Dr. Vasantraodada Patil Shetkari Shikshan Mandal's

PADMABHOOSHAN VASANTRAODADA PATIL INSTITUTE OF TECHNOLOGY, BUDHGAON, SANGLI- 416304.

An Autonomous Institute

Affiliated to Dr. Babasaheb Ambedkar Technological University, Lonere, Raigad

(Accredited by NAAC)

M. Tech Electrical Engineering

Curriculum for Post Graduate Degree Programme

(M. Tech. Electrical Engineering)

In accordance with the *National Education Policy (NEP) 2020*, including curriculum structure and evaluation scheme

Effective from Academic Year 2025–2026

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M. Tech Electrical Engineering

Curriculum Structure and Evaluation Scheme

(Academic Year 2025-26 onwards)

Semester – I

Course Category	Course Code	Course Name	Teaching Scheme				Evaluation Scheme					Total
							Theory			Practical		
			L	T	P	Credits	Scheme		Minimum Marks for Passing	Max	Min	
PCC	0EEPC501	Modern Control System	3	1	-	4	ISE 1 MSE ISE 2 ESE	10 20 10 60	40	-	-	100
PCC	0EEPC502	Advanced Power Electronics	3	1	-	4	ISE 1 MSE ISE 2 ESE	10 20 10 60	40	-	-	100
PEC	0EEPE503	Program Elective-I	3	1	-	4	ISE 1 MSE ISE 2 ESE	10 20 10 60	40	-	-	100
RMC	0EERM504	Research Methodology	3	1	-	4	ISE 1 MSE ISE 2 ESE	10 20 10 60	40	-	-	100
HSSM	0EEHS505	Entrepreneurship	3	-	-	3	ISE 1 MSE ISE 2 ESE	10 20 10 60	40	-	-	100
PCC	0EEPCL506	PG Lab-I	-	-	2	1	ISE ESE	- -	-	60 40	24 16	100
TOTAL			15	4	2	20	Total Marks					600

- **Credit Distribution:**

Course Category	PCC	PEC	RMC	HSSM	Total
Credits	09	04	04	03	20

Programme Elective-I	
0EEPE503A	Power System Modelling
0EEPE503B	Power System for Grid Resilience
0EEPE503C	Power Quality and Harmonics

- **Total Contact Hours per week:** 21, **Total Credits:** 20

ISE1: In Semester Evaluation 1, **ISE2:** In Semester Evaluation 2, **MSE:** Mid Semester Examination, **ESE:** End Semester Examination, **PCC:** Professional Core Course, **PEC:** Program Elective Course, **RMC:** Research Methodology Course, **HSSM:** Humanities Social Science and Management

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(Academic Year 2025-26 onwards)

Semester – II

Course Category	Course Code	Course Name	Teaching Scheme				Evaluation Scheme					Total
							Theory				Practical	
			L	T	P	Credits	Scheme	Minimum Marks for Passing		Max	Min	
PCC	0EEPC551	Control Techniques for Drives	3	-	-	3	ISE 1 10 MSE 20 ISE 2 10 ESE 60	40		-	-	100
PCC	0EEPC552	Advanced Power System Protection	3	-	-	3	ISE 1 10 MSE 20 ISE 2 10 ESE 60	40		-	-	100
PCC	0EEPC553	Distributed Generation and Smart Grid	3	-	-	3	ISE 1 10 MSE 20 ISE 2 10 ESE 60	40		-	-	100
PEC	0EEPE554	Program Elective-II	3	-	-	3	ISE 1 10 MSE 20 ISE 2 10 ESE 60	40		-	-	100
PEC	0EEPE555	Program Elective-III	3	-	-	3	ISE 1 10 MSE 20 ISE 2 10 ESE 60	40		-	-	100
HSSM	0EEHS556	Communication Skill	3	-	-	3	ISE 1 10 MSE 20 ISE 2 10 ESE 60	40		-	-	100
PCC	0EEPCL557	PG Lab-II	-	-	2	1	ISE	-	-	60	24	100
							ESE	-	-	40	16	
PCC	0EEPCL558	Seminar	-	-	2	1	ISE	-	-	60	24	100
							ESE	-	-	40	16	
		TOTAL	18	-	4	20	Total Marks					800

- **Credit Distribution:**

Course Category	PCC	PEC	HSSM	Total
Credits	11	06	03	20

Programme Elective-II		Programme Elective-III	
0EEPE554A	Transients in Power System	0EEPE555A	Intelligent Control System
0EEPE554B	Renewable Energy Systems	0EEPE555B	Industrial Automation
0EEPE554C	Power System Optimization	0EEPE555C	Discrete Time Control System

- **Total Contact Hours per week:** 22, **Total Credits:** 20

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M. Tech Electrical Engineering

Curriculum Structure and Evaluation Scheme

(Academic Year 2026-27 onwards)

Semester – III

Course Category	Course Code	Course Name	Teaching Scheme				Evaluation Scheme						Total
							Theory				Practical		
			L	T	P	Credits	Scheme		Minimum Marks for Passing		Max	Min	
PEC	0EEPE601	Program Elective-IV	3	1	-	4	ISE 1 MSE ISE 2 ESE	10 20 10 60	40		-	-	100
OEC	0EEOE602	Open Elective-I	3	-	-	3	ISE 1 MSE ISE 2 ESE	10 20 10 60	40		-	-	100
OEC	0EEOE603	Open Elective-II	3	-	-	3	ISE 1 MSE ISE 2 ESE	10 20 10 60	40		-	-	100
DIS	0EEDS604	Project Work Phase-I	-	-	-	10	ISE ESE	-	-	-	60 40	24 16	100
CCC	0EECC605	Yoga for Stress Management	-	-	2	AU	ISE	-	-	-	50	20	-
TOTAL			09	1	2	20	Total Marks						400

- **Credit Distribution:**

Course Category	PEC	OEC	DIS	CCC	Total
Credit	04	06	10	AU	20

Programme Elective-IV	
0EEPE601A	Artificial Neural Network and Fuzzy Logic
0EEPE601B	HVDC
0EEPE601C	Control System Design

Open Elective-I		Open Elective-II	
0EEOE602A	Electric and Hybrid Vehicle	0EEOE603A	Energy Storage Systems
0EEOE602B	Design of Mechatronic Systems	0EEOE603B	Sustainable Power Generation Systems
0EEOE602C	Components and Applications of Internet of Things	0EEOE603C	Energy Management and Audit

- **Total Contact Hours per week:** 12, **Total Credits:** 20

OEC: Open Elective Course, **DIS:** Dissertation / Project, **CCC:** Co-curricular Course

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(Academic Year 2026-27 onwards)

Semester – IV

Course Category	Course Code	Course Name	Teaching Scheme				Evaluation Scheme						Total
							Theory				Practical		
			L	T	P	Credits	Scheme		Minimum Marks for Passing		Max	Min	
DIS	0EEDS651	Project Work Phase-II	-	-	-	20	ISE	-	-	-	100	40	200
							ESE				100	40	
TOTAL			-	-	-	20	Total Marks						200

- **Credit Distribution:**

Course Category	DIS	Total
Credit	20	20

- **Summary of Semester wise Credits**

Semester I	Semester II	Semester III	Semester IV	Total Credits
20	20	20	20	80

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Modern Control System

Course Code and Course Title	0EEPC501 Modern Control System			
Semester	I			
Prerequisites	Linear Control Systems			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	1	-	
Credit	4			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Compute observer parameters for state estimation of dynamic systems using full order observer design techniques..	3
CO2	Analyze dynamics of a linear system by State Space Representation.	4
CO3	Analyze the stability of nonlinear control systems using phase plane techniques.	4
CO4	Evaluate state-feedback control of linear systems using pole placement techniques to assess closed-loop performance.	5

Course Content

Unit No.	Contents	Hrs.
Unit 1	**State Space Representation** The Concept of State and State Models, State Diagram, State Space and State Trajectory, State Space Representation using physical variables, Phase Variable and Canonical Variables.	6
Unit 2	**Solution of State Equations** Solution of State Equation, State Transition Matrix and its Properties, Computation of State Transition Matrix using Laplace Transformation, Power Series Method, Cayley-Hamilton Method, Similarity Transformation Method. Concepts of Controllability, Observability, Kalman's test for controllability and observability.	7
Unit 3	**Pole Placement Techniques** Pole placement design, Necessary and Sufficient Condition for arbitrary Pole Placement, Evaluation of State Feedback Gain Matrix K by direct substitution method and Ackerman's formula, Selection of Location of Desired Closed Loop Poles.	6
Unit 4	**Observer Design** Concept of state observer, necessary and sufficient condition for state observation, State Observer Design, Full Order/Reduced Order Observer Design, evaluation of state observer gain matrix by direct substitution and Ackerman's formula, Observer Based State Feedback Control.	6

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Unit 5	**Nonlinear Control System** Introduction, Properties of Nonlinear System, Behaviour of Non-Linear System, Classification of Nonlinearities, Common Physical Nonlinearities: Saturation, Friction, Backlash, Dead-Zone, Relay, On-Off Nonlinearity, Nonlinear Spring, Limit cycle, Jump resonance.	7
Unit 6	**Phase Plane and Describing Functions Method** Phase- Plane Method, Singular points, Stability of Nonlinear System, Construction of Phase Trajectories, isocline method, Describing Functions Method, Describing function of dead zone, saturation, relay, relay with dead zone. Stability Analysis by Describing Function Method.	7
	Total Hours	**39**

Text Books:

1. Katsuhiko Ogata, Modern Control Engineering, Prentice-Hall, 3rd edition, 2010.
2. Katsuhiko Ogata, State Space Analysis of Control System, Prentice-Hall, 2nd

Reference Books:

1. Benjamin C. Kuo and Farid Golnaraghi, Automatic Control Systems, John Wiley & Sons., 9th edition, 2014.
2. I. J. Nagarath and M. Gopal, Control system Engineering, New Age, 6th edition, 2017.

Useful link /Web Resources:

1. Prof A P Tiwari, State space Approach to Control System Analysis and Design, IIT Mandi, https://nptel.ac.in/courses/108106374.
2. Dr. Arun D. Mahindrakar, Nonlinear Control System, IIT Madras, https://nptel.ac.in/courses/108106024.
3. Prof. S. Majhi, Advanced Control Systems, IIT Guwahati, https://nptel.ac.in/courses/108103007.

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Advanced Power Electronics

Course Code and Course Title	0EEPC502 Advanced Power Electronics			
Semester	I			
Prerequisites	Power Electronics, Power Quality, Power System			
Teaching Scheme (hours per week)	**Lecture**	**Tutorial**	**Practical**	
	3	1	-	
Credit	4			
Evaluation Scheme	**ISE 1**	**MSE**	**ISE 2**	**ESE**
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		**BL**
CO1	Explain the operation and applications of advanced switch-mode converters.	3
CO2	Apply PWM control techniques to rectifiers and inverters for improved power quality and efficient energy conversion.	3
CO3	Analyse the performance of multilevel inverters and matrix converters with various modulation and control methods.	4
CO4	Explain the working of soft-switching and resonant converters.	3

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Advanced Switch Mode Power Converters** Review of non-isolated choppers, Cuk dc-dc converter, isolated choppers, Full bridge dc-dc converter, Half-bridge converter, Forward converter, Flyback converter, Push-pull converter.	7
Unit 2	**PWM Rectifiers** Advantages & disadvantages of three phase thyristor converter, Single phase and three phase VS and CS PWM converters working, types, Control of PWM rectifiers, analysis and application.	6
Unit 3	**PWM Inverters** Principle of two-level inverters, Sinusoidal PWM (SPWM), Selective Harmonic Elimination PWM (SHE-PWM), Space Vector PWM (SVPWM), Harmonic analysis and performance parameters, Applications of PWM inverters in motor drives, renewable energy systems, and power quality improvement.	7
Unit 4	**Multilevel Inverters** Concept, types of multilevel inverters, diode-clamped, flying-capacitor, and cascaded multilevel inverters, applications, comparison, Multiple carrier PWM for MLI.	6
Unit 5	**Matrix Converters**	6

	Basic principles, working, topologies and control methods of Matrix converters, analysis, applications.	
Unit 6	**Soft Switching and Resonant Converters** Zero Voltage Switching (ZVS) and Zero Current Switching (ZCS) principles, Series and Parallel Resonant Converters, advantages, limitations and applications in high-frequency power conversion.	7
	Total Hours	**39**

Text Books:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics: Converters, Applications, and Design, Wiley, 3rd edition, 2003.
2. Andrzej M. Trzynadlowski, Introduction to Modern Power Electronics, Wiley, 3rd edition, 2015.

Reference Books:

1. Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson, 4th edition, 2013.
2. Bimal K. Bose, Power Electronics and Motor Drives: Advances and Trends, Academic Press (Elsevier), 2006.

Useful link /Web Resources:

1. Prof. Avik Bhattacharya, Advance Power Electronics and Control, IIT Roorkee, https://nptel.ac.in/courses/108107128.
2. Prof. Bhim Singh, Advance Power Electronics, IIT Delhi, https://nptel.ac.in/courses/108102584.
3. Prof. David Perreault, Power Electronics, MIT Open Learning, https://ocw.mit.edu/courses/6-334-power-electronics-spring-2007/.

Power System Modelling

Course Code and Course Title	0EEPE503A Power System Modelling			
Semester	I			
Prerequisites	Power System Analysis, Electrical Machines, Control Systems, Power Electronics			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	1	-	
Credit	4			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Identify appropriate models of power system components for steady-state and dynamic studies.	2
CO2	Formulate synchronous machine and excitation system models using fundamental equations.	3
CO3	Assess small-signal and transient stability of power systems using analytical methods.	4
CO4	Prepare reports on stability enhancement methods and power system modelling approaches.	4

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Introduction to Power System Modelling** Importance and need for modelling in power system studies, Areas of power system analysis (steady-state, dynamic, stability studies), Basic concepts of power system dynamics: steady-state, transient, and small-signal stability, Modelling of non-electrical components: boiler, steam turbine, hydro turbine, governor system.	6
Unit 2	**Transformer and Transmission Line Modelling** Transformer modelling: two-winding, auto-transformer, tap-changing, phase-shifting transformer, Transmission line modelling: short, medium, and long lines, Special transformer connections and their modelling aspects.	7
Unit 3	**Synchronous Machine Modelling** Synchronous machine models for steady-state analysis, Park's transformation, current and flux linkage models, Equivalent circuits of synchronous machines, Determination of machine parameters, Synchronous machine connected to an infinite bus: steady-state behaviour.	7
Unit 4	**Excitation Systems** Fundamentals and role of excitation systems in stability, Excitation system configurations: DC generator, alternator-rectifier, static excitation systems, Standard block diagram representation	6

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	of excitation systems, Voltage regulators: electromechanical and solid-state, Voltage response ratio and exciter voltage ratings.	
Unit 5	**Power System Stabilizers and Small Signal Stability** Introduction to power system stability: steady-state, transient, voltage, and small-signal, Small-signal stability analysis of synchronous generator connected to infinite bus, Application of Routh–Hurwitz criterion for stability assessment, Power System Stabilizers (PSS): concepts, control signals, tuning, and field implementation.	7
Unit 6	**Transient and Voltage Stability** Transient stability: equal area criterion, factors affecting transient stability, Methods of improving transient stability, Voltage stability and voltage collapse: causes, effects, and preventive measures, Impact of excitation systems and reactive power compensation on voltage stability, Security aspects and contingency considerations (conceptual).	6
	Total Hours	**39**

Text Books:

1. Machowski Jan, Power System Dynamics: Stability and Control, Wiley, 3rd edition, 2020.
2. Joe H. Chow, Juan J. Sanchez-Gasca, Power System Modelling, Computation, and Control, Wiley, 1st edition, 2019.

Reference Books:

1. J. Duncan Glover, Thomas Overbye, Mulukutla S. Sarma, Power System Analysis and Design, Cengage Learning, 6th Edition, 2017.
2. Prabha Kundur, Neal J. Balu, Mark G. Lauby, Power System Stability and Control, McGraw Hill Professional, Special Indian Edition, 2017.

Useful link /Web Resources:

1. Dr. A.M. Kulkarni, Power System Dynamics and Control, IIT Bombay, https://nptel.ac.in/courses/108101004.
2. Prof. Arindam Ghosh, Power Systems Analysis, IIT Kanpur, https://nptel.ac.in/courses/108104051.

Power System for Grid Resilience

Course Code and Course Title	0EEPE503B Power System for Grid Resilience			
Semester	I			
Prerequisites	Power System Analysis, Power System Stability and Control, Power Electronics			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	1	-	
Credit	4			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

	Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:	BL
CO1	Explain the frameworks, metrics, and factors influencing resilience in modern power systems.	3
CO2	Analyse the dynamic behaviour of power system components under transient and stability conditions.	4
CO3	Evaluate the impact of renewable integration and oscillations on grid performance and resilience.	4
CO4	Develop effective control or protection strategies to enhance power system resilience against disturbances.	3

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Introduction to Power System Resilience** Definition and importance of power system resilience, Key challenges and vulnerabilities in power grids, Frameworks and metrics for assessing grid resilience.	6
Unit 2	**Power System Modelling and Analysis** Power system components and their mathematical representation, Power flow analysis and optimization techniques, Stability analysis: transient, voltage, and frequency stability, Harmonic analysis and mitigation strategies.	7
Unit 3	**Power System Oscillations** Overview of Sub synchronous oscillations (SSO) and its classification, Analysis of renewable energy systems, Impact of series compensation on SSO, Damping methods using advanced control system.	6
Unit 4	**Grid Integration of Renewable Energy Sources** Impact of renewable energy sources on grid resilience, Grid codes and standards for renewable energy integration, Power quality issues and solutions, Battery energy storage for grid resilience.	7

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Unit 5	**Case Studies and Real-World Applications** Analysis of grid resilience in response to natural disasters and cyber-attacks, Case studies of power system oscillations and their impact on grid resilience, Evaluation of resilience-enhancing strategies in power grids, Role of advanced technologies in enhancing grid resilience.	7
Unit 6	**Research Trends and Future Directions** Emerging technologies and trends in power system resilience, Research challenges and opportunities in the field, Discussion on ongoing research projects and advancements.	6
	Total Hours	39

Text Books:

1. Prabha Kundur, Neal J. Balu, Mark G. Lauby, Power System Stability and Control, McGraw Hill Education, 2nd Edition, 2022
2. Federico Milano, Advances in Power System Modelling, Control and Stability Analysis, Institution of Engineering and Technology, 1st Edition, 2016

Reference Books:

1. Manohar Mishra, Ramesh C. Bansal, Yog Raj Sood, Electric Power Systems Resiliency: Modelling, Opportunity and Challenges, Academic Press, 1st Edition, 2022
2. Anurag K. Srivastava, Chen-Ching Liu, Sayonsom Chanda, Resiliency of Power Distribution Systems, Wiley, 1st Edition, 2023

Useful link /Web Resources:

1. Dr. B. Kalyan Kumar, Power System Stability and Control, IIT Madras, https://nptel.ac.in/courses/108106026.
2. Prof. N. P. Padhy, Prof. Subho Pau, Advanced Distribution System Analysis and Operation, IIT Roorkee, https://nptel.ac.in/courses/108107716.

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Power Quality and Harmonics

Course Code and Course Title	0EEPE503C Power Quality and Harmonics			
Semester	I			
Prerequisites	Power Electronics, Power Quality, Power System			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	1	-	
Credit	4			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Classify different power quality problems, their causes, and effects on distribution and transmission networks.	2
CO2	Analyse harmonic generation from nonlinear loads, their impact on power factor, losses, and equipment performance.	4
CO3	Evaluate passive, active, and hybrid filtering solutions for harmonic mitigation and voltage disturbance compensation.	4
CO4	Analyse power quality monitoring techniques and examine emerging trends in smart grid integration.	4

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Fundamentals of Power Quality** Definition, scope, and importance of power quality in modern electrical systems, Desirable features of electric power supply, Classification of power quality problems, Sources and consequences of power quality disturbances in distribution and transmission networks, Load characteristics and their impact on PQ, Power quality indices and evaluation procedures	7
Unit 2	**Harmonics Generation** Fundamentals of harmonics: periodicity, Fourier representation, harmonic indices, Sources of harmonics: nonlinear loads, power electronic converters, arc furnaces, rotating machines etc.	6
Unit 3	**Harmonic Effects, and Standards** Impact of harmonics: on power factor, losses, resonance, neutral overloading, interference with communication systems, and equipment derating, Harmonic limits and standards.	6
Unit 4	**Harmonic Mitigation and Filtering Techniques** Passive filters, Active filters: shunt, series, hybrid configurations; principle of operation, control strategies, Case studies, Hybrid filters: shunt hybrid, series hybrid, unified power quality conditioner (UPQC) concepts, High power factor rectifiers and multi-pulse converters for harmonic suppression.	7

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Unit 5	**Voltage Disturbances and Mitigation** Voltage sags, swells, flicker, notching, interruptions: causes, characterization, and measurement, Equipment sensitivity and end-user issues, Mitigation methods: Dynamic Voltage Restorer, Distribution), Uninterruptible Power Supplies, Ferro-resonant transformers, superconducting magnetic energy storage.	7
Unit 6	**Power Quality Measurement, Monitoring, and Modelling** Instrumentation techniques: analog, digital, real-time PQ analyzers, Power quality monitoring standards and protocols, Data acquisition, storage, and interpretation; presentation of harmonic data, Future trends in PQ monitoring and smart grid integration.	6
	Total Hours	**39**

Text Books:

1. Roger C. Dugan et al, Electrical Power Systems Quality, McGraw Hill Education, 3rd edition, 2017.
2. Alexander Kusko, Thompson Marc T., Power Quality in Electrical Systems, McGraw-Hill, 1st Education, 2007.

Reference Books:

1. Ahmed F. Zobaa; Shady H. Abdel Aleem, Power Quality in Future Electrical Power Systems
2. Muhammad Mokhzaini Azizan, Power Quality - New Insights, IntechOpen, 2024

Useful link /Web Resources:

1. Prof. Prof. Bhim Singh, "Power Quality," IIT Delhi, https://nptel.ac.in/courses/108102179.
2. Dr. Mahesh Kumar, "Power Quality in Power Distribution Systems," IIT Madras, https://nptel.ac.in/courses/108106025.

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Research Methodology

Course Code and Course Title	0EERM504 Research Methodology			
Semester	I			
Prerequisites	Engineering Mathematics, Basic Communication & Technical Writing Skills, Project/ Seminar, Computer Programming / Tools for Research			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	1	-	
Credit	4			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Identify research problems from contemporary issues in Electrical Engineering.	2
CO2	Formulate hypotheses based on literature review and research gaps.	3
CO3	Evaluate experimental data using appropriate statistical techniques.	4
CO4	Prepare research reports and technical papers with proper citation and ethical practices.	4

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Introduction to Research** Meaning, Objectives, Motivation and Importance of Research, Types of Research: Fundamental, Applied, Analytical, Descriptive, Empirical, Qualitative, Quantitative, Research Process & Life Cycle, Identification and Definition of a Research Problem, Ethical Aspects in Research, Plagiarism and IPR issues (Patents, Copyrights, Trademarks)	6
Unit 2	**Literature Review and Hypothesis Formulation** Need and Importance of Literature Survey, Sources of Literature and Review Techniques (Databases, Reference Managers), Development of Working Hypothesis, Characteristics of a Good Hypothesis, Concept of Variables (Independent, Dependent, Confounding)	6
Unit 3	**Research Design and Sampling** Concepts and Features of a Good Research Design, Types of Research Designs: Descriptive, Experimental, Exploratory, Case Study, Principles of Experimental Design, Sampling Design: Concepts, Sampling Procedure, Criteria for Selecting a Sampling Method, Types of Sampling Methods (Probability and Non-Probability)	7
Unit 4	**Data Collection and Processing**	7

	Sources of Data: Primary & Secondary, Methods of Data Collection: Observation, Interview, Questionnaire, Schedule, Online Tools, Measurement in Research: Scales (Nominal, Ordinal, Interval, Ratio), Reliability & Validity, Scaling Techniques and Construction of Questionnaires, Data Processing: Editing, Coding, Classification, Tabulation, Visualization	
Unit 5	**Statistical Analysis and Hypothesis Testing** Statistical Analysis in Research: Descriptive and Inferential Statistics, Measures of Central Tendency, Dispersion, Skewness, Correlation and Regression Analysis, Hypothesis Testing: Parametric & Non-Parametric Tests, Chi-Square Test, t-Test, F-Test, ANOVA, ANCOVA, Multivariate Analysis (Introductory Concepts)	7
Unit 6	**Interpretation and Report Writing** Interpretation of Results: Precautions and Importance, Research Report: Types, Contents, Structure and Layout, Mechanics of Report Writing, Referencing Styles (APA, IEEE etc.), Writing Research Papers: Layout, Abstract, Keywords, Results, Discussion, Research Proposal Writing and Paper Publication Process, Impact Factor, Citation Index, h-index, Acknowledgments.	6
	Total Hours	39

Text Books:

1. C. R. Kothari, Gaurav Garg, Research Methodology: Methods and Techniques, New Age International Publishers, 4th edition, 2019.
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, SAGE Publications, 4th edition, 2020.

Reference Books:

1. Soumitro Banerjee, Research Methodology for Natural Sciences, IISc Press, 1st edition, 2022.
2. Deepak Chawla, Neena Sondhi, Research Methodology: Concepts and Cases, Vikas Publishing House, 2nd edition, 2016.

Useful link /Web Resources:

1. Prof. Soumitro Banerjee, Research Methodology in Natural Sciences, IISER Kolkata, https://nptel.ac.in/courses/127106227.
2. Prof. Edamana Prasad, Prof. Prathap Haridoss, Research Methodology, IIT Madras, https://nptel.ac.in/courses/121106007.

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Entrepreneurship

Course Code and Course Title	0EEHS505 Entrepreneurship			
Semester	I			
Prerequisites	Industrial Management, UHV			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

	Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:	BL
CO1	Explain the evolution, traits, and challenges of entrepreneurship through case-based understanding.	2
CO2	Apply creativity, design thinking, and validation techniques to convert innovative ideas into prototypes.	3
CO3	Analyse business models, financial options, and legal frameworks for new ventures.	4
CO4	Determine growth, sustainability, and leadership strategies for successful entrepreneurial ventures.	3

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Foundations of Entrepreneurship** Historical and modern perspectives of entrepreneurship, Entrepreneurial Journey: Indian and global case studies, Myths and realities: key entrepreneurial qualities, Entrepreneurial failure and learning from mistakes.	7
Unit 2	**Ideation to Prototype** Entrepreneurial discovery and opportunity identification, Creativity and design thinking for innovation, Ideation methods; prototyping techniques, Testing, validation, and commercialization of ideas.	6
Unit 3	**Business Models and Planning** Mission, vision, and value proposition development, Business Model Canvas and business model generation, Competitive advantage and strategies for start-ups, Team building and legal forms of business.	6
Unit 4	**Marketing and Financing Start-ups**	7

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	Principles of marketing management for start-ups, Market research, segmentation, and positioning. Financial statements, costing, break-even analysis, Raising financial resources: bootstrapping, crowd sourcing, angel investors, VCs, debt financing.	
Unit 5	**Innovation, Technology, and Legal Aspects** Technological innovation in entrepreneurship, Disruption and innovation-driven business models, Legal aspects: IPR, GST, labour law, due diligence, Government incentives, incubation, acceleration.	7
Unit 6	**Growth, Sustainability, and Leadership** Growth hacking, strategies for scaling ventures, Human resource management in start-ups, Risk assessment and strategy management, Entrepreneurial culture, ethics, sustainability, Future outlook: India as start-up nation, global trends.	6
	Total Hours	**39**

Text Books:

1. Rajeev Roy, Entrepreneurship, Oxford University Press, 3rd edition, 2020.
2. Debasish Biswas, Chanchal Dey, Entrepreneurship Development in India, Routledge, 1st edition, 2021.
3. Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, Entrepreneurship, Tata McGraw Hill, 9th edition, 2013.

Reference Books:

1. Deependra Sharma, Entrepreneurship in India, Taylor & Francis, 1st edition, 2022.
2. Antonella Zucchella, Giovanna Magnani, International Entrepreneurship: Theoretical Foundations and Practices, Barnes & Noble, 1st edition, 2016.

Useful link /Web Resources:

1. Prof. C. Bhaktavatsala Rao, Entrepreneurship, Department of Management Studies, IIT Madras, https://onlinecourses.nptel.ac.in/noc21_mg70/preview.
2. Prof. Rajat Agrawal & Prof. Vinay Sharma, Innovation, Business Models and Entrepreneurship, Department of Management Studies, IIT Roorkee, https://nptel.ac.in/courses/110107094.
3. Prof. B.K. Chakravarthy, Understanding Incubation and Entrepreneurship, IDC, IIT Bombay, https://nptel.ac.in/courses/107101092.

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PG Lab-I

Course Code and Course Title	0EEPCL506 PG Lab-I			
Semester	I			
Prerequisites	Control System, Power Electronics, Power Quality			
Teaching Scheme (hours per week)	**Lecture**	**Tutorial**	**Practical**	
	-	-	2	
Credit	1			
Evaluation Scheme	**ISE**		**ESE**	
	60 Marks		40 Marks	

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		**BL**
CO1	Observe the impact of control signal variations on converter output.	2
CO2	Simulate systems to analyse system performance and dynamic behaviour.	4
CO3	Investigate the behaviour of power systems using simulation-based studies.	4

The PG lab -I will be comprising of at least TWO experiments from each of the core technical courses. Minimum 8 experiments should be conducted.

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Control Techniques for Drives

Course Code and Course Title	0EEPC551 Control Techniques for Drives			
Semester	II			
Prerequisites	Power Electronics, Electrical Drives			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

	Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:	BL
CO1	Explain the operation and control of DC motor drives using converters and choppers.	3
CO2	Apply scalar and vector control techniques to induction motor drives for torque and speed regulation.	3
CO3	Analyse control strategies of synchronous, PMSM, BLDC, and SRM drives.	4
CO4	Analyse advanced and emerging control methods such as sensorless, renewable-energy based, and EV drives.	4

Course Content

Unit No.	Contents	Hrs.
Unit 1	**DC Motor Drives** Converter-fed DC drives: phase-controlled rectifiers, dual converters, four-quadrant operation; Chopper-controlled DC drives: duty-ratio control, current-limit control, inversion operation, field weakening; Closed-loop speed control of DC drives: inner current loop and outer speed loop; Dynamic performance and pulsating torque analysis.	7
Unit 2	**Scalar Control of Induction Motor Drives** Principles of speed control of induction motor: stator voltage, rotor resistance, frequency variation; Scalar control: V/f control, slip compensation, flux optimization, Closed-loop scalar control with slip compensation; Performance evaluation and limitations of scalar control.	6
Unit 3	**Vector Control of Induction Motor Drives** Concept of vector control: decoupling of torque and flux; Direct and indirect vector control, synchronous and stationary reference frames; Field-Oriented Control (FOC): principles, coordinate transformations (Park & Clarke), feed-forward and decoupling compensation, implementation aspects; Direct Torque Control (DTC): hysteresis and space-vector-based DTC, torque ripple minimization.	7
Unit 4	**Synchronous Motor Drives**	7

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	Synchronous motor drives: self-control, VSI/CSI-fed drives, load-commutated inverter-fed drives; Permanent Magnet Synchronous Motor (PMSM) drives: modelling, torque equations, implementation of vector control.	
Unit 5	**BLDC, SRM and Electric Vehicle Drives** Brushless DC (BLDC) drives: control strategies and commutation techniques; Switched Reluctance Motor (SRM) drives: torque/current control, voltage control, converter topologies; Electric vehicle (EV) propulsion drives: configuration, control strategies, regenerative braking.	6
Unit 6	**Renewable-Energy-Based Drives and Emerging Techniques** Control of solar PV-powered drives; Control of DFIG drives for wind energy applications; Sensorless control: back-EMF, MRAS, observer-based methods; Overview of advanced control: predictive, adaptive, and intelligent drive control trends.	6
	Total Hours	**39**

Text Books:

1. R. Krishnan, Electric Motor Drives: Modelling, Analysis, and Control, Pearson Education, Revised edition, 2025.
2. Ion Boldea, Electric Drives, CRC Press, 4th edition, 2025.

Reference Books:

1. Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson Education, 2002.
2. Austin Hughes & Bill Drury, Electric Motors and Drives: Fundamentals, Types and Applications, Elsevier, 5th edition, 2019.

Useful link /Web Resources:

1. Dr. S.P. Das, Advanced Electric Drives, IIT Kanpur, https://nptel.ac.in/courses/108104011.
2. Prof. K. Gopakumar, Industrial Drives - Power Electronics, IISc Bangalore, https://nptel.ac.in/courses/108108077.

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Advanced Power System Protection

Course Code and Course Title	0EEPC552 Advanced Power System Protection			
Semester	II			
Prerequisites	Power System, Switchgear and Protection			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Differentiate static relay comparators and interpret their amplitude and phase comparison characteristics.	2
CO2	Evaluate the performance of differential, overcurrent, and distance protection schemes using analytical methods.	4
CO3	Implement microprocessor-based protection algorithms for overcurrent and distance relays.	3
CO4	Examine the role of numerical relays and communication standards in modern substation protection systems.	3

Course Content

Unit No.	Contents	Hrs.
Unit 1	Static Relays Need for advanced protection systems; advantages of static relays, Basic construction and working principle of static relays, Level detectors and mixing circuits, Duality between amplitude and phase comparators, Amplitude comparators: circulating current type, opposed voltage type, rectifier bridge, direct and instantaneous comparators, General equations for two-input comparators.	7
Unit 2	Phase Comparators and Overcurrent Protection Phase comparators: coincidence circuit type, block-spike comparator, integrating type, rectifier and vector product type, Hybrid comparators, Static overcurrent relays: instantaneous, definite time, and inverse definite time (IDMT) relays, Coordination aspects of static overcurrent relays.	6
Unit 3	Differential and Distance Relays Principle and analysis of static differential relays, Differential relay schemes: biased and harmonic restraint methods, Transformer differential protection – duo bias scheme, Static distance relays: impedance, reactance, and MHO relays, Sampling comparators for realization of reactance and MHO characteristics.	7

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Unit 4	Multi-Input Comparators and Power Swing Effects Conic section characteristics of comparators, Three-input amplitude comparator, hybrid comparator, Switched distance and polyphase distance schemes, Phase fault and ground fault schemes, Power swings: analysis, impact on distance relay performance, principles of out-of-step tripping and blocking, Effect of line length and source impedance on distance protection.	6
Unit 5	Microprocessor Based Protective Relays Block diagram and flowchart approach of microprocessor-based relays, Overcurrent, impedance, directional, and reactance relays, Mathematical formulation for distance relays: measurement of resistance and reactance, Realization of MHO and offset MHO characteristics, Basic principles of digital computer relaying and relay algorithms.	6
Unit 6	Numerical Relays and Modern Protection Standards Concept and advantages of numerical relays, Hardware and software architecture of numerical relays, Protection and control using IEC 61850: concept, communication framework, benefits, Ethernet-based protection schemes and substation automation, Introduction to adaptive and intelligent protection systems.	7
	Total Hours	**39**

Text Books:

1. Ravindranath B, M Chander, Power System Protection and Switchgear, New Age, 2nd Edition, 2018.
2. Badri Ram, D.N. Vishwakarma, Power System Protection and Switchgear, McGraw Hill Education, 2nd Edition, 2017.

Reference Books:

1. Gerhard Ziegler, Numerical Distance Protection: Principles and Applications, Wiley, 4th Edition, 2011.
2. J. Lewis Blackburn, Thomas J. Domin, Protective Relaying: Principles and Applications, CRC Press, 4th Edition, 2014.

Useful link /Web Resources:

1. Prof. Bhaveshkumar R. Bhalja, Power System Protection and Switchgear, IIT Roorkee, https://nptel.ac.in/courses/108107167.
2. Prof. S.A. Soman, Power System Protection, IIT Bombay, https://nptel.ac.in/courses/108101039.
3. Prof. Ashok Kumar Pradhan, Power System Protection, IIT Kharagpur, https://nptel.ac.in/courses/108105167.

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Distributed Generation and Smart Grid

Course Code and Course Title	0EEPC553 Distributed Generation and Smart Grid			
Semester	II			
Prerequisites	Power System, Renewable Energy Sources			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Explain the characteristics, benefits, and challenges associated with distributed generation systems.	3
CO2	Analyse microgrid structures, control strategies, and operational modes for reliable energy management.	4
CO3	Analyse the role of communication, automation, and data analytics in smart grid functionality.	4
CO4	Evaluate regulatory frameworks, interoperability issues, and emerging trends in distributed and smart grid technologies.	4

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Introduction to Distributed Generation** Overview of conventional vs. distributed generation; Energy crises and need for distributed generation; Review of renewable energy systems: Solar PV, Wind, Biomass, Micro-turbines, Fuel cells, and Small Hydro; Advantages, challenges, and classification of DG systems.	6
Unit 2	**Distributed Generation Systems and Technologies** DG topologies and configurations; Standards for interconnection of DG with utility grid: IEEE 1547, IEC standards; Power electronic interfaces and control of DG systems; Energy storage technologies: Batteries, Supercapacitors, Flywheels; Captive power plants and hybrid DG systems.	7
Unit 3	**Grid Integration and Operational Issues** Requirements for grid interconnection: voltage, frequency, and THD limits; Synchronization and power flow control in grid-connected DG systems; Impacts of DG integration on power system: voltage regulation, stability, protection, and reliability; Islanding and anti-islanding techniques (passive, active, and communication-based); Power quality and harmonic distortion considerations.	7

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Unit 4	**Microgrids: Architecture and Control** Concept, components, and configurations of microgrids (AC, DC, and hybrid); Control architectures: centralized, decentralized, and hierarchical control; Operational modes: grid-connected and islanded operation; Power management, droop control, and load sharing; Protection coordination and communication infrastructure in microgrids.	7
Unit 5	**Smart Grid Technologies and Communication** Evolution from microgrid to smart grid: definition, objectives, and characteristics; Smart metering infrastructure (AMI), demand response, and energy management systems; Communication technologies: IoT, SCADA, PMUs, and IEC 61850; Cybersecurity issues in smart grids; Role of ICT and data analytics in smart grid operation.	6
Unit 6	**Applications, Standards, and Future Trends** Smart grid policies, regulatory framework, and international standards; Integration of EVs and energy storage in smart grids; Distributed energy resource management (DERMS); Microgrid economics and techno-economic assessment; Future research directions: AI-enabled energy systems, blockchain in grid management, and sustainable energy transition.	6
	Total Hours	**39**

Text Books:

1. Anne-Marie Borbely, Jan F. Kreider, Distributed Generation: The Power Paradigm for the New Millennium, CRC Press, 1st Edition, 2001.
2. Stuart Borlase, Smart Grids: Advanced Technologies and Solutions, CRC Press, 2nd Edition, 2018.

Reference Books:

1. S. Chowdhury, S.P. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, IET, 1st Edition, 2009.
2. Math H. J. Bollen, Fainan Hassan, Integration of Distributed Generation in the Power System, Wiley-IEEE Press, 1st Edition, 2011.

Useful link /Web Resources:

1. Dr. Vinod John, Power Electronics and Distributed Generation, IISc Bangalore, https://nptel.ac.in/courses/108108034.
2. Prof. Avik Bhattacharya, Dc Microgrid and Control System, IIT Roorkee, https://nptel.ac.in/courses/108107143.
3. Prof. N.P. Padhy Prof. Premalata Jena, Smart Grid: Basics to Advanced Technologies, IIT Roorkee, https://nptel.ac.in/courses/108107113.

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Transients in Power System

Course Code and Course Title	0EEPE554A Transients in Power System			
Semester	II			
Prerequisites	Power System, Power Quality and Harmonics			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Explain the mechanisms and effects of switching, lightning, and temporary overvoltages in power systems.	2
CO2	Model transmission lines and underground cables to study transient behavior using distributed parameter theory.	3
CO3	Analyse transient phenomena caused by shunt capacitor switching and nonlinear loads.	4
CO4	Simulate and interpret power system transients using digital computational tools such as EMTP.	3

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Introduction to Power System Transients** Definition and classification of transients: switching, lightning, and temporary, Sources and nature of transients in power systems, RL and RLC circuit transients with sinusoidal excitation, Double-frequency transients and Laplace transform methods, Importance of transient study in planning and design, Role of grounding in transient control and mitigation.	6
Unit 2	**Travelling Waves on Transmission Lines** Lumped vs. distributed parameter lines; wave equation derivation, Reflection and refraction of travelling waves at discontinuities, Lattice diagrams and energy considerations, Attenuation, distortion, and distortionless line condition, Behaviour of travelling waves at line terminations.	6
Unit 3	**Lightning, Switching, and Temporary Overvoltages** Lightning overvoltages: mechanisms, interaction with power system, and protection using ground wires and surge arresters, switching overvoltages: short line faults, energizing transients, reclosing phenomena, and control techniques, Temporary overvoltages: line dropping, load rejection, and resonance effects, very fast transient overvoltages (VFTO) and associated insulation coordination.	7

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Unit 4	**Modelling of Transmission and Cable Systems** Line parameters: resistance, inductance, capacitance, and conductance, Bundle conductors, equivalent GMR and equivalent radius, Modal propagation, α-β-0 transformation, and symmetrical component approach, Effect of ground return and skin effect; transposition schemes, Overview of cable types, impedance and admittance matrices for three-phase systems, and comparison with overhead lines.	7
Unit 5	**Transients due to Shunt Capacitor Switching and Nonlinear Loads** Characteristics of three-phase shunt capacitor switching transients, Influence of system parameters on transient magnification, Switching overvoltages in capacitor banks and mitigation techniques, Transient effects in nonlinear loads such as electric arc furnaces, Flicker generation and measurement.	6
Unit 6	**Computation of Power System Transients** Fundamentals of transient computation and numerical techniques, Digital evaluation of line parameters and importance of line modelling, Introduction to EMTP: structure, solution algorithms, and modules; Steady-state initialization and time-step solutions, Applications of EMTP in system planning, insulation coordination, and protection studies.	7
	Total Hours	**39**

Text Books:

1. Akihiro Ametani, Naoto Nagaoka, Yoshihiro Baba, Teruo Ohno, Power System Transients: Theory and Applications, CRC Press, 2nd edition, 2020.
2. Juan A. Martinez-Velasco, Power System Transients: Parameter Determination, CRC Press, 1st edition, 2009.

Reference Books:

1. Juan A. Martinez-Velasco, Transient Analysis of Power Systems: Solution Techniques, Tools, and Applications, Wiley-IEEE Press, 1st edition, 2015.
2. Hermann W. Dommel, EMTP Theory Book, Microtran Power System Analysis Corporation, 1st edition, 1992.

Useful link /Web Resources:

1. Prof. Ananth Krishnan, Transmission lines and electromagnetic waves, IIT Madras, https://nptel.ac.in/courses/108106157.
2. Prof. Debapriya Das, Power System Engineering, IIT Kharagpur, https://nptel.ac.in/courses/108105104.

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Renewable Energy Systems

Course Code and Course Title	0EEPE554B Renewable Energy Systems			
Semester	II			
Prerequisites	Electrical Machines, Power Electronics, Power Plant Engineering, Power Systems			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Analyse the global and Indian energy scenario, identifying the importance of renewable energy in sustainable development.	4
CO2	Design and evaluate solar photovoltaic and wind energy conversion systems considering performance, control, and environmental factors.	3
CO3	Examine the issues and requirements related to grid integration of renewable energy systems, focusing on power quality and reliability.	4
CO4	Compare different energy storage technologies and assess their applications in renewable-based hybrid systems.	4

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Energy Scenario and Fundamentals of Renewable Systems** Overview of global and Indian energy demand and consumption patterns; Classification of energy sources: conventional and non-conventional; Energy efficiency, energy security, and sustainability Environmental impacts of energy use and climate change issues; Global environmental initiatives: Kyoto Protocol, Clean Development Mechanism (CDM), and Prototype Carbon Fund (PCF); Drivers and barriers to renewable energy adoption	6
Unit 2	**Solar Photovoltaic Energy Systems** Principles of photovoltaic conversion and current-voltage characteristics; Solar cell technologies: mono/polycrystalline, thin film, and emerging PV technologies; Equivalent circuit and performance modelling of PV systems; Design aspects of PV arrays, effect of shading and temperature; Solar tracking systems, Maximum Power Point Tracking (MPPT) techniques; Building-integrated PV systems: components, sizing, and economics	7
Unit 3	**Wind Energy Conversion System** Fundamentals of wind energy conversion: wind speed and power relation, Betz limit; Wind resource assessment: wind speed measurement and statistical modelling; Wind turbine components, aerodynamics, and generator selection; Power electronics converters in wind turbine systems; Wind Energy Conversion System; Control of Wind Turbine; Control	7

	strategies for maximum power extraction, reactive power control, and grid support; Environmental and site selection considerations for wind farms	
Unit 4	**Case Studies of Solar Power Plant Design** Overview of solar power plant configurations: on-grid, off-grid, and hybrid systems; Components of solar power systems: panels, inverters, batteries, mounting and monitoring systems; Net metering concepts and calculations for 5 kW residential solar systems; Industrial solar power systems: sizing and design for 200 kW installations; Economic analysis, advantages, and limitations of solar power deployment	7
Unit 5	**Grid Integration of Renewable Energy Sources** Interface requirements and standards for renewable-grid interconnection; Voltage and frequency operating limits for stable operation; Impact of renewables on grid performance and load scheduling; Power quality concerns: harmonics, transients, voltage sags, and flickers; Reactive power support, synchronization, and protection aspects; Smart inverters and grid code compliance	6
Unit 6	**Energy Storage Systems for Renewable Applications** Need and benefits of energy storage in renewable systems; Types of storage: (a) Mechanical: Pumped hydro, flywheel, compressed air, (b) Electrochemical: Batteries (Li-ion, flow, NaS), battery management systems, (c) Thermal & Phase Change Materials (PCM), (d) Hydrogen-based: Electrolysis, storage, and fuel cells; Applications of hybrid storage for stability and reliability improvement	6
	Total Hours	**39**

Text Books:

1. Kothari D.P. and Singal K.C., Renewable Energy Sources and Emerging Technologies, PHI Learning Pvt. Ltd., 3rd Edition, 2020.
2. Bent Sorensen, Renewable Energy Conversion, Transmission and Storage, Elsevier Science, 1st Edition, 2007.

Reference Books:

1. Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro, Power Conversion and Control of Wind Energy Systems, IEEE Press, Wiley, 1st Edition, 2011.
2. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, Wiley, 2nd Edition, 2013

Useful link /Web Resources:

1. Prof. Vaibhav Vasant Goud Prof. R. Anandalakshmi, Renewable Energy Engineering: Solar, Wind And Biomass Energy Systems, IIT Guwahati, https://nptel.ac.in/courses/103103206.
2. Prof. P. Mondal, Technologies for Clean and Renewable Energy Production, IIT Roorkee, https://nptel.ac.in/courses/103107157.
3. Prof. Amreesh Chandra, Physics of Renewable Energy Systems, IIT Kharagpur, https://nptel.ac.in/courses/115105127.

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Power System Optimization

Course Code and Course Title	0EEPE554C Power System Optimization			
Semester	II			
Prerequisites	Power System, Electric Circuit Analysis and Mathematics			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Analyse various optimization techniques applicable to power system operation, including classical and intelligent search methods.	4
CO2	Solve economic dispatch and unit commitment problems using suitable optimization algorithms.	3
CO3	Analyse hydrothermal coordination and optimal power flow problems considering system constraints and operational objectives.	4
CO4	Evaluate multi-objective optimization approaches for achieving trade-offs among economic, technical, and environmental goals in power systems.	4

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Fundamentals of Optimization** Definition and Classification of Optimization Problems – Unconstrained and Constrained Optimization, Optimality Conditions – Classical Optimization Techniques (Linear and Non-linear Programming, Mixed Integer Programming), Intelligent Search Methods (Optimization Neural Network, Genetic Algorithms, Particle Swarm Optimization).	6
Unit 2	**Optimization for Economic Dispatch Problem** Economic Dispatch Problem, Thermal System Dispatching with Network Losses, Lambda-Iteration Method, Gradient Methods of Economic Dispatch, Newton's Method, Economic Dispatch using Dynamic Programming and Genetic Algorithms	7
Unit 3	**Optimization for Unit Commitment** Constraints in Unit Commitment, Thermal Unit Constraints, Other Constraints, Hydro Constraints, Fuel Constraints, Unit Commitment Solution Methods – Priority-List Method, Dynamic Programming, Lagrange Relaxation, Particle Swarm Optimization, Genetic Algorithm.	7

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Unit 4	**Hydrothermal Coordination** Long-Range and Short-Range Hydro-Scheduling, Hydroelectric Plant Models, Short-Term Hydrothermal Scheduling Problem, Gradient Approach, Hydraulically Coupled Hydro Units, Pumped Storage Hydro Plants, Hydro-Scheduling using Linear Programming and Dynamic Programming.	7
Unit 5	**Optimal Power Flow** Optimal Power Flow Problem, Gradient Method, Linear Sensitivity Coefficients, Linear and Non-Linear Programming Methods, Security-Constrained OPF, Interior Point Algorithm, Genetic Algorithm and Particle Swarm Optimization-based OPF.	6
Unit 6	**Multi-objective Optimization** Introduction to Multi-objective Optimization, Concept of Pareto Optimality, Multi-objective Genetic Algorithm (MOGA), Fitness Assignment, Sharing Function, Economic Emission Dispatch using MOGA and Multi-objective Particle Swarm Optimization.	6
	Total Hours	**39**

Text Books:

1. Allen J. Wood and B. F. Wollenberg, Power Generation, Operation and Control, John Wiley & Sons.
2. D. P. Kothari and J. S. Dhillon, Power System Optimization, PHI Learning Pvt. Ltd.

Reference Books:

1. Olle I. Elgerd, Electric Energy Systems Theory – An Introduction, TMH.
2. Jizhong Zhu, Optimization of Power System Operation, John Wiley & Sons.
3. Soliman Abdel Hady and Abdel Aal Hassan Mantawy, Modern Optimization Techniques with Applications in Electric Power Systems.
4. Kwang Y. Lee and Mohammed A. El-Sharkawi, Modern Heuristic Optimization Techniques, John Wiley & Sons.

Useful link /Web Resources:

1. Prof. Uday K Khankhoje, Optimization Theory and Algorithms, IIT Madras, https://nptel.ac.in/courses/108106478.
2. Prof. C. Balaji, Design and Optimization of Energy systems, IIT Madras, https://nptel.ac.in/courses/112106064.
3. Prof. Gururaj Mirle Vishwanath, Prof. Narayana Prasad Padhy, Economic Operations and Control of Power Systems, IIT Kanpur, https://nptel.ac.in/courses/108104191.

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Intelligent Control System

Course Code and Course Title	0EEPE555A Intelligent Control System			
Semester	II			
Prerequisites	Linear Algebra and Differential Equations, Signals and Systems, Basic Probability and Statistics.			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

	Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:	BL
CO1	Explain the fundamental concepts, architecture, and characteristics of intelligent control systems.	2
CO2	Apply fuzzy logic and neural network principles to model and analyse nonlinear control systems.	3
CO3	Develop intelligent control algorithms using ANN, fuzzy logic, and hybrid approaches such as neuro-fuzzy and adaptive control.	3
CO4	Utilize optimization techniques like Genetic Algorithms for tuning and performance enhancement of intelligent control systems.	3

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Introduction to Intelligent Control** Concept and evolution of intelligent control; Comparison of conventional and intelligent control; Characteristics and hierarchical structure of intelligent control systems; Basic elements—knowledge base, inference mechanism, and learning; Overview of computational intelligence techniques (ANN, Fuzzy, GA, Expert Systems) and their role in control.	6
Unit 2	**Fuzzy Logic and Fuzzy Control Systems** Concept of fuzzy sets and fuzzy logic; Classical vs fuzzy sets; Membership functions and their selection; Fuzzy rules and reasoning; Fuzzification and defuzzification techniques; Design of fuzzy controllers – direct and supervisory fuzzy control; Fuzzy PID controller – design and tuning; Stability considerations in fuzzy control systems.	7
Unit 3	**Artificial Neural Networks: Structures and Learning** Biological neuron and artificial neuron models; Activation functions; Supervised, unsupervised, and reinforcement learning; Single and multilayer feedforward networks; Backpropagation algorithm; Radial basis function networks; Self-organizing maps and competitive learning; Performance considerations in training.	6

Unit 4	**Neural Networks for Control** Feedback and recurrent neural networks; Hopfield and adaptive resonance theory (ART) models; Neural network-based modelling of nonlinear systems; Neural network-based controllers – inverse control, model reference control, and predictive control; Adaptive and learning control using neural networks; Case studies in power system stability and drive control.	7
Unit 5	**Neuro-Fuzzy and Hybrid Intelligent Control** Integration of fuzzy logic and neural networks: Neuro-fuzzy modelling and adaptive neuro-fuzzy inference system (ANFIS); Architecture and learning algorithms for ANFIS; Neuro-fuzzy controllers – structure, training, and implementation; Model-based and indirect adaptive neuro-fuzzy control; Stability and performance analysis.	6
Unit 6	**Evolutionary and Genetic Algorithm-Based Control** Fundamentals of genetic algorithms (GAs): Encoding, selection, crossover, mutation; Parameter tuning and fitness evaluation; GA-based system identification and control optimization; Tuning of PI/PID controllers using GAs; Introduction to other evolutionary techniques (PSO, DE, ACO); Intelligent optimization in electrical drives, power system control, and renewable integration.	7
	Total Hours	**39**

Text Books:

1. Laurance Fausett, Englewood Cliffs, N.J., 'Fundamentals of Neural Networks', Pearson Education.
2. Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 3rd Edition ,2010.
3. Huỳnh Thái Hoàng, Intelligent Control Systems, VNU-HCM Publisher, 2006
4. Kelvin M. Passino, Biomimicry for Optimization, Control and Automation, Springer, 2006.

Reference Books:

1. S.N.Sivanandam and S.N.Deepa, Principles of Soft computing, Wiley India Edition, 2nd Edition,2013
2. Simon Haykin, 'Neural Networks', Pearson Education, 2003.
3. M.Gen and R,Cheng, Genetic algorithms and optimization, Wiley Series in Engineering Design and Automation, 2000.
4. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice Hall of India, 2nd Edition, 2012.

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Industrial Automation

Course Code and Course Title	0EEPE555B Industrial Automation			
Semester	II			
Prerequisites	Measurement and Instrumentation, Control System, Electrical Drives			
Teaching Scheme (hours per week)	**Lecture**	**Tutorial**	**Practical**	
	3	-	-	
Credit	3			
Evaluation Scheme	**ISE 1**	**MSE**	**ISE 2**	**ESE**
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		**BL**
CO1	Explain the structure and operation of industrial automation systems.	3
CO2	Apply knowledge of sensors, actuators, and power electronic devices in automation applications.	3
CO3	Develop PLC programs and simulate industrial control processes.	3
CO4	Analyse the integration of PLC, SCADA, and DCS in industrial automation environments.	4

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Introduction To Industrial Automation Systems** Architecture of industrial automation system, elements of automated system, advantages, industrial automation trends.	6
Unit 2	**Sensors And Actuators** Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices DIAC, TRIAC, power MOSFET and IGBT, DC and AC servo drives, VFD.	7
Unit 3	**Computer Aided Measurement and Control Systems** Role of computers in measurement and control, Elements of computer aided measurement and control, man-machine interface, computer aided process control hardware, process related interfaces, Communication and networking, Industrial communication systems, Data transfer techniques, Computer aided process control software, Computer based data acquisition system, Internet of things (IoT) for plant automation.	6
Unit 4	**Programmable Logic Controllers** Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and	6

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	networking, PLC selection, PLC Installation, Advantage of using Automation overview, Requirement of automation systems.	
Unit 5	**Supervisory Control and Data Acquisition** Architecture of Industrial Automation system, Introduction to supervisory control and data acquisition (SCADA), SCADA architecture and components, communication between PLC and SCADA, Basics of data communication-RS 485, Ethernet, Industrial communication protocols: Modbus, Profibus, CAN.	7
Unit 6	**Distributed Control System** Overview of DCS, Difference between PLC and DCS, DCS architecture and components software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, HMI, Features of DCS, Advantages of DCS. Case study: DCS for power plant.	7
	Total Hours	**39**

Text Books:

1. Jon Stenerson and Chuck Petruzella, Industrial Automation and Process Control, 2nd Edition, McGraw Hill Education, 2017.
2. John W. Webb and Ronald A. Reis, Programmable Logic Controllers: Principles and Applications, 6th Edition, Pearson Education, 2011.

Reference Books:

1. B. Wayne Bequette, Process Control: Modelling, Design and Simulation, 1st Edition, Prentice Hall, 2003.
2. Krishna Kant, Computer-Based Industrial Control, 2nd Edition, Prentice Hall of India, 2011.

Useful link /Web Resources:

1. Prof. S. Mukhopadhyay, Prof. S. Sen, Industrial Automation and Control, IIT Kharagpur, https://nptel.ac.in/courses/108105063.
2. Prof. David Trumper, Mechatronics, Massachusetts Institute of Technology, https://ocw.mit.edu/courses/2-737-mechatronics-fall-2014/.

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Discrete Time Control System

Course Code and Course Title	0EEPE555C Discrete Time Control System			
Semester	II			
Prerequisites	Modern Control System			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Analyse dynamics of discrete-time control system.	4
CO2	Analyse the stability of discrete time system.	4
CO3	Representation of discrete time control system in state space.	2
CO4	Develop of discrete-time control systems by pole placement and state observers.	3

Course Content

Unit No.	Contents	Hrs.
Unit 1	The Z and inverse Z transform Introduction of discrete time system, Z- transform, propertied of Z- transform, transform of elementary function, obtaining the Z transform by the convolution integral methods, Inverse Z transform, Inverse Z transform by inversion integral method, Z transform method for solving difference equations.	7
Unit 2	Z- plan analysis of discrete time control Impulse sampling and data hold, transform of impulse sampled signal, transform of signal involving both ordinary and starred Laplace transforms.	6
Unit 3	Block diagram analysis Pulse transfer function, Pulse transfer function by difference equation, direct programming method, block diagram analysis.	6
Unit 4	Stability of discrete time system Introduction, mapping between S plane and Z plane, equivalence between Z domain and S domain, stability analysis by Jury test and bilinear transformation with Routh criterion.	6
Unit 5	State space representation of discrete time control system Introduction, state space representation of discrete time control system, solving discrete time state space equation, Z-transform method, state transition matrix by Z transform and Cayley- Hamilton method.	7

Unit 6	Design of discrete time system Concepts of Controllability and observability, Kalman's test for controllability and observability; Discrete time system Design via pole placement and observer.	7
	Total Hours	**39**

Text Books:

1. Katsuhiko Ogata, Discrete time control systems, PHI Publication, Second edition.

Reference Books:

1. M. Gopal, Digital control and state variable methods, Tata McGraw Hill publication, Second edition

Communication Skill

Course Code and Course Title	0EEHS556 Communication Skill			
Semester	II			
Prerequisites	Basic knowledge of English grammar and vocabulary			
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical	
	3	-	-	
Credit	3			
Evaluation Scheme	ISE 1	MSE	ISE 2	ESE
	10 Marks	20 Marks	10 Marks	60 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		BL
CO1	Demonstrate effective verbal and non-verbal communication in academic and professional settings.	3
CO2	Implement effective presentation strategies and public speaking techniques to design, structure, and deliver impactful messages tailored to diverse audiences.	3
CO3	Construct well-organized technical documents and research-driven writing by implementing appropriate formats, citation styles, and ethical communication practices.	3
CO4	Apply interpersonal and intercultural communication strategies in collaborative environments.	3

Course Content

Unit No.	Contents	Hrs.
Unit 1	**Foundations of Communication** Introduction: Nature & Scope of Communication, Verbal & Nonverbal Communication, Communication Barriers & Overcoming Them, Cultural Sensitivity in Communication, Technical Communication: Nature and Demands, Listening & Feedback Skills.	6
Unit 2	**Oral Communication and Presentation Skills** Public Speaking Fundamentals; Presentation Design; Delivery Techniques; Handling Q & A Sessions.	7
Unit 3	**Technical and Professional Writing** Principles of Technical Writing; Report Writing; Proposals and Memos; Email Etiquette; Summaries and Abstracts.	6
Unit 4	**Academic and Research Communication** Literature Review Techniques; Citation and Referencing; Research Paper Writing; Plagiarism and Ethics; Poster and Conference Presentations.	6
Unit 5	**Interpersonal Communication, Teamwork, and Leadership**	7

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	Interpersonal dynamics and emotional intelligence; Team communication and collaboration in research projects; Leadership communication and conflict resolution; Negotiation and persuasion skills; Cultural adaptability in global teams.	
Unit 6	**Communication for Career Development** Resume and Cover Letter Writing; Interview Preparation; Group Discussions; Networking and Professional Etiquette.	7
	Total Hours	**39**

Text Books:

1. Sanjay Kumar and Pushp Lata, Communication Skills, Oxford University Press, 2nd Edition, 2020.
2. Meenakshi Raman and S. Sharma, Technical Communication, Oxford University Press, 3rd Edition, 2017.
3. Mohd. Ashraf Rizvi, Effective Technical Communication, Tata McGraw Hill, 2nd Edition, 2017.

Reference Books:

1. M.K. Sehgal and Vandana Khetarpal, Business Communication, Excel Books, Latest Edition, 2021.
2. Gopalaswamy Ramesh, The ACE of Soft Skills, Pearson, 1st Edition, 2010.
3. Communication Works, Teri Kwale Gamble and Michael Gamble, Tata McGraw Hill Education, 1st Edition, 2010.
4. Kenneth Anderson, Joan Maclean, and Tossny Lynch, Study Speaking: A Course in Spoken English for Academic Purposes, Cambridge University Press, 1st Edition, 2004.
5. K. Aswathappa, Organisational Behaviour, Himalayan Publication, Mumbai, 1st Edition, 1991.
6. N. Atreya and Guha, Effective Credit Management, MMC School of Management, Mumbai, 1st Edition, 1994.
7. K.R. Balan and C.S. Rayudu, Effective Communication, Beacon, New Delhi, 1st Edition, 1996.

PG Lab-II

Course Code and Course Title	0EEPCL557 PG Lab-II		
Semester	II		
Prerequisites	Control System, Electrical Drives, Power Plant Engineering, Power System		
Teaching Scheme (hours per week)	Lecture	Tutorial	Practical
	-	-	2
Credit	1		
Evaluation Scheme	ISE		ESE
	60 Marks		40 Marks

	Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:	BL
CO1	Analyse the performance characteristics of advanced electrical systems under various operating and control conditions.	4
CO2	Develop simulation models to evaluate the effectiveness of modern protection, control, and generation techniques.	3
CO3	Analyse the impact of intelligent and optimization-based control strategies on overall system performance.	4

The PG lab -I will be comprising of at least TWO experiments from each of the core technical courses. Minimum 10 experiments should be conducted.

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Seminar

Course Code and Course Title	0EEPCL558 Seminar		
Semester	II		
Prerequisites	Communication Skill, Basic Knowledge of Core Electrical Engineering Subjects		
Teaching Scheme (hours per week)	**Lecture**	**Tutorial**	**Practical**
	-	-	2
Credit	1		
Evaluation Scheme	**ISE**		**ESE**
	60 Marks		40 Marks

Course Outcomes (COs): - Upon successful completion of this course, the student will be able to:		**BL**
CO1	Analyse contemporary research trends through systematic literature survey.	**4**
CO2	Present technical information effectively through written report and oral presentation.	**3**

The Seminar shall be based on a state-of-the-art topic approved by the concerned guide. Each student must select a recent and technically significant topic after conducting a thorough literature survey from reputed sources such as Scopus/ESCI indexed journals, conference papers, and standard reference books. The student should prepare a comprehensive report in the prescribed format. The seminar work aims to enhance the student's ability to review, analyse, and present current developments in Electrical Engineering. The student must periodically discuss progress with the assigned faculty guide. The student shall deliver an oral presentation at the end of the semester. The evaluation will be based on topic selection, report quality, presentation skills, and overall understanding of the subject.

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