacturing aspects and manufacturing companies, Simulation of Battery Energy Storage system used in Power System.

Unit III	**Fuel Cell**	**09 hrs.**	**COs Mapped-CO1, CO3**

Types of Fuel cells, their construction and working principle, the material used in the making of fuel cells, safety aspects, thermal rating and aging effect, specifications, advantages, disadvantages and applications, manufacturing aspects and manufacturing companies. Modeling and simulation of the power system of battery, solar and fuel cell-powered Hybrid Electric vehicle

Unit IV	**Super-Capacitors**	**09 hrs.**	**COs Mapped-CO1, CO3**

Construction and working principle of SC, Technical and commercial specifications, comparison of SC with batteries, safety aspects, thermal rating and aging effect, advantages, disadvantages and applications, manufacturing aspects and manufacturing companies. Modeling and simulation of super-capacitors

Unit V	**Charging Infrastructure**	**09 hrs.**	**COs Mapped-CO2**

Electric supply requirements IS specifications, the approval process for charging stations, and different levels of charging. Mobile storage system: electric vehicle, G2V, V2G.

Text Books
1. Handbook on Battery Energy Storage System, Asian Development Bank
2. James M. Eyer, Joseph J. Iannucci and Garth P. Corey, Energy Storage Benefits and Market Analysis, Sandia National Laboratories, 2004.
3. Smith, C. B., Energy Management Principles, Pergamum, 2007
Reference Books
1. Breeze Paul, Power System Energy Storage Technologies, Elsevier Science Publishing Co Inc
2. Komarnicki, Przemyslaw, Lombardi, Pio, Styczynski, Zbigniew, Electric Energy Storage Systems: Flexibility Options for Smart Grids, Springer; Softcover reprint of the original 1st ed. 2017
3. Garcia, Jorge, Analysis and Design of Hybrid Energy Storage Systems, MDPI AG (17 April 2020)

Strength of CO-PO Mapping						
Course Outcomes	**Program Outcomes**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	--	--	3	3	3	2
CO2	--	--	3	3	3	2
CO3	--	--	3	3	3	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 – (Units 1 to 2, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

M. Tech Electrical (Power System)
Pattern 2024 Semester: I
2406504C: Power Sector Economics and Management (Elective I)

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 4 hrs./week	TH: 04	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objectives: The course objectives are to

1. Provide students with a thorough understanding of the key concepts of power economics
2. Illustrate how these concepts and standard economic tools can be used to analyze power-related policy issues
3. Introduce fundamental concepts, types of the power market, and price of power

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

	Course Outcomes	Bloom's Level
CO1	Define various terminologies related to power systems and economics	Understand
CO2	Describe market models and mechanisms for electricity as a commodity	Understand
CO3	Explain concepts of trading, auctions, and strategic behavior of players in the power market	Understand
CO4	Elaborate on legal, financial, and economic issues related to transmission congestion management, locational marginal pricing, and ancillary management	Understand

COURSE CONTENTS

Unit I	Energy policy, governance, and regulations.	09 hrs.	COs Mapped CO1

Introduction, Framework of the Indian power sector, Reform initiatives, Availability based tariff, Electricity act 2003, Open access issues, Power exchange. Public Policy and Governance: Good Governance, Social Development, and Social Accountability. Post Reform Policy, Making and Governance in Monopoly Sectors: Restructuring, New Independent Regulatory Agencies, and other Governance Arrangements, New Policies in these Sectors. Need for regulation and deregulation of the power industry. Role of regulation and evolution of regulatory commission in India, Regulatory process in India, stages of tariff determination.

Unit II	Electricity trading & risk management	09 hrs.	COs Mapped CO1, CO3

Trading methods. Bidding strategies. Electricity Auctions: Generation Auction Markets, Auction Mechanism, Country Practices, Decision making and strategies in generation auction markets. LMP-based markets, auction models and price formation, Spot Pricing Models, and Decomposition models. Social surplus.

Risk Management in Markets: Market risk, Short-term vs. Long-term, Counterparty (credit) risk, Margining, EMIR, Liquidity risk, Market liquidity, Funding liquidity, Operational risk, Quantifying Risk, Risk modeling techniques, Value at -risk & stress testing, Parametric, historical simulation & Monte Carlo, the impact of price volatility, relation with collateralization & margining, Risk Hedging Contracts, Forward, Future, Option, Swap and Spot markets, and Risk evaluation in Electricity Trading.

Unit III	Electricity Markets and Pricing	09 hrs.	COs Mapped CO1, CO2, CO3

The Philosophy of Market Models: Monopoly model, Single buyer model, Wholesale competition model, Retail competition model, distinguishing features of electricity as a commodity, Four pillars of market design, Cournot, Bertrand, and Stackelberg competition model.

Electricity Markets Pricing: Electricity price basics, Market Clearing price (MCP), Zonal and locational MCPs. Dynamic, spot pricing and real-time pricing, Dispatch based pricing, Power flows, and prices. Optimal power flow, Spot prices for real and reactive power. Unconstrained real spot prices, constraints.

Unit IV	**Restructuring of the power industry**	**09 hrs.**	**COs Mapped CO1, CO2**

Introduction: Deregulation of the power industry, restructuring process, Issues involved in deregulation, Deregulation of various power systems, Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long, run costs, Various costs of production, Market models: Market models based on Contractual arrangements, Comparison of various market models, Electricity other commodities.

Unit V	**Transmission congestion management and pricing of transmission network**	**09 hrs.**	**COs Mapped CO1, CO4**

Introduction: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management, Classification of congestion management methods. Calculation of ATC, non–market methods, Market methods, Nodal pricing, Inter zonal and Intra zonal congestion management, Price area congestion management, Capacity alleviation method. Transmission pricing, Principles, Classification, Rolled in transmission pricing methods, Marginal transmission pricing paradigm, Composite pricing paradigm, Merits, and demerits of different paradigms.

Text Books

1. Daniel Kirschen and Goran Strbac, “Fundamentals of Power System economics”, John Wiley & Sons Ltd, 2004.
2. S. A. Khaparde and A. R. Abhyankar, “Restructured Power Systems”, Alpha Science, U.K., 2011.
3. Hisham Khatib, “Economic Evaluation of Projects in the Electricity Supply Industry,” IEEE Power and Energy Series 44, The Institution of Electrical Engineers, London.

Reference Books

1. Loi Lei Lai, “Power System Restructuring and Deregulation”, John Wiley & Sons Ltd. • Ross R. McKitrick, “Economic evaluation of Environmental policies”.
2. Pieter Glasbergen, “Environmental Policy in an International Context: Perspectives” The Open University.
3. Y. P. Abbi, et al, “Hand Book on Energy Audit and Environment Management”, TERI.

Strength of CO-PO Mapping

Course Outcomes	**Program Outcomes**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	--	--	3	--	3	--
CO2	--	--	3	--	3	--
CO3	--	--	3	--	3	--
CO4	--	--	3	--	3	--

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1, (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2, (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: I
2406505: Research Methodology and Intellectual Property Rights

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 03 hrs./week	TH: 03	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objectives: The course objectives are to

1. Enable students to undertake independent research, and to analyze and present their findings
2. Familiarize students with the basic techniques of collection, analysis, interpretation, presentation of data, and research ethics
3. Empower students to write a research paper and research proposal
4. Introduce concepts in IPR and patent law

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

	Course Outcomes	Bloom's Level
CO1	Explain the meaning of research and types of research	Understand
CO2	Understand ethical practices in research	Understand
CO3	Write a research paper, research proposal and thesis/dissertation with proper guideline	Apply
CO4	Identify the type of IPR, file a patent and understand legal requirements	Apply

COURSE CONTENTS

Unit I	Literature Review and Problem Formulation	09 hrs.	COs Mapped- CO1, CO2, CO3, CO4

Introduction: Research characteristics, need, and objectives, motivation in research, research methods vs methodology, types of research.
Research problem and question: Research formulation, defining and formulating the research problem, selecting the problem, the necessity of defining the problem, and breaking a problem into sub-problems.
Literature review: Sources, types of literature, the importance of literature review, identifying research gap, development of the working hypothesis, different tools for literature survey.

Unit II	Reading and Summarizing Paper	09 hrs.	COs Mapped- CO2, CO3, CO4

Reading and summarizing paper: Document-level and paragraph-level readings, critical reading, creative reading, (finding ideas), summarizing and identifying advantages and the drawbacks of research study, generalizing results from a research paper to related research problems, comparing the approach, creativity in research.
Research ethics: ethical practices in research such as plagiarism, acknowledgment, authorship, multiple publications, simultaneous publications, and research integrity, Avoiding plagiarism

Unit III	Writing a Research Paper, Thesis/Dissertation, and Research Proposal	09 hrs.	COs Mapped- CO1, CO2, CO3, CO4

Thesis/dissertation writing: significance of thesis/dissertation, structure, and components of thesis/dissertation, different steps in writing,
Research Paper Writing: types of technical papers, motivation in writing, components of a research paper, importance, purpose, and structure of each component,
Writing Research Proposal: Importance of research funding in research, standard formats for

different research schemes of AICTE, DST.

Unit IV	Intellectual Property Rights and Patents	09 hrs.	COs Mapped- CO1, CO2, CO3, CO4

Intellectual Property Rights: History, Types (Seven types of Intellectual Property Rights) viz. Patent, Industrial Designs, Trademark, Copyright, Geographical Indication, Integrated Circuit Layout, Trade Secrets.
Patents: Introduction to the Indian Patent system patent laws, history of patent law, history of Indian Patent System, Procedures for Patent application, Patent infringement and enforcement, patent licensing, and Patent prosecution. Criteria of patentability, Rights granted for IP owners.

Unit V	Legal Requirements	09 hrs.	COs Mapped- CO1, CO2, CO3, CO4

Patentable subject matter, Novelty, Utility (patent), Inventive step and non-obviousness, Industrial applicability, Person skilled in the art, Prior art, Inventorship, Sufficiency of disclosure, Unity of invention, Intellectual property brokering, Intellectual property education, Intellectual property infringement, Intellectual property valuation. Government's Role in Fostering IP

Text Books

1. Louis Cohen, Lawrence Manion, and Keith Morrison, Research Methods in Education, 7th Edition, Cambridge University Press, ISBN – 978-0415-58336-7
2. Anthony, M., Graziano, A.M., and Raulin, M.L., Research Methods: A Process of Inquiry, Allyn and Bacon
3. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, APH Publishing Corporation

Reference Books

1. Kothari, C.R., Research Methodology: Methods and Techniques. New Age Int. (P) Ltd. 2004
2. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., An Introduction to Research Methodology, RBSA Publishers, 2002
3. Suresh Sinha, Anil K Dhiman, Research Methodology, ESS Publications, Vol. 2

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	2	3	--	--	--	1
CO2	2	3	--	--	--	1
CO3	2	3	--	--	--	1
CO4	2	3	--	--	--	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 – (Units 1 to 2, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: I
2406506: Power System Lab-I

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Practical: 06 hrs./week	PR: 03	Term Work: 50 Oral: 50

Course Objectives: The course objectives are to

1. Inculcate computational skills through solving power system problems.
2. Enhance the use of software to solve power system analysis problems.
3. Develop programming and simulation skills.

Course Outcomes: At the end of this course, students will be able to

	Course Outcomes	Bloom's Level
CO1	Model electrical system components and develop an algorithm	Understand
CO2	Prepare a write-up of the experiment individually with an appropriate conclusion	Understand
CO3	Write a program/perform simulation for a different condition in a power system	Apply
CO4	Evaluate the performance of the power system under different conditions	Evaluate

List of Laboratory Experiments

Sr. No.	Laboratory Experiments	COs Mapped
GROUP-1 (Minimum 3 experiments) (Programming)		
1	Y bus and Z bus calculation	**CO2, CO3,**
2	Newton Raphson and fast decoupled load flow method.	**CO2, CO3**
3	Short circuit analysis of the multi-bus system.	**CO2, CO3**
4	Economic load dispatch	**CO2, CO3**
GROUP-2 (Minimum 3 experiments) (Simulation/Programming)		
1	Simulation of equal area criteria for transient stability	**CO2, CO3, CO4**
2	Heffron's Philips constant and initial condition calculation	**CO2, CO3**
3	Simulation of small signal analysis of the multi-machine system.	**CO1, CO2, CO3, CO4**
4	Design of PSS	**CO1, CO2, CO3, CO4**
GROUP-3 (Minimum 3 experiments) (Simulation)		
1	Simulation of the three-phase converter and THD analysis.	**CO2, CO3, CO4**
2	Simulation of Buck and Boost converter.	**CO1, CO2, CO3, CO4**
3	Simulation of three-phase SPWM inverter.	**CO1, CO2, CO3, CO4**
4	Simulation of space vector control of three-phase inverter.	**CO1, CO2, CO3**

Guidelines for Laboratory Conduction

Guidelines for laboratory conduction are as follows:

1. In the beginning, the instructor should state the learning outcomes of the experiment and should provide a problem statement to the students.
2. Students should solve the problem and then simulate the experiment.
3. To have variations in the numerical problem, different parameters can be set for different students.
4. In each laboratory session, each student will have to perform the experiment individually.
5. Assessment must be based on the understanding of theory, and attentiveness during lab sessions.
6. Timely submission of the experiment write-up by students should be ensured.

Guidelines for the instructor's manual

Guidelines for the instructor's manual are given below:

1. It should have a title, learning outcomes, aim, software requirement, theory, the problem with the solution, simulation results, comparison (result table, if any), and conclusion.
2. All the experiments should have at least one numerical problem, which should be solved analytically, then it should be verified by the simulation. For that matter, theory can be restricted to only definitions and concepts (no detailed explanation).
3. Simulation printouts should have readable and self-explanatory block diagrams and figures.

Guidelines for Student's Lab Journal

Guidelines for the student's lab manual are given below.

1. Students should write the theory, the problem with a solution, and the conclusion on their own in their own handwriting.
2. Students should write a program on their own and should compare analytical and simulated results and provide critical comments on that.
3. Students should try using different values of the parameters in the numerical problem and should observe the changes in the results.
4. Hand-writing must be clean and neat.

Guidelines for Term Work Assessment

1. The student's term work will be through continuous assessment.
2. Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing where each rubric carries ten marks.

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	2	3	3	3	--	3
CO2	2	3	--	--	--	3
CO3	2	3	2	2	--	2
CO4	2	3	2	2	--	2

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: II
2406511: Digital Power System Protection

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 03 hrs./week	TH: 03	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objectives: The course objectives are to

1. Impart knowledge of construction and operation of protective devices.
2. Acquaint with the application of proper protective devices and use of instrumentation in protection system

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

	Course Outcomes	Bloom's Level
CO1	Draw and explain block diagram of various numerical relay.	Understand
CO2	Choose the suitable signal processing technique and filters for protection	Apply
CO3	Simulate and analyze different types of faults in power system to decide protection criteria.	Analyze
CO4	Develop an algorithm for protective relaying and applications	Create

COURSE CONTENTS

Unit I	**Overview of Power System Protection**	**09 hrs.**	**COs Mapped CO1, CO2, CO3, CO4**

Overview of Static relays, Transmission line protection, Transformer protection, Need for digital protection Digital Relays- Basic elements of a digital relay and their functions, signal conditioning subsystem, conversion subsystem, digital relay subsystem

Unit II	**Digital Relaying**	**09 hrs.**	**COs Mapped CO2, CO3, CO4**

Signal processing techniques– Sinusoidal based algorithms, Fourier Analysis based algorithms, least squares-based algorithm, Discrete Fourier Transforms, Wavelet Transforms, and Kalman Filtering. Travelling Wave Protection scheme, Digital Protection of Transformers.

Unit III	**Digital Filters**	**09 hrs.**	**COs Mapped CO3, CO4**

Fundamentals of Infinite Impulse Response Filters, Finite Impulse Response filters, Filters with sine and cosine windows, Correction of errors introduced by Instrument Transformers- PTs and CTs detection of an unsaturated fragment of the wave shape, CT saturation correction procedure

Unit IV	**Decision Making in Protective Relays**	**09 hrs.**	**COs Mapped CO1, CO2, CO3, CO4**

Deterministic decision making, Statistical Hypothesis testing, Decision making with multiple criteria, Adaptive decision schemes, Adaptive Differential protective scheme

Unit V	**Digital Relaying Applications:**	**09 hrs.**	**COs Mapped CO1, CO2, CO3, CO4**

Applications of Fuzzy Logic and ANN for power system protection, Fault location algorithm, Wide Area Monitoring, and Protection

Text Books

1. J. B. Gupta, "Switchgear and Protection", S. K. Kataria & Sons.
2. A.T.Johns and S.K.Salman, "Digital Protection for Power Systems", Institution of Engineering and Technology (IET) digital library
3. Waldemar Rebizan, "Digital Signal Processing in Power System Protection and Control", Springer Publication
4. A.G.Phake, James S.Thorp, "Computer Relaying for Power Systems", John-Wiley and sons

Reference Books

1. Y.G. Paithankar, S.R. Bhide, "Fundamentals of Power System Protection" PHI, 2008
2. J. Lewis Blackburn, "Protective Relaying" Marcel Dekker INC. 1997
3. James S. Thorp, "Computer Relaying for Power Systems" John Willey & sons
4. Badri Ram, D N Vishwakarma, "Power System Protection and Switchgear", Tata Mc Graw Hill, 2005
5. Prof. S. A. Soman, "Web course on Power System Protection" on the website http://nptel.iitm.ac.in

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	--	--	3	--	3	--
CO2	--	--	3	--	3	--
CO3	--	--	3	3	3	--
CO4	--	--	3	3	3	3

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 – (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: II
2406512: Applications of Power Electronics in Power System

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 3 hrs./week Tutorial: 1 hrs./week	TH: 03 TU: 01	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks Tutorial: 25 Marks

Course Objectives: The course objectives are to

1. Introduce the necessity of reactive power control in the power system.
2. Enable students to understand the configuration and operation of devices for shunt and series compensation
3. Explore the configuration and operation of UPFC

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

	Course Outcomes	Bloom's Level
CO1	Explain the use of FACTS to improve the system stability and reliability	Understand
CO2	Summarize the requirement of reactive power compensation for power system stability	Understand
CO3	Choose the appropriate compensation device	Apply
CO4	Compare different types of FACTS Controllers	Analyze

COURSE CONTENTS

Unit I	**Introduction**	**09 hrs.**	**COs Mapped CO2**

Voltage source inverter (VSI), Synchronous reference frame theory, Instantaneous reactive power theory, Introduction to Active filter.

Unit II	**Reactive Power Compensation**	**09 hrs.**	**COs Mapped CO2, CO3, CO1**

Analysis of uncompensated AC line, Passive reactive power compensation, introduction to load and line compensation, compensation by a series capacitor connected at the midpoint of the line, effect on power transfer capacity by series compensation, Compensation by shunt capacitors and reactors, effect on power transfer capacity by shunt compensation, Synchronous condenser.

Unit III	**Static VAR Compensators.**	**09 hrs.**	**COs Mapped CO2, CO3, CO4**

Analysis of SVC, Configuration of SVC, SVC Controller, Modelling of SVC, Voltage regulator Design, Voltage control by the SVC, Advantages of the slope in the SVC Dynamic Characteristic, Influence of the SVC on System Voltage, Design of the SVC Voltage Regulator.

Unit IV	**Reactive power compensation using SVC**	**09 hrs.**	**COs Mapped CO2, CO3, CO4**

Introduction to different SVC devices (Thyristor-controlled reactor (TCR), Thyristor controlled transformer (TCT), Fixed capacitor-Thyristor controlled reactor (FC-TCR), Thyristor switched capacitor (TSC), Thyristor-switched capacitor-thyristor controlled reactor (TSC-TCR), Principle of operation, Analysis and control, Applications

Unit V	Static Synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC), and Unified Power Flow Controller	09 hrs.	COs Mapped CO2, CO3, CO4

Introduction, Principle of operation, Analysis and control, Applications of Static Synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC), and Unified Power Flow Controller

Text Books

1. K.R. Padiyar: HVDC Power Transmission System, New Age Intl. Co, 2015
2. Yong Hua Song & Allan T Johns, "Flexible AC Transmission Systems (FACTS)", IEE power and energy series, 2008.
3. Narain G.Honorani, Laszlo Gyugyi, "Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems", Wiley-IEEE Press, 1999.

Reference Books

1. Edward Wilson Kimbark, Direct Current Transmission, Vol-1, John Wiley & Sons, 1971.
2. Jos Arrillaga, Yonghe H. Liu, Neville R. Watson, Nicholas J. Murray, Self-Commutating Converters for High Power Applications Wiley Publishers, 2009.
3. K.R. Padiyar, "Facts Controllers in Power Transmission and Distribution", New Age International Publishers, 2016.
4. R. Mohan Mathur and Rajiv K. Varma, "Thyristor- Based FACTS controllers for electrical transmission systems", IEEE Press, 2002.

List of Tutorials (Maintain separate record of all tutorial in file)

1. MATLAB simulation for line compensation using series capacitor methods
2. MATLAB simulation for line compensation using shunt capacitor methods.
3. MATLAB simulation for Thyristor-controlled reactor (TCR),
4. MATLAB simulation for Thyristor controlled transformer (TCT)
5. MATLAB simulation for Thyristor switched capacitor (TSC).
6. MATLAB simulation for Thyristor-switched capacitor-thyristor controlled reactor (TSC-TCR).
7. MATLAB simulation for Fixed Capacitor-Thyristor controlled reactor (FC-TCR).
8. MATLAB simulation for Static Synchronous Compensator (STATCOM).
9. MATLAB simulation for Unified Power Flow Controller (UPFC).
10. MATLAB simulation for Static Synchronous Series Compensator (SSSC).

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	--	--	3	--	3	--
CO2	--	--	3	--	3	--
CO3	--	--	3	--	3	--
CO4	--	--	3	--	3	--

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 – (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: II
2406513: Power Quality Assessment and Mitigation

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 3 hrs./week Tutorial: 1 hrs./week	TH: 03 TU: 01	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks Tutorial: 25 Marks

Course Objectives: The course objectives are to

1. Develop an understanding of concepts of power quality issues
2. Enable students to classify various power quality issues with causes and effects.
3. Introduce cost-effective mitigation techniques for the power quality problem.

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

	Course Outcomes	Bloom's Level
CO1	Identify various power quality issues and explain their causes	Understand
CO2	Use the IEEE standards to carry out power quality monitoring for the chosen parameters	Understand
CO3	Analyze power quality parameters and evaluate the impact on equipment	Evaluate
CO4	Select a cost-effective mitigation technique for the power quality problem and prepare a PQ audit report	Analyze

COURSE CONTENTS

Unit I	**Power Quality**	**09 hrs.**	**COs Mapped- CO1, CO2**

Origin of power quality variation & events, power quality indices, causes and effects of power quality disturbances, Characterization of power quality events & event classification. Power quality measuring instruments, Analysis of Power outages, unbalanced distortions, voltage sag, flickers & load balancing.

Unit II	**Processing of Stationary Signals**	**09 hrs.**	**COs Mapped- CO2, CO3**

Stationary signals: Overview of analysis methods, frequency domain analysis and signal transformation, estimation of harmonics & inter-harmonics.

Unit III	**Processing of Stationary & Non-Stationary Signals**	**09 hrs.**	**COs Mapped- CO2, CO3**

Non –stationary signals: Power quality data analysis methods, discrete STFT for analyzing time–evolving signal components, wavelet transform, block-based modeling.

Unit IV	**Power Factor Correction & Mitigation of Harmonics**	**09 hrs.**	**COs Mapped- CO2, CO3, CO4**

Modeling of networks and components under non-sinusoidal conditions: transmission and distribution systems, power quality problems created by drives and their impact on drives, Power factor improvement techniques, Passive Compensation, and Harmonic Filters.

Unit V	**Custom Power Devices**	**09 hrs.**	**COs Mapped- CO2, CO3, CO4**

Introduction of APF, DSTATCOM, DVR and UPQC, Structure & control of power converters, load compensation using DSTATCOM and APF, Generation of reference currents, DVR/UPQC structures & control.

Text Books

1. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Publication.
2. M. H. J. Bollen, "Understanding Power Quality Problems, Voltage Sag and Interruptions," New York: IEEE Press, 2000, Series on Power Engineering
3. Arrillaga, M. R. Watson, S. Chan, "Power System Quality Assessment," John Wiley and Sons.

Reference Books

1. Ewald F. Fuchs, Mohammad A. S. Masoum, "Power Quality in Power Systems and Electrical Machines" Elsevier Publication.
2. EnriquesAcha, Manuel Madrigal, "Power System Harmonics: Computer Modeling and Analysis," John Wiley and Sons Ltd.
3. Arrillaga, M. R. Watson, "Power System Harmonics," John Wiley and Sons

List of Tutorials (Maintain separate record of all tutorial in file)

1. Study on the impact of power outages in industrial and commercial operations.
2. Study on different power quality measuring instruments and their applications.
3. Study on Fast Fourier Transform (FFT) and its application in harmonic analysis.
4. Study on discrete Short-Time Fourier Transform (FFT) and its application in harmonic analysis.
5. Analysis and remedies methods to improve power system stability under transient disturbances.
6. Analysis and remedies methods to improve power system stability under unbalanced distortions.
7. Study on different power factor improvement techniques.
8. Study on the operation of harmonic filters and their impact on power quality improvement.
9. Study and design of passive filters to mitigate harmonic distortions.
10. Study on the working and operation of various custom power electronics devices used for power quality improvement.

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	--	--	3	--	3	--
CO2	--	--	3	--	3	--
CO3	--	--	3	--	3	--
CO4	--	--	3	--	3	--

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 – (Units 1 to 2, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: II
2406514A: Controllers for Electric Vehicle (Elective II)

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 03hrs./week	TH: 03	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks

Course Objectives: The course objectives are to

1. Emphasize the need for electric vehicle
2. Introduce electric vehicle components
3. Present control aspects in the electric vehicle system

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

	Course Outcomes	Bloom's Level
CO1	List out various components with their application	Understand
CO2	Explain electric vehicle configuration	Understand
CO3	Compare the configuration and control of various electric motor drives	Apply
CO4	Calculate motor torque requirement.	Apply
CO5	Analyze the performance of SRM	Analyze

COURSE CONTENTS

Unit I	**Introduction to Electric Vehicles**	**09hrs.**	**COs Mapped CO1**
Electric Vehicle: Need, Types, Cost and Emissions, End of life. Electric Vehicle Technology: layouts, cables, components, Controls. Performance of Electric Vehicles, Power Converter topologies for an electric vehicle, Alternate charging sources, Wireless & Solar. Electric Vehicle Policies			
Unit II	**Electric Vehicle Motors**	**09 hrs.**	**COs Mapped CO1, CO2**
Motors (Induction, BLDC) Types, Principle, Construction, Switched Reluctance Motors (SRM) Drives, Permanent Magnet Motors, Motor Torque Calculations for Electric Vehicle. Electric Drive Trains (EDT), Series HEDT (Electrical Coupling), Power Rating Design, Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling), Torque Coupling and Speed Coupling.			
Unit III	**Introduction to Electric Components**	**09 hrs.**	**COs Mapped CO1, CO3**
Components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration, and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration, and control of Switch Reluctance Motor drives, drive system efficiency.			
Unit IV	**Control of BLDC Motor**	**09 hrs.**	**COs Mapped CO3, CO4**
Drives, Sensorless Techniques, Switched Reluctance Motor Drives.			
Unit V	**Switched Reluctance Motor Drives**	**09 hrs.**	**COs Mapped**

			CO3, CO4, CO5

Basic Magnetic Structure, Torque Production, SRM Drive Converter, Modes of Operation, Generating Mode of Operation (Regenerative Braking), Sensor less Control

Text Books

1. Wei Liu, "Hybrid Electric Vehicle System Modeling and Control", General Motors, USA, John Wiley & Sons, Inc., 2017.
2. Teresa Donateo, "Hybrid Electric Vehicles", Published by ExLi4EvA, 2017
3. Tom Denton, "Electric and Hybrid Vehicles", Taylor & Francis, 2018.

Reference Books

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2nd Edition ISBN: 978-1-119-94273-3 August 2012
2. Mehrdad EhsaniYimin Gao Stefano Longo Kambiz M. Ebrahimi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", Taylor & Francis Group, LLC, 2018
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi. "Modern Electric, Hybrid Electric and Fuel Cells, Fundamental Theory and Design", CRC Press

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	**2**	**3**	**4**	**5**	**6**
CO1	--	--	3	--	3	--
CO2	--	--	3	--	3	--
CO3	--	--	3	--	3	--
CO4	--	--	3	--	3	--
CO5	--	--	3	--	3	--

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 – (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: II
2406514B: Power System Planning and Reliability (Elective II)

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 03 hrs./week	TH: 03	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam: 20 Marks End Sem Exam: 60 Marks

Prerequisite Courses: Power system and stability

Course Objectives: The course objectives are to

1. Introduce the significance of system stability and load forecasting
2. Enable students to understand the transmission system and its reliability aspect
3. Explore distribution systems and various failures

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

	Course Outcomes	Bloom's Level
CO1	Explain the characteristics of loads, concepts of load and its types for power system forecasting	Understand
CO2	State the significance of reliability in power systems and various methods and tools used for reliability exploration	Apply
CO3	Define the concepts of reliability in a generation	Understand
CO4	Describe the concepts of reliability in the transmission system	Understand

COURSE CONTENTS

Unit I	**System Planning & Load Forecasting**	**09 hrs.**	**COs Mapped CO1, CO2, CO3, CO4**

Objectives of planning, long and short-term planning, load forecasting: classification and characteristics of loads, approaches to load forecasting factors affecting load patterns, methodology of forecasting, energy forecasting, peak demand forecasting, total forecasting, annual and monthly peak demand forecasting, and applications load forecasting.

System planning: objectives, long-term and short-term planning, stages in planning, policy studies, planning standardization studies, system, and network reinforcement studies.

Unit II	**Inter Connected System Reliability Analysis**	**09 hrs.**	**COs Mapped CO2, CO3, CO4**

Probability array method, two inter-connected systems with independent loads, effects of limited and unlimited tie capacity, imperfect tie, two connected systems with correlated loads, the expression for cumulative probability and cumulative frequency

Unit III	**Generating System Reliability Analysis**	**09 hrs.**	**COs Mapped CO3, CO4**

Generating System Reliability Analysis I
Generation system model, capacity outage probability tables, recursive relation for capacitive model building, sequential addition method, unit removal, evaluation of loss of load and energy indices.
Generating System Reliability Analysis II
Frequency and duration methods, evaluation of equivalent transitional rates of identical and non-identical units, evaluation of cumulative probability and cumulative frequency of non-identical generating units, level daily load representation, merging generation and load models, examples

Unit IV	Transmission System	09 hrs.	COs Mapped CO1, CO2, CO3, CO4

Introduction, objectives of transmission planning, network reconfiguration, system, and load point indices, and data required for composite system reliability, transmission system reliability evaluation: average interruption rate method, reliability analysis of protection systems for high voltage transmission lines, model analysis, and average interruption rate.

Unit V	Distribution System	09 hrs.	COs Mapped CO1, CO2, CO3, CO4

Distribution System Reliability Analysis I (Radial configuration)
Basic techniques, radial networks, evaluation of basic reliability indices, performance indices, load point, and system reliability indices, customer-oriented, loss, and energy-oriented indices, examples distribution system reliability analysis ii (parallel configuration) the basic technique, inclusion of bus bar failures, scheduled maintenance, temporary and transient failures, weather effects, common mode failures, evaluation of various indices, examples

Text Books

1. Roy Billington, "Power System Reliability Evaluation", Gordan & Breach Scain Publishers, First Edition, 1990.
2. Endrenyi, J., "Reliability Modelling in Electric Power System" John Wiley, First Edition, 1980.
3. Richard E. Brown, "Electric Power Distribution Reliability", CRC Press, First Edition, 2002

Reference Books

1. Shahidehpour M, Yamin H, Li z, "Market operations in electric power systems Forecasting, Scheduling, and Risk Management", John Wlley & sons, First Edition, 2002.
2. Billinton R, Allan R, "Reliability evaluation of power systems", Plenum Press New York, second Edition, 1992.
3. S.C. Savulescu, "Real-Time Stability assessment in modern power system control centers", John Wiley & Sons, First Edition, 2009

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO1	--	--	3	--	3	--
CO2	--	--	3	--	3	--
CO3	--	--	3	--	3	--
CO4	--	--	3	--	3	--

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for Continuous Comprehensive Evaluation	Marks Allotted
1	Assignment 1 – (Units 1 to 2, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: II
2406514C: Microgrid Operation and Control (Elective II)

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Theory: 03 hrs./week	TH: 03	Continuous Comprehensive Evaluation: 20 Marks In Sem Exam:20 Marks End Sem Exam:60 Marks

Prerequisite Courses: Basic concepts of microgrid and its modelling.

Course Objectives: The course objectives are to

1. Introduce the concept of distributed generation
2. Enable students to understand the dynamics and modeling of microgrid
3. Explore the microgrid and its configuration

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

	Course Outcomes	Bloom's Level
CO1	Explain concepts related to microgrid	Understand
CO2	Discuss modeling aspects, control mechanism and stability analysis of microgrid	Understand
CO3	Analyze different hierarchical control schemes for microgrid system	Analyze

COURSE CONTENTS

Unit I	**Introduction to Microgrids**	**09 hrs.**	**COs Mapped CO1**
Introduction to the concept of microgrid, the overview of the structure and architecture of microgrid with brief control, operational aspects. Till date pilot microgrid projects and their outcomes.			
Unit II	**Decentralized Local Controllers**	**09 hrs.**	**COs Mapped CO1**
AC-microgrids: Control Mechanism of the DGs connected in a microgrid. Virtual synchronous generator (VSG) and Droop control. Transient frequency response, active power Response, reactive power sharing, and voltage regulation			
Unit III	**DC-Microgrids**	**09 hrs.**	**COs Mapped CO2**
DC microgrid control mechanism, droop control, issues in achieving active power sharing with impedance droop, and remedies to achieve active power sharing.			
Unit IV	**Modelling and Stability Analysis of Microgrids**	**09 hrs.**	**COs Mapped CO2, CO3**
Review of the concepts of power system modeling, dynamics, and stability, dynamic modeling of individual components in AC and DC microgrids, state space modal analysis and influence of system parameters on the microgrid dynamics, and brief concept on the design of microgrid stabilizers to improve stability.			
Unit V	**Control Scheme for Microgrids**	**09 hrs.**	**COs Mapped CO3**
Implementation of hierarchical control with centralized and distributed control schemes for AC and DC microgrids, advantages and disadvantages of centralized and distributed control schemes, AC-AC, AC-DC, and DC-DC microgrid clustering, coordinated control schemes in multi-microgrids, frequency, voltage regulations, and volt-VAR support, Load Frequency Control (LFC) in Micro Grid			

System, Voltage Control in Micro Grid System, Reactive Power Control in Smart Grid.
Text Books
1. N. D. Hatziargyriou, "Microgrids Architecture and control", IEEE Press Series, John Wiley & Sons Inc, First Edition, 2013. 2. H. Bevrani, B. François, and T. Ise, "Microgrid Dynamics and Control", John Wiley & Sons, First Edition 2017.
Reference Books
1. Bidram, V. Nasirian, A. Davoudi, F. L. Lewis, Cooperative Synchronization in Distributed Microgrid Control, Springer, First Edition 2017. 2. Power System Stability and Control, P. Kundur, McGraw-Hill, Inc., Second Edition, 1994.

Strength of CO-PO Mapping						
Course Outcomes	**Program Outcomes**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	--	--	2	--	3	--
CO2	--	--	3	--	3	--
CO3	--	--	3	--	3	--

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Assignment 1 – (Units 01 to 02, before the in-semester exam)	4 Marks
2	Class Test I (Based on units 01 and 02, before the in-semester exam)	4 Marks
3	Assignment 2 – (Units 03 to 05, before the end-semester exam)	4 Marks
4	Class Test II (Based on Units 03 to 05, before the end-semester exam)	8 Marks

F. Y. M. Tech. Electrical (Power System) Pattern 2024 Semester: II 2406515: Power System Lab-II		
Teaching Scheme:	**Credit Scheme:**	**Evaluation Scheme:**
Practical: 06 hrs./week	**PR: 03**	**Term Work:50** **Oral: 50**

Course Objectives: The course objectives are to

1. Inculcate computational skills through solving power system problems.
2. Enhance the use of software to solve power system analysis problems.
3. Develop programming and simulation skills.

Course Outcomes: At the end of this course, students will be able to		
	Course Outcomes	**Bloom's Level**
CO1	Model electrical system components and develop an algorithm	Understand
CO2	Prepare a write-up of the experiment individually with an appropriate conclusion	Understand
CO3	Write a program/perform simulation for a different condition in a power system	Apply
CO4	Evaluate the performance of the power system under different conditions	Evaluate

List of Laboratory Experiments		
Sr. No.	**Laboratory Experiments**	**COs Mapped**
GROUP-1 (Minimum 4 experiments) (Programming)		
1	Demonstrating the phenomenon of aliasing due to under-sampling.	**CO2, CO3**
2.	Implementation of Differential Equation Algorithm (DEA) by Numerical differentiation and integration	**CO2, CO3**
3.	Calculation of phasor using least square algorithm	**CO2, CO3, CO4**
4.	Calculation of phasor using full cycle and half cycle DFT	**CO2, CO3, CO4**
5.	Simulation of numerical differential protection of transformer.	**CO1, CO2, CO3, CO4**
GROUP-2 (Minimum 5 experiments) (Simulation/Programming)		
1	Study of operation of DSTATCOM.	**CO1, CO2, CO3, CO4**
2	Analysis and design of Shunt Active Power Filters	**CO1, CO2, CO3, CO4**
3	Simulation and analysis of DVR	**CO1, CO2, CO3, CO4**
4	Simulation and analysis of STATCOM/ SVC FACTS controller	**CO1, CO2, CO3, CO4**
5	Study of operation of Unified Power Flow controller	**CO1, CO2, CO3, CO4**

6	Simulation and Analysis of Series and Shunt compensation of EHV Transmission line	**CO1, CO2, CO3, CO4**
7	Simulation and Analysis of TCSC/SSSC FACTS controller	**CO1, CO2, CO3, CO4**

Guidelines for Laboratory Conduction

Guidelines for laboratory conduction are as follows:

1. In the beginning, the instructor should state the learning outcomes of the experiment and should provide a problem statement to the students.
2. Students should solve the problem and then simulate the experiment.
3. To have variations in the numerical problem, different parameters can be set for different students.
4. In each laboratory session, each student will have to perform the experiment individually.
5. Assessment must be based on the understanding of theory, and attentiveness during lab sessions.
6. Timely submission of the experiment write-up by students should be ensured.

Guidelines for the instructor's manual

Guidelines for the instructor's manual are given below:

1. It should have a title, learning outcomes, aim, software requirement, theory, the problem with the solution, simulation results, comparison (result table, if any), and conclusion.
2. All the experiments should have at least one numerical problem, which should be solved analytically, then it should be verified by the simulation. For that matter, theory can be restricted to only definitions and concepts (no detailed explanation).
3. Simulation printouts should have readable and self-explanatory block diagrams and figures.

Guidelines for Student's Lab Journal

Guidelines for the student's lab manual are given below.

1. Students should write the theory, the problem with a solution, and the conclusion on their own in their own handwriting.
2. Students should write a program on their own and should compare analytical and simulated results and provide critical comments on that.
3. Students should try using different values of the parameters in the numerical problem and should observe the changes in the results.
4. Hand-writing must be clean and neat.

Guidelines for Term Work Assessment

1. The student's term work will be through continuous assessment.
2. Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing where each rubric carries ten marks.

Strength of CO-PO Mapping						
Course Outcomes	**Program Outcomes**					
	1	**2**	**3**	**4**	**5**	**6**
CO1	2	3	3	3	--	3
CO2	2	3	--	--	--	3
CO3	2	3	2	2	--	2
CO4	2	3	2	2	--	2

F. Y. M. Tech. Electrical (Power System) Pattern 2024 Semester: II 2406516: Seminar I		
Teaching Scheme:	**Credit Scheme:**	**Evaluation Scheme:**
Practical: 06 hrs./week	**PR: 03**	**Term Work - 50 Marks** **Oral - 50 Marks**

Course Objectives: The course objectives are to

1. Empower students to identify the latest topic in the field of power system engineering
2. Encourage students to carry out literature survey and problem identification
3. Enhance presentation and report writing skills

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

	Course Outcomes	Bloom's Level
CO1	Identify the seminar topic in the field of power system engineering by literature survey	Understand
CO2	Understand how research papers are written and understand modeling, theory, concept, and simulation related to the topic of interest	Apply
CO3	Effectively communicate the seminar topic by oral presentation	Apply
CO4	Prepare a detailed seminar report	Create

COURSE CONTENTS

Seminar I will be based on a minor project. The topic for the minor project will be based on subjects studied in Semester-I. The student shall submit the seminar report in a standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department.	**COs Mapped-CO1, CO2, CO3, CO4**

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	--	3	3	3	3
CO2	3	--	3	3	3	3
CO3	--	3	3	--	3	3
CO4	--	3	3	--	3	3

Guidelines for the Evaluation of Seminar I

Sr. No.	Components for Seminar I Evaluation (TW)	Marks Allotted
1	Content coverage and understanding	10 Marks
2	Oral Presentation and Question Answer	10 Marks
3	Report writing and submission	5 Marks

F. Y. M. Tech. Electrical (Power System)
Pattern 2024 Semester: II
2406517: Software in Electrical Engineering

Teaching Scheme:	Credit Scheme:	Evaluation Scheme:
Practical: 04 hrs./week	PR: 02	Term Work: 50

Prerequisite Courses: MATLAB Simulation and Programming

Course Objectives: The course objectives are to

1. Make students aware of software used for the analysis of power system
2. Develop an understanding of the usage of simulation and programming software for any specific application or problem

	Course Outcomes	Bloom's Level
At the end of this course, the student will be able to		
CO1	Model power system under steady state and transient state.	Apply
CO2	Use different electrical software such as MATLAB, DigSILENT, ETAP, PSCAD, PSIM	Apply
CO3	Develop simulations and programming using different software	Create
CO4	Interpret and evaluate the results obtained from programming and simulations.	Evaluate

LAB EXPERIMENTS	COs Mapped- CO1, CO2, CO3, CO4

This lab will cover simulation and programming assignments on a platform like MATLAB, PSCAD, PSIM, PSPICE, Dig SILENT, ETAP, etc. The problems will be related to the core subjects and Electives. This will include simulation of one research paper, finding steady state and transient response of RLC circuit using all software platforms, simulation of load flow problem using MATLAB and ETAP, harmonic analysis of 3-phase inverter using MATLAB and PSIM, etc.

Strength of CO-PO Mapping

Course Outcomes	Program Outcomes					
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	3	3	3	2	--
CO2	2	--	3	3	2	3
CO3	2	--	3	3	2	3
CO4	3	3	3	3	2	3

Guidelines for Laboratory Conduction

Guidelines for laboratory conduction are as follows:

1. In the beginning, the instructor should state the learning outcomes of the experiment/assignment and should provide a problem statement to the students.
2. Students should solve the problem and then simulate the experiment using various simulation platforms
3. To have variations in the numerical problem, different parameters can be set for different students.
4. In each laboratory session, each student will have to perform the experiment individually.
5. Assessment must be based on the understanding of theory, and attentiveness during lab

sessions.
6. Timely submission of the experiment write-up by students should be ensured.

Guidelines for the Continuous Comprehensive Evaluation

1. The student's term work will be through continuous assessment.
2. Each experiment from the lab journal is assessed for thirty marks based on three rubrics. Rubric R-1 for timely completion, R-2 for understanding, and R-3 for presentation/journal writing where each rubric carries ten marks.