Scheme of Instruction and Syllabi

Master of Engineering

A TWO YEAR (I–IV Semesters) PG Program

in

POWER SYSTEMS AND POWER ELECTRONICS

(AICTE Model Curriculum with effect from AY 2026-27)

(R–26 Regulation)

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

(Autonomous Institution under UGC, affiliated to Osmania University)

Department of Electrical and Electronics Engineering

Accredited with NAAC- (A++)

Chaitanya Bharathi (Post), Gandipet, Hyderabad–500075

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

OUR MOTTO: SWAYAM TEJASWIN BHAVA

Vision and Mission of the Institute

Vision

To be a centre of excellence in technical education and research.

Mission

To address the emerging needs through quality technical education and advanced research.

Vision And Mission of The Department of EEE

Vision

To achieve Academic and Professional Excellence in Teaching and Research in the frontier areas of Electrical and Electronics Engineering **Visa -Versa** as a Valuable Resource for Industry and Society.

Mission

Empowering Faculty and Student Rendezvous to Nurture Interest for Conceptual Keystone, Applied Multidisciplinary Research, Inspiring Leadership and Efficacious Entrepreneurship culture, Impeccable Innovation in frontier areas to be synergetic with Environmental, Societal and Technological Developments of the National and International community for Universal Intimacy.

M1: Emphasis on providing Strong Theoretical Foundation & Engineering Leadership Eminence, infusion of Creativity and Management skills while maintaining Ethics and Moral for Sustainable Development. (Individual development)

M2: Enable the Faculty and Student Interactions to trigger interest for Applied Multidisciplinary Research and Entrepreneurship Culture resulting in Significant Advancement of the field of Specialization with Involvement of Industries and Collaborative Educational Networks. (Sense of Ownership, Networking and Eco system Development).

M3: Extend the Conducive Neighborhoods for Innovation in frontier areas to keep pace with Environmental, Societal and Technological Developments of the National and International Community to Serve Humanity. (Service to Society, Atmanirbhar Bharat)

Program Educational Objectives of M.E (Power Systems & Power Electronics) Program

PEO 1: Will excel in Power System and Power Electronics area.

PEO 2: Will become successful in executing software-related applications.

PEO 3: Will carry out research in new technologies relevant to PS & PE.

PEO 4: Will develop professional ethics, effective communication skills and knowledge of societal impacts of computing technologies.

Program Outcomes of M.E (Power System & Power Electronics) Program

PO 1: An ability to independently carry out research/investigation and development work to solve practical problems.

PO 2: Ability to write and present a substantial technical report/document.

PO 3: Student should be able to demonstrate a degree of mastery over the area as per the Specialization of the Program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO 4: The student will be able to analyze, design and develop new control strategies in the areas of Power systems and Power electronics suitable for Industry requirements.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2026-27 (R26)

M.E (Power Systems and Power Electronics)

SEMESTER–I

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours Per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	26EEC101	Real-Time Control of Power Systems	3	-	-	3	40	60	3
2	26EEC102	Analysis of Power Converters	3	-	-	3	40	60	3
3	26EEE1XX	**Program Elective-I**	3	-	-	3	40	60	3
4	26EEE1XX	**Program Elective-II**	3	-	-	3	40	60	3
5	26MEM101	Research Methodology and IPR	2	-	-	3	40	60	2
6	26XXA1XX	Audit Course-I	2	-	-	2		50	NC
	PRACTICALS								
7	26EEC103	Advanced Power System Lab	-	-	2	-	50	--	1
8	26EEC104	Advanced Power Electronic Circuits and Drives Lab	-	-	2	-	50	--	1
9	26EEC105	Advanced Python Programming for Electrical Engineering Lab	-	1	2	-	50	-	2
Total			**16**	**1**	**6**	**-**	**350**	**350**	**18**
	Clock Hours Per Week: 23								

L: Lecture D: Drawing CIE: Continuous Internal Evaluation T: Tutorial

P: Practical/Project Seminar/Dissertation SEE: Semester End Examination

26EEC101

REAL-TIME CONTROL OF POWER SYSTEMS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on power system operation, control and analysis

COURSE OBJECTIVES: This course aims to:

1. understand the importance of state estimation in power systems.
2. know the importance of security and contingency analysis.
3. understand SCADA, its objectives, and its importance in power systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Understand supervisory control and data acquisition.
2. Develop mathematical models for analysis of linear and nonlinear state estimation, Observability and Contingency analysis of any practical Power System
3. Prepare the practical input data required for linear and nonlinear state estimation methods and contingency analysis.
4. Analyze the power system security and challenges in secure operation of power systems.
5. have a complete overview of Real Time operation of Power Systems (RTPS), communication and protocols employed in RTPS.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	2	2
CO 2	3	2	2	2
CO 3	2	2	3	1
CO 4	2	1	2	3
CO 5	2	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Computer Control of Power Systems: Need for real time and computer control of power systems, operating states of a power system, SCADA - Supervisory control and Data Acquisition systems implementation considerations, energy control centers, software requirements for implementing the above functions.

UNIT -II

State Estimation: Different types of State Estimations, Theory of WLS state estimation, sequential and non-sequential methods process measurements, Bad data Observability, Bad data detection, identification and elimination.

UNIT -III

Security Analysis of Power Systems: Concept of security – Security analysis and monitoring – factors affecting Power System Security – Contingency Analysis for Generator and Line Outages by Fast Decoupled Inverse Lemma–based approach – Network Sensitivity factors. Contingency selection

UNIT -IV

Synchrophasor Measurement Units: Introduction, Phasor representation of sinusoids, a generic PMU, GPS, Phasor measurement systems, Communication options for PMUs, Functional requirements of PMUs and PDCs, Phasors for nominal frequency signals, types of frequency excursions in power systems, DFT estimation at off nominal frequency with a nominal frequency clock.

UNIT -V

State Load Dispatch Center (SLDC): Inter Connectivity of Sub-LDCs & SLDCs, Hierarchy of Data Transfer, Functions & Responsibilities of SLDC, Real Time Operation carried at SLDC.

TEXTBOOKS:

1. John J. Grainger and William D. Stevenson, Jr., "Power System Analysis", International Edition, McGraw-Hill, 1994.
2. Allen J.Wood and Bruce F. Wollenberg, "Power Generation operation and control", John Wiley & Sons, 1984.

SUGGESTED READING:

1. A.G. Phadka and J.S. Thorp, "Synchronized Phasor Measurements and Their Applications", Springer, 2008
2. IEEE Proc, "Special Issue on Computer Control of Power Systems", July 1974.
3. L.P. Singh, "Advanced Power System Analysis and Dynamics", Wiley Eastern Ltd., 1986.
4. NPTEL Course Name: Economic Operations And Control Of Power Systems", Instructors: Prof. Gururaj Mirle Vishwanath, IIT Kanpur, Prof. Narayana Prasad Padhy, IIT Roorkee (https://onlinecourses.nptel.ac.in/noc23_ee128/preview)
5. NPTEL Course Name: "Smart Grid: Basics to Advanced Technologies", Instructors: Prof. N. P. Padhy, Prof. Premalata Jena, IIT Roorkee (https://onlinecourses.nptel.ac.in/noc23_ee60/preview)

26EEC102

ANALYSIS OF POWER CONVERTERS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Power Electronics

COURSE OBJECTIVES: This course aims to:

1. Understand and analyze the characteristics and operation of advanced power semiconductor devices, including wide bandgap devices and their impact on converter performance.
2. Analyze and evaluate the operation of DC–DC converters and Inverter topologies with appropriate control techniques.
3. Examine and assess resonant converters and front-end AC–DC converters

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Analyze the characteristics and quadrant operation of power semiconductor devices, including wide bandgap devices and select appropriate switching devices for power converters.
2. Evaluate the performance of isolated and non-isolated DC–DC converters under different conduction modes and design appropriate filter components
3. Apply different PWM techniques and assess harmonic behavior in inverter configurations
4. Analyze the operation of resonant and soft-switching converters for high-frequency applications
5. Assess front-end AC–DC converters with power factor correction and harmonic mitigation techniques

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	3
CO 2	3	2	3	3
CO 3	3	2	3	3
CO 4	3	2	3	2
CO 5	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Overview of Switching Power Devices: Static and dynamic characteristics of switching devices: BJT, MOSFET, IGBT, Quadrant operation of switches, Wide band gap devices (GaN, SiC)- Construction and applications.

UNIT -II

DC-DC Converters: Non-isolated DC-DC converters- buck, boost, buck-boost, CUK converters under continuous and discontinuous conduction operation - Isolated DC-DC converters- forward, fly-back, push-pull, half-bridge and full-bridge converters - Relationship between input and output voltages - design of filter inductor and capacitors, Dual active bridge converter.

UNIT -III

Inverters: Single-phase and three-phase inverters - PWM techniques- single, multiple and sinusoidal PWM techniques, Uni-polar & bi-polar Modulation, current source inverter, multi-level inverters

UNIT -IV

Resonant Converters: Introduction, Basic resonant circuit concepts, Classification - Load resonant converters, Resonant switch converters, zero voltage switching clamped voltage converters, Resonant DC link inverters, High frequency link integral half cycle converters,

UNIT -V

Front-End AC-DC Converters: Evaluation of input power factor and harmonic factor, Conventional methods of power factor improvement- Semi-converter, extinction angle control, symmetrical angle control, PWM Control, active front-end converters

TEXTBOOKS:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics- Converters, Applications”, 3rd Edition J. Wiley & Sons, 2003.
2. M.H. Rashid “Power Electronics- Circuits, Devices, and Applications”, 4th Edition Pearson, 2013.
3. Bin Wu, High Power Converters and AC Drives, Wiley-Interscience, 2017, 2nd Edition.

SUGGESTED READING:

1. Abraham I. Pressman, Keith Billings & Taylor Morey, “Switching Power Supply Design”, 3rd Edition, McGraw Hill International, 2009.
2. L. Umanand, “Power Electronics Essentials & Applications”, 1st Edition, Wiley publishing Company, 2014.
3. B. Jayant Baliga, Fundamentals of Power Semiconductor Devices, Springer, 2018, 2nd Edition.
4. Derek A Paice, Power Electronic Converter Harmonics Multipulse Method for Clean Power, IEEE Press, 1995.
5. http://freevideolectures.com
6. http://engineeringvideolectures.com

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Advance Power Electronics and Control	Prof. Avik Bhattacharya	IIT Roorkee

26MEM101

RESEARCH METHODOLOGY AND IPR

Instruction	2 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

COURSE OBJECTIVES: To make the students to

1. Motivate to choose research as career
2. Formulate the research problem, prepare the research design
3. Identify various sources for literature review and data collection report writing
4. Equip with good methods to analyze the collected data
5. Know about IPR copyrights

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Define research problem, review and asses the quality of literature from various sources
2. Improve the style and format of writing a report for technical paper/ Journal report, understand and develop various research designs.
3. Collect the data by various methods: observation, interview, questionnaires.
4. Analyze problem by statistical techniques: ANOVA, F-test, and Chi-square.
5. Understand apply for patent and copyrights.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	2	1	3	3	2
CO 2	3	3	3	1	3	3
CO 3	3	2	2	2	3	2
CO 4	3	1	2	2	3	1
CO 5	3	3	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Research Methodology: Research Methodology: Objectives and Motivation of Research, Types of Research, research approaches, Significance of Research, Research Methods verses Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general. Defining the Research Problem: Selection of Research Problem, Necessity of Defining the Problem

UNIT - II

Literature Survey Report writing: Literature Survey: Importance and purpose of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. Report writing: Meaning of interpretation, layout of research report, Types of reports, Mechanics of writing a report. Research Proposal Preparation: Writing a Research Proposal and Research Report, Writing Research Grant Proposal.
Introduction to latex, Basic rules, LaTeX templates — Reports

UNIT- III

Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Steps in sample design, types of sample designs.

UNIT - IV

Data Collection and Analysis: Data Collection: Methods of data collection, importance of Parametric, non-parametric test, testing of variance of two normal population, use of Chi-square, ANOVA, Ftest, z-test.
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UNIT - V

Patents and Copyright: Patent: Macro economic impact of the patent system, Patent document,Patent Filling Procedures, Granting of patent, Rights of a patent, patent protection. Copyright: Meaning.Copyrights protection, steps involved for applying copyrights registrations process, Enforcement of Intellectual Property Rights: Infringement of intellectual property rights, Case studies of patents and IP Protection. IP as a Global Indicator of Innovation, Major Amendments in IP laws And Acts in India.

TEXTBOOKS:

1. C.R Kothari, “Research Methodology, Methods & Technique”; New Age International Publishers, 2004
2. R. Ganesan, “Research Methodology for Engineers”, MJP Publishers, 2011
3. Y.P. Agarwal, “Statistical Methods: Concepts, Application and Computation”, Sterling Publs., Pvt., Ltd., New Delhi, 2004.

SUGGESTED READING:

1. Ajit Parulekar and Sarita D’ Souza, “Indian Patents Law – Legal & Business Implications”; Macmillan India ltd, 2006
2. B. L.Wadehra; “Law Relating to Patents, Trademarks, Copyright, Designs & Geographical Indications”; Universal law Publishing Pvt. Ltd., India2000.
3. P. Narayanan; “Law of Copyright and Industrial Designs”; Eastern law House, Delhi 2010.

26EEC103

ADVANCED POWER SYSTEMS LAB

Instruction	2P Hours per week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1

Prerequisite: Students should have prior knowledge of power systems

COURSE OBJECTIVES: This course aims to:

1. Understand the I–V and P-V characteristics of a PV module.
2. Measure the sequence reactance of synchronous machine and 3-phase transformer.
3. Estimate efficiency, regulation of a single-phase transmission line and to understand the characteristics of various relays.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Find the sequence reactance of the synchronous machine and 3-phase transformer.
2. Plot the relay characteristics.
3. Calculate efficiency, regulation and ABCD constants of single-phase transmission line.
4. Learn about various types of faults.
5. Validate the I–V and P-V characteristics of a PV module.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	2	2	3	2
CO 3	2	2	3	2
CO 4	2	2	3	2
CO 5	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Determination of ABCD constants of a single- phase transmission line
2. Study of Inverse time characteristics of over current relay
3. Study of microprocessor based inverse current relay characteristics.
4. Study of over voltage and under voltage relays

5. Single PV module I-V and P-V characteristics with radiation and temperature changing effect.
6. I-V and P-V characteristics with series and parallel combination of Solar modules.
7. Effect of shading and Effect of tilt angle on I-V and P-V characteristics of solar module.
8. Finding MPP by varying the resistive load by varying the duty cycle of the DC-DC converter.
9. Mitigation of power quality parameters using series compensator
10. Mitigation of power quality parameters using Shunt compensator
11. Mitigation of power quality parameters using UPQC
12. Study & amp; Analysis of Voltage drop in Radial / Ring main distribution system.
13. Characteristics of Electromagnetic type Earth fault relay
14. Power Angle Characteristics of 3- Phase Synchronous Machine with infinite bus bars.
15. Harmonic analysis of non-liner loads using a power analyzer.
16. Study of various system faults using a DC analyzer.
17. Study of symmetric & asymmetric fault in the transmission line.
18. Study of Power transfer through a transmission system

Note: TEN experiments will be conducted to cover all five Course Outcomes.

26EEC104

ADVANCED POWER ELECTRONIC CIRCUITS AND DRIVES LAB

Instruction	1+2P Hours per week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1

Prerequisite: Students should have prior knowledge of Power Electronics and Electrical Machines.

COURSE OBJECTIVES: This course aims to:

1. Evaluate the performance of AC-AC and DC-DC converter topologies.
2. Analyze various inverter configurations using advanced modulation and high-frequency switching techniques.
3. Simulate open-loop and closed-loop control architectures for high-performance DC and AC motor drive systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Analyze the impact of source inductance and non-ideal parameters on the performance of phase-controlled converters.
2. Design inductors used in DC-DC Converter and illustrate the converter performance with different types of loads.
3. Simulate various voltage control techniques for power converters.
4. Implement different control schemes for DC Drives and verify it experimentally and/or through simulation.
5. Implement different control schemes for AC Drives and verify it experimentally and/or through simulation.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	2	1
CO 2	3	1	3	3
CO 3	2	1	2	1
CO 4	3	1	3	2
CO 5	3	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

Part-A

1. Performance analysis of phase-controlled rectifiers with source inductance (single phase and three phase).
2. Analysis of three phase AC voltage controller with R & RL loads.
3. Analysis of DC-DC converters (a) Buck converter (b) Buck-Boost converter.
4. Closed loop control of Buck and Boost converter.
5. Analysis of ZVS buck converter.
6. Analysis of ZCS buck converter.
7. Analysis of single-phase and Three phase IGBT inverter.
8. Analysis of single-phase series-resonant inverter.
9. Quasi-square wave control of a Single-phase Full bridge VSI.
10. Voltage control of an inverter using unipolar & bipolar PWM techniques.
11. Design and development of inductors for dc-dc converter applications.
12. Simulation of a Space Vector PWM-Based Three-Phase Voltage Source Inverter.

Part-B

1. Three -phase fully controlled converter fed dc drive.
2. Speed control of dc drive using dc chopper.
3. Simulation of chopper fed dc drive.
4. Closed-loop control of permanent magnet dc drive.
5. Experimental study of Static Kramer's drive.
6. Simulation of open loop based scalar controlled induction motor drive.
7. Simulation of closed loop scalar controlled induction motor drive.
8. Simulation of vector (Rotor field oriented) controlled induction motor drive.
9. Load Testing of BLDC Motor.
10. Speed Control of SRM.
11. Speed Control of PMSM.

Note:

1. From each section at least Five Experiments should be conducted.
2. A minimum of three hardware experiments be conducted from Part-A and two from Part-B.

26EEC105

ADVANCED PYTHON PROGRAMMING FOR ELECTRICAL ENGINEERING LAB

Instruction	1+2P Hours per week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	2

Prerequisite: Students should have basic knowledge of Python programming, electrical engineering fundamentals (power systems, machines, power electronics), and mathematical concepts such as linear algebra and calculus.

COURSE OBJECTIVES: This course aims to:

1. Apply computational techniques to analyze power system components such as Y-bus, fault analysis, and contingency studies.
2. Model and simulate power electronic converters, drives, and inverter systems using Python.
3. Analyze power quality issues such as harmonics and design appropriate mitigation techniques.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Analyze power system performance under fault and contingency conditions using computational methods.
2. Apply stability analysis techniques such as root locus and Bode plots to evaluate system behavior.
3. Design and analyze electric drives and control systems, including DC motor speed control using converter-fed drives.
4. Model and analyze electric vehicle systems, including EV load impact and charger design.
5. Develop and simulate power electronic circuits and converters including PWM generation, inverter operation, and DC–DC converter modeling.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	2	2
CO 2	3	2	2	2
CO 3	2	3	2	3
CO 4	3	2	2	3
CO 5	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Formation of Y-bus matrix.
2. Electric vehicle load impact analysis.
3. Stability analysis using Root locus and Bode plots.
4. Contingency analysis of radial distribution.
5. Implementation of complex number operations for power system analysis.
6. Fault current calculation using sequence networks.
7. Generation of Pulse Width Modulation (PWM) signals.
8. Speed control of DC motor using converter-fed drive.
9. Electric Vehicle (EV) charger modeling.
10. Harmonic analysis of non-linear loads.
11. Three-phase inverter waveform generation.
12. Design of MPPT controller using PSO.
13. State-space modeling of DC–DC converters.
14. Design of active power filter.
15. Closed-loop control of BLDC motor.

Note: At least **TEN** experiments should be conducted in the semester

26EEE101

POWER SYSTEM DEREGULATION

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Basic Electrical Engineering, Power Systems Analysis, Power System Operation and Control, Fundamentals of Economics (basic level).

COURSE OBJECTIVES: This course aims to:

1. Understand the concept of deregulation and the transition from vertically integrated to restructured power systems.
2. Introduce the entities, market models, and architecture of competitive electricity markets.
3. Explain the fundamentals of economics applicable to power market operations.
4. Analyze congestion management methods and transmission pricing mechanisms in deregulated environments.
5. Study ancillary services, market power, and generator bidding strategies in restructured power systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Explain the concept of deregulation, restructured power system entities, and global deregulation experiences including India.
2. Apply fundamental economic principles to analyze consumer, supplier, and market equilibrium in electricity markets.
3. Analyze different electricity market models, market architecture, and trading arrangements including spot, day-ahead, and real-time markets.
4. Evaluate market power, generator bidding strategies, and ancillary service management in competitive electricity markets.
5. Analyze congestion management methods, locational marginal pricing, financial transmission rights, and transmission pricing mechanisms.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	1
CO 2	3	2	3	1
CO 3	3	2	3	2
CO 4	3	2	3	2
CO 5	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT – I

Introduction to Power System Deregulation: Introduction to Deregulation, Operation of Vertically Integrated Power Systems, Fundamentals of Restructured Systems, Entities in Deregulated Markets — GENCOs, TRANSCOs, DISCOMs, ISO and Market Operator, Power Pools, Energy Brokerage Systems, Benefits of Deregulation, Background to Deregulation — Industrialized and Developing Countries, Reforms in Indian Power Sector.

UNIT – II

Fundamentals of Electricity Markets: Fundamentals of Economics for Power Markets, Consumer and Supplier Behaviour, Market Equilibrium, Marginal Cost of Production, Perfectly Competitive Market, Electricity as a Commodity, Features of Electricity Market, Four Pillars of Market Design.

UNIT – III

Electricity Market Models and Architecture: Electricity Market Models — PoolCo, Bilateral Contracts and Hybrid, Market Models based on Contractual Arrangements, Market Architecture, Spot Market, Day-ahead Market and Retail Market, Forward and Real-Time Markets, Models for Trading Arrangements, ISO and TSO Models.

UNIT – IV

Market Operations and Ancillary Services: Objectives of Market Operations, Market Power — Sources, Effects and Mitigation, Generator Bidding Strategies, Types of Ancillary Services, Load-Generation Balancing Services, Reactive Power and Voltage Control Services, Co-optimization of Energy and Reserve Markets.

UNIT – V

Congestion Management and Transmission Pricing: Definition and Causes of Congestion, Congestion Management Methods — Market and Non-Market, Power Transfer Distribution Factors, Locational Marginal Pricing, Financial Transmission Rights, Transmission Network Pricing Methods, Loss Allocation Methods.

TEXTBOOKS:

1. Loi Lei Lai, "Power System Restructuring and Deregulation", 1st Edition, John Wiley & Sons Ltd., 2001.
2. Bhattacharya, Kankar, Math HJ Bollen, and Jaap E. Daalder. Operation of restructured power systems. 1st Edition, Kluwer Academic Publishers. 2001.

SUGGESTED READING:

1. Lorrin Philipson, H. Lee Willis, "Understanding Electric Utilities and De-Regulation", Marcel Dekker Pub., 1998.
2. Steven Stoft, "Power System Economics: Designing Markets for Electricity", John Wiley and Sons, 2002.
3. M. Ilic, F. Galiana and L. Fink, "Power System Restructuring: Engineering and Economics", Kluwer Academic Publishers, 1998.
4. Md Shahidephpour & M. Alomoush, ‘Restructured Electrical Power Systems’, Marcel Dekker Inc, 2001.
5. Daniel Kirschen and Goran Strbac, "Fundamentals of Power System Economics," John Wiley & Sons Ltd., 2004.

WEB RESOURCES:

1. NPTEL Course on Restructured Power Systems: nptel.ac.in/courses/108101005/ (Prof. S.A. Khaparde & Dr. A.R. Abhyankar, IIT Bombay / IIT Delhi)

26EEE102

DESIGN OF POWER ELECTRONIC CONVERTERS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have an introductory course on power electronics.

COURSE OBJECTIVES: This course aims to:

1. Understand and analyze gate driver circuits, thermal design principles, and heat management techniques in power electronic systems.
2. Design and develop magnetic components, snubber circuits, and essential converter components considering high-frequency operation and losses.
3. Apply and evaluate EMI mitigation techniques, filtering methods, and PCB layout practices for reliable and efficient power converter design.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Develop gate driver circuits for various fully controlled power semiconducting switching devices.
2. Analyze thermal characteristics and heat sink design for power semiconductor devices.
3. Design inductors, transformers, and magnetic components considering high-frequency effects including filters and device ratings considerations.
4. Develop Evaluate snubber circuits and select appropriate passive components for protection and improved converter performance.
5. Analyze and apply EMI/EMC mitigation techniques, including filter design and PCB layout practices, for noise reduction in power electronic systems.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	3	2
CO 2	3	2	3	2
CO 3	3	2	3	2
CO 4	3	2	3	2
CO 5	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Gate Drivers Design: Gate driver circuits for fully controlled switches, level shifting, isolation using optocouplers, need of floating supply, Pulse transformer-based gate drivers,

UNIT -II

Thermal Design: Power loss, Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for heat sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types choosing of heat sinks.

UNIT -III

Inductor Design: Behavior of inductors and capacitors in high frequency switching applications, Magnetic losses, conducting losses, magnetic materials, magnetic core, Design of inductor and design of transformer.

UNIT -IV

Design of Snubber Circuits: RC snubber circuit, under damped, over damped and critically damped cases. Design of RC snubber, RCD snubbers, Selection of power converter capacitor, PCB ground and design of PCB

UNIT -V

EMI in Power Electronics: Introduction of EMI, EMI measurements, EMI in power electronics. Common mode noise and differential mode noise, design solution of EMI, EMI filter enclose design. Proper PC layout, shielded cables, twisting of wire design of EMI filter.

TEXTBOOKS:

1. Ned Mohan, Tore M. Undeland, William P. Robbins, “Power Electronics: Converters, Applications, and Design”, 3rd Edition Wiley, 2007.
2. Muhammad H. Rashid, “Power Electronics: Circuits, Devices and Applications”, 4th Edition, Pearson Education, 2017.
3. Mark I. Montrose, “EMC and the Printed Circuit Board: Design, Theory, and Layout Made Simple”, Wiley-IEEE Press, 1998.

SUGGESTED READING:

1. S. P. Seth, “Elements of Electromagnetic Fields”, Danpat Rai & Co, 2011.
2. François Costa, Eric Laboure, Bertrand Revol, “Electromagnetic Compatibility in Power Electronics”, Wiley, 2014.
3. Ashutosh Pramanik, “Electromagnetism Theory and Applications”, 3rd Edition, PHI Pvt. Ltd., 2015.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Design of Power Electronic Converters https://archive.nptel.ac.in/courses/117/103/117103148/	Prof. Shabari Nath	IIT, Guwahati

26EEE103

SIGNAL PROCESSING TECHNIQUES

Instruction	3L Hours per week
Duration of Semester End Examination	3 Hours
Semester End Examination	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Basic knowledge on the courses signals & systems and digital signal processing

Foundational knowledge of Signals and Systems, Digital Signal Processing, and the basics of Power System components.

COURSE OBJECTIVES: To provide basic knowledge on digital signals and systems.

1. Understand the applications of Digital signal filtering techniques in smart grid.
2. To understand the application of signal processing in power system.

COURSE OUTCOMES: After completion of this course, students will be able to:

1. Understand the basic operations of signals in time domain & complex frequency domain.
2. Design digital filters for the given specifications.
3. Interpret the concepts of Multi rate digital signal processing.
4. Understand the need of signal processing in power systems.
5. Apply different filtering techniques to smart grid.

Course Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	3	2
CO 2	2	2	3	3
CO 3	3	2	3	3
CO 4	3	3	3	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Discrete Fourier Transforms: Overview of DFT- Radix-2 DIT & DIF FFT algorithms, **Radix-4-Split radix** FFT-Linear convolution using FFT - Overlap save & add methods.

UNIT -II

Digital filters: Review of digital filter design and structures-Basic FIR/IIR filter design and structures- Design techniques of linear phase FIR filters-IIR filters by impulse invariance-bilinear transformation - cascaded - lattice structures and parallel realization of FIR & IIR filters.

UNIT-III

Multirate DSP: Introduction - Decimator and Interpolator- Sampling rate conversion – Multistage decimator and interpolator-polyphase filters- Uniform digital filter banks

UNIT -IV

Power Systems signals in terms of Smart Grid: Need for Signal Processing in Basics of power quality issues-Inrush Current in Power Transformers - Over Excitation of Transformers-Transients in Instrument Transformers-Frequency Variation- Voltage Magnitude Variations-Voltage Frequency Variations-power system protection-Wide area dynamic analysis.

UNIT -V

Filter design Applications: Adaptive IIR filters, RLS algorithms- GRLS, Gauss-Newton and RM-Basic Digital System-Parametric Notch FIR Filters-Sine and Cosine FIR Filters-Parametric Filters applications in smart grid.

TEXTBOOKS:

1. Advanced Digital Signal Processing, J.G. Proakis,M.Salehi,1992,McGraw–Hill.
2. Power Systems Signal Processing for Smart Grids, P.F.Ribeiro, C.A.Duque, P.Marcioda Silveira and A.S. Cerqueira, John Wiley and Sons Ltd.,2014, 2nd Edition.

REFERENCEBOOKS:

1. Adaptive Filter Theory, S.Haskin, PrenticeHall,2001,2ndEdition.
2. Signal Processing: The Model Based Approach, J.V.Candy, McGraw-Hill Book Company,1987.
3. Statistical Digital Signal Processing and modeling, M.H.Hayes,John Wiley & Sons,1996.
4. Handouts on DSP Processors.
5. Digital Signal Processing –A computer Based Approach, S. K. Mitra, MGH,2001,2ndEdition.

NPTEL Course link: Signal Processing Techniques and Its Applications By Prof. Shyamal Kumar Das Mandal, IIT Kharagpur

26EEE104

DIGITAL CONTROL SYSTEMS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on control system

COURSE OBJECTIVES: This course aims to:

1. Understand the basics of digital control systems and sampling.
2. Apply Z-transform and state-space methods for system analysis.
3. Design digital controllers and observers.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Explain the basics of digital control systems and sampling techniques.
2. Apply Z-transform methods for discrete-time system analysis.
3. Analyze stability and response of digital control systems.
4. Develop state-space models of discrete-time systems.
5. Design digital controllers and observers.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	2	2
CO 2	2	3	2	3
CO 3	2	3	2	2
CO 4	2	2	3	2
CO 5	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Introduction Digital control system: Introduction: Types of signals, discrete type and continuous type control system - sampling process: Need for sampling in digital control, · Sampling theorem (basic idea), Sampling techniques - Digital control systems: Forms of signal in digital control, Quantizing, Quantization error, Data acquisition, Conversion and Distribution system: Multiplexer, sample and hold circuit, analog to digital converter: Need for ADC Type of ADC, digital to analog converter:Need for DAC Type of DAC - Reconstruction of input signal by hold circuit.

UNIT -II

Z-Transform: Definition of Z-transform- Region of Convergence (ROC) and its significance - Z-transforms of elementary functions: step, ramp, polynomial, exponential and sinusoidal functions - Important properties of Z-transform: Linearity property, Time shifting property, Scaling property - theorems of Z-transform: Convolution theorem, Initial value theorem, Final value theorem - Inverse Z-transform: analytical method and computational method, Z-transform method of solving different equations, numerical.

UNIT -III

Z-Plane Analysis of Discrete-Time Control Systems: Impulse sampling - Data hold: Transfer function of ZoH and first order hold - Pulse transfer function - Realization of digital controllers and digital filters - Mapping between s-plane and z-plane - Stability analysis of closed loop systems in z-plane: Jury stability test, Bi-linear transformation - Transient and steady state analyses: rise time ,delay time, peak time, peak overshoot, settling time.

UNIT -IV

State Space Analysis in digital control system: Introduction of state variable model: oncept of state, state variables, and state-space representation - various canonical models: Controllable canonical form, Observable canonical form, Diagonal (modal) canonical form, Jordan canonical form - Characteristic equation and state transition matrix, Pulse transfer function matrix, Discretization of continuous time state space equations, Lyapunov stability analysis in discrete domain.

UNIT -V

Design of controller in discrete domain: Controllability, Observability, State feedback controller design: Design via pole placement. Observer Design: State observers, optimal control: Steady state quadratic optimal control, optimal controller design for servo system.

TEXTBOOKS:

1. K. Ogata, “Discrete time control systems”, 2nd Edition, Pearson Education, 2006.
2. M. Gopal, “Digital control engineering”, 2nd Edition, New Age Int. Ltd., 2014.

SUGGESTED READING:

1. Ktsuhiko Ogata, “Modern control Engineering”, 5th Edition, Pearson Education India, 2015.
2. B.C. Kuo, “Digital Control Systems”, Oxford University Press, 2012, 2nd Edition.

NPTEL Courses:

S. No.	NPTEL Course Name	Instructor	Host Institute
1	Digital Control systems	Dr. Indrani Kar, Prof. Somnath Majhi |	IIT Roorkee

26EEE105

SMART APPLIANCES AND INTERNET OF THINGS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of basic programming skills, algorithm design, basics of probability & statistics

COURSE OBJECTIVES: This course aims to:

1. Provide knowledge of modern domestic applications
2. Provide knowledge of IoT communication, and control technologies
3. Introducing cloud computing and applications of IoT in smart cities and electrical vehicles.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Understand and evaluate the characteristics of smart home appliances.
2. Understand the behavior of IoT and their applications.
3. Manage smart communication systems with multiple sensors and protocols.
4. Understand various cloud computing techniques.
5. Design and simulate smart homes, smart cities, and Electric Vehicles with IoTs and cloud computing.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	3	2	3
CO 2	3	2	2	3
CO 3	3	2	2	3
CO 4	3	2	2	3
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Modern Domestic Appliances: Solid State Lamps: Introduction - Review of Light sources - white light generation techniques Characterization of LEDs for illumination application. Power LEDs- High brightness LEDs Electrical and optical properties. LED driver considerations-Power management topologies - color issues of white LEDs- Dimming of LED sources, BLDC motors for pumping and domestic fan appliances, inverter technology-based home appliances, Smart devices and equipment.

UNIT -II

IoT Communication Technologies: Introduction IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Wireless Sensor Networks, Machine-to-Machine Communications. Interoperability in IoT

UNIT -III

IoT Control Technologies and Programming: Introduction Arduino Programming, Integration of Sensors and Actuators with Arduino, Internet of Things Open-Source Systems. Introduction Python programming, Introduction Raspberry. Implementation of IoT with Raspberry Pi, Smart Grid Hardware Security

UNIT -IV

IoT Cloud Computation: Introduction Software Defined Networking (SDN). SDN for IoT, Data Handling and Analytics, Cloud Computing methods, Edge Computing, Fog Computing.

UNIT -V

Applications of IoT: Smart Cities and Smart Homes, Electric Vehicles, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring, Energy Management, Role of ML and AI in IoT

TEXTBOOKS:

1. Vinod Kumar Khanna, "Fundamentals of Solid-State Lighting", 1st Edition, CRC press, 2014.
2. Chang-liang Xia, "Permanent Magnet Brushless DC Motor Drives and Controls", 1st Edition, John Wiley & Sons Singapore Pvt. Ltd., 2012.
3. K. Siozios, D. Anagnostos, D. Soudris, E. Kosmatopoulos, "IoT for Smart Grids Design Challenges and Paradigms", 1st Edition, Springer, 2019

SUGGESTED READING:

1. Craig Di Louie, "Advanced Lighting Controls: Energy Saving Productivity, Technology & Applications", 1st Edition, Fairmont Press, Inc., 2006.
2. Robert S Simpson, "Lighting Control: Technology and Applications", 1st Edition, Focal Press, 2003.
3. Arturas Zukauskus, Michael S. Shur & Remis Gaska, "Introduction solid state lighting", 1st Edition, Wiley-Interscience, 2002.
4. Mohan, Undeland and Robbins, "Power Electronics: Converters, Applications and Design", 1st Edition, John Wiley and Sons, 1989.

NPTEL Course:

S.No.	Course Name	Instructor Name	Host Institute	NPTEL-Link
1	Introduction to Internet of Things.	Prof. Sudip Misra	IIT Kharagpur	Introduction To Internet Of Things - Course

26EEE106

SMART ELECTRICAL DISTRIBUTION SYSTEM

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on electrical distribution systems

COURSE OBJECTIVES: This course aims to:

1. Understand the load patterns of power distribution systems.
2. Model the distribution systems components and understand the analysis methods specially developed for the distribution systems.
3. Understand the transition of conventional electrical distribution system smart electrical distribution system.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Recognize the structure and load characteristics of a power distribution system.
2. Model and analyze the smart power distribution system.
3. Analyze the distribution system power flow and short circuit studies.
4. Analyze the various functionalities of smart distribution technologies along with energy storage.
5. Follow the regulations and market models for smart distribution systems.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	3
CO 2	3	2	2	2
CO 3	3	3	3	2
CO 4	2	1	1	2
CO 5	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Introduction Smart Distribution: Fundamentals of the Electrical Power Distribution System and feeder configuration, Distribution system loading, Load Characteristics, Distribution Transformer, Single phase and three Phase Transformer connections.

UNIT -II

Distribution System Modeling: Impedance of distribution system, Modeling of distribution line, cables, Distribution Transformer, Distributed generation, loads and reactive power sources. Modeling and study of voltage regulators in distribution network

UNIT -III

Distribution System Analysis: Load flow for distribution system: Backward/forward method, Direct method, load flow application for weakly meshed distribution system, Short Circuit analysis: Sequence based, Thevenin's Equivalent and Phase variable based, LG, LL, LLG, LLLG fault analysis and its applications.

UNIT -IV

Smart Distribution Technologies: Distribution automation, automated meter reading (AMR), automated metering infrastructure (AMI), Automated Fault Location, Isolation and Service Restoration, Outage Management Systems (OMS), Energy Storage, **Operational challenges arising from the integration of renewable energy sources and Electric vehicles.**

UNIT -V

Regulation and Market Models for Smart Distribution Systems: Demand Response, Tariff Design**,** Net metering Time of the day pricing (TOD), Time of use pricing (TOU), Consumer privacy and data protection, consumer engagement etc. Cost benefit analysis of smart grid projects.

TEXTBOOKS:

1. A.S. Pabla, "Electric Power Distribution", 4th Edition, Tata McGraw Hill Publishing Co. Ltd., 2017.
2. Abdelhay A. Sallam and Om P. Malik, "Electric Distribution Systems", 2nd Edition, IEEE Press Series, 2019.

SUGGESTED READING:

1. W. H. Kersting, "Distribution System Modeling and Analysis", 4th Edition, CRC Press, 2017.
2. D. John, "Electric Power Substations Engineering", 3rd Edition, McDonald (Editor), CRC Press, 2016.
3. James A. Momoh, "Smart Grid: Fundamentals of Design and Analysis", John Wiley & Sons, 2021
4. Smart Grid: Basics to Advanced Technologies, https://onlinecourses.nptel.ac.in/noc23_ee60/preview

NPTEL Course:

NPTEL Course	**Link**	**Professor**	**Offering institute**
Electrical Distribution System Analysis	https://onlinecourses.nptel.ac.in/noc21_ee69/preview	Prof. G. B. Kumbhar	IIT Roorkee

26EEE107

MODELING AND ANALYSIS OF RENEWABLE ENERGY SOURCES

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Renewable Energy Resources

COURSE OBJECTIVES: This course aims to:

1. Understand the design and modeling of renewable energy resources
2. Understand the operation of renewable energy resources.
3. Understand the basics of single-phase grid connected systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Apply new techniques for modeling solar PV
2. Develop new tracking techniques and reconfiguration methods for PV and power enhancement of PV systems
3. Design and modeling of wind energy systems
4. Understanding the working fuel cell design and operating conditions
5. Understanding the concepts of single-phase grid connected PV systems

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	1	2
CO 2	3	2	2	2
CO 3	3	3	2	2
CO 4	2	3	2	2
CO 5	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Modeling of Solar PV System: Introduction, Principle of direct solar energy conversion into electricity in a solar cell - properties - Solar cell and its types - structure- I-V characteristics of a PV module - solar PV modeling and equations - modeling techniques - cell efficiency - fill factor - Applications.

UNIT-II

Maximum power point tracking: Need for Maximum power tracking - effect of irradiation and temperature on PV characteristics – Partial Shading - Tracking techniques and solar PV array reconfiguration. Standalone and grid interactive systems.

UNIT-III

Modeling of Wind Energy System: Wind speed and power relation, the power extracted from wind, wind distribution, and wind speed predictions. Wind power systems: system components, Types of Turbines, Turbine rating. Choice of generators, electrical load matching, Variable speed operation, Modelling of Wind generator, maximum power operation. design features, stand-alone wind system.

UNIT-IV

Fuel Cell Modeling: Fuel cell definition, the difference between batteries and fuel cells, fuel cell components, principle and working of the fuel cell, Mathematical Modelling of Fuel cell system performance characteristics, efficiency, fuel cell stack, fuel cell power plant: fuel processor, fuel cell power section, power conditioner, Advantages, and disadvantages.

UNIT -V

Single-Phase Grid-Connected Photovoltaic Systems: Introduction- Demands for Grid-Connected PV Systems- Power Converter Technology for Single Phase PV Systems, Transformer less AC-Module Inverters (Module-Integrated PV Converters, Transformer less Single-Stage String Inverters, DC-Module Converters in Transformer less Double-Stage PV Systems

TEXTBOOKS:

1. Ali Keyhani Mohammad Marwali and Min Dai, “Integration and Control of Renewable Energy in Electric Power System” John Wiley publishing company
2. Wind Turbine Technology – David A Spera, ASME Press, 2009
3. S. Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012
4. Suleiman M,Sharkh, Mohammad A.Abu-Sara Georgios I. Orfanoudakis, Babar Hussain, "Power Electronic Converters for Microgrid”, Wiley-IEEE Press, 2014

SUGGESTED READING:

1. Power Conversion and Control of Wind Energy Systems, Bin Wu, 2011, Wiley-IEEE, 1st Edition.
2. Wind Electrical Systems, S.N. Bhadra, 2005, Oxford, 7th Impression.
3. Wind Power Integration – Connection and System Operational Aspects, Brendan Fox, 2014, IET, 2nd Edition.
4. Renewable Energy Devices and Systems with Simulations in MATLAB and ANSYS, Frede Blaabjerg, Dan M. Ionel, CRC press, 2017, 1st Edition.

Web resources:

S.No.	NPTEL Course Name	Instructor	Host Institute	Course URL
1	Solar Photovoltaics: Fundamentals, Technology and Applications	Prof. Soumitra Satapathi	IIT Roorkee	https://onlinecourses.nptel.ac.in/noc24_ph26/preview

26EEE108

ADVANCED ELECTRIC DRIVES

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Electrical Machines

COURSE OBJECTIVES: This course aims to:

1. Understand the concept of advanced modelling and control of machines.
2. Understand the concept of axis transformation and modeling and control aspects of DC motors, Induction motors and Conventional Synchronous Motors.
3. Study the working principles and control aspects of special motors: Brushless DC motor, Switched Reluctance Motor drives, Permanent Magnet Syn. Motor, Syn. Reluctance Motor, and Stepper Motor.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Identify the need of linear transformation and illustrate the DC motor speed control.
2. Illustrate the concept of modeling and speed sensor-less control of Induction machine in dq0 frame.
3. Analyze how independently control the torque and flux of Induction motor and exposure to latest techniques
4. Explore the concept of PMSM and SRM Drive techniques.
5. Explore the concept of BLDC, Sy RM Drive techniques

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	3	1	1
CO 2	3	3	2	3
CO 3	3	3	2	2
CO 4	3	2	2	2
CO 5	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT-I

Elements of Generalized theory of Electrical Machines: Generalized theory and Kron's primitive machine model; Reference frame theory. Space Phasor representation,

DC Drive: Modeling of Separately excited DC machine, Series DC machine, Effect of shifting of brush Axis, Review of Controllers, Speed control of a separately excited DC drive with inner current loop and outer speed loop, Introduction to Digital Control of Drives using PWM and Embedded Controllers

UNIT-II

Asynchronous Machine Drive-I: Scalar Control versus Vector Control, vector control of induction motor: Principles of vector control, Indirect vector control, implementation – block diagram; estimation of flux, flux weakening operation. Sensor less vector control of induction motor: Estimation techniques.

UNIT-III

Asynchronous Machine Drive-II: Direct Torque Control of Induction Motor Drives, Flux and torque control, Switching implementation, Sensorless operation. Introduction to Model Predictive Control (MPC) for drives.

UNIT-IV

Special Machine Drive-I: Control of Special Machines: Principle of operation of PMSM and Switched Reluctance Motors- Switched Reluctance Motor for EVs (elementary treatment only)

UNIT- V

Special Machine Drive-II: BLDC, Stepper Motors, Synchronous Reluctance motors. -Axial Flux Motors (Elementary treatment only)

TEXTBOOKS:

1. P. C. Krause, O. Wasynczuk, and S. D. Sudhoff, “Analysis of Electric Machinery”, McGraw Hill Book Company.
2. B. K. Bose, “Power Electronics and AC Drives”, Prentice Hall, 2002.
3. Bin Wu, “High-Power Converters and AC Drives”, John Wiley and Sons, 2006.
4. “Electric Vehicle Technology Explained” – James Larminie

SUGGESTED READING:

1. R. Krishnan, “Electric Motor Drive: Modeling, Analysis and Control”, Prentice Hall of India, 2001.
2. P. S. Bimbra, “Generalized theory of Electrical Machines”, Khanna Publication, 2006.
3. H. Abu Rub, A. Iqbal, J. Guzinski, “High Performance Control of AC Drives With MATLAB/Simulink Models”, John Wiley and Sons, 2012.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Advanced Electric Drives	Dr. S.P. Das	IIT Kanpur
2	Modelling and Analysis of Electric Machines	Dr. Krishna Vasudevan	IIT Madras

26EEE109

DISTRIBUTION SYSTEM PLANNING AND AUTOMATION

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Should have basic knowledge in power system transmission and power system analysis.

COURSE OBJECTIVES: This course aims to:

1. Study sub-transmission, Distribution substations
2. Understand the philosophy of Distribution Automation and SCADA
3. Explore the reforms in the power systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. To analyze and forecast electrical load demand using modern techniques
2. Analyze primary and secondary distribution systems.
3. Find the voltage regulation and impact of capacitors in the distribution systems.
4. Explain the concept of reforms in the power sector & demonstrate the need and functioning of the SCADA system.
5. Understand the concept of substation metering and its revenue generation.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	3	3
CO 2	3	1	2	3
CO 3	3	1	3	2
CO 4	3	1	2	3
CO 5	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT –I

Distribution System Planning- Planning and forecasting techniques – Present and future – Role of computers- Load Characteristics- Load forecasting using ANN – Load management – tariffs and metering of energy

UNIT -II

Primary distribution systems and Distribution Sub–Stations: Distribution substations –Bus schemes – comparison of switching schemes- Substation location and rating- Types of feeders – voltage levels-uniformly distributed load, Non uniformly distributed load, Distribution Feeder Analysis.

UNIT -III

Distribution voltage regulation: Three-phase balanced and non-three-phase primary lines, analysis distribution and equipment costs, introduction Distribution system voltage regulation, voltage standards, voltage control, feeder-voltage regulators, line-drop compensation, Capacitors in Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure determine optimum capacitor size and location.

UNIT -IV

Distribution System Automation: Reforms in power sector – Methods of improvement – Reconfiguration – Automation – Communication systems – Sensors –Basic architecture of Distribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions – Communication media for distribution system automation- Communication protocols for Distribution systems – IEC 61850 and IEEE 802.3 standards

UNIT -V

Distribution system management: Integrated sub–station metering system – Revenue improvement – issues in multi–year tariff and availability-based tariff.

TEXTBOOKS:

1. Turan Gonen, Electric Power Distribution System Engineering, 2nd Edition, CRC Press, 2008.
2. A S Pabla, Electric Power Distribution, 5th Edition, Tata McGraw-Hill Publishing Co. Ltd., 2004.

SUGGESTED READING:

1. M.K. Khedkar, G.M. Dhole, “A Textbook of Electric power Distribution Automation”, University Science Press, New Delhi, 2010
2. Anthony J Pansini, “Electrical Distribution Engineering”, CRC Press, 1992
3. James Momoh, “Electric Power Distribution, automation, protection & control”, CRC Press, 2007.
4. Electrical Distribution System Analysis, https://nptel.ac.in/courses/108107112

NPTEL Courses:

S.NO.	NPTEL Course Name	Instructor	Link	Host Institute
1	Operation and Planning of Power Distribution Systems	Prof. Sanjib Ganguly	https://nptel.ac.in/courses/117103149	IITG

26EEE110

MACHINE LEARNING APPLICATIONS IN POWER ENGINEERING

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of basic programming skills, algorithm design, basics of probability & statistics

COURSE OBJECTIVES: This course aims to:

1. Understand the basics of Machine Learning
2. Apply different machine learning models to various datasets.
3. Introduce advanced concepts and methods of machine learning.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Understand basic concepts of Machine Learning Techniques
2. Understand the different types of datasets.
3. Develop skills in using machine learning algorithms for solving practical problems.
4. Analyze and work with different datasets.
5. Apply Machine Learning Algorithms for Electrical Engineering problems.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	2	2
CO 2	3	2	2	2
CO 3	3	2	2	3
CO 4	3	2	2	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT-I

Introduction Machine Learning (ML): Introduction -Types of Learning : Supervised, Unsupervised, Reinforcement Learning - Data Representation - Hypothesis space - Inductive Bias -Evaluation - Training and test set - cross-validation- Applications of ML.

UNIT-II

Supervised Learning: Regression - Linear Regression, Logistic Regression, Classification - Naive Bayes Classifiers, K-Nearest Neighbor (K-NN), Decision Trees, Support Vector Machine (SVM) - Underfitting and overfitting - Causes of overfitting - Methods to prevent over fitting - Advantages and Disadvantages of supervisory learning- Application of supervised learning.

UNIT-III

Unsupervised Learning: Clustering - Types of Clustering - K-means clustering, Hierarchal clustering- Agglomerative, Divisive - Gaussian mixture model – Introduction to Association – Association algorithms- Apriori, Eclat, FP-Growth algorithms -Advantages and Disadvantages of Unsupervised learning, Difference between Supervised and Unsupervised Learning- Application of unsupervised learning.

UNIT-IV

Dimensionality Reduction Techniques: Introduction - Importance of dimensionality reduction - Feature selection- Filter methods, Wrapper methods, Embedded methods - Advantages of feature selection - Feature extraction- Principal Component Analysis (PCA), Independent Component Analysis (ICA), Advantages of feature extraction, Latent Dirichlet Allocation (LDA).

UNIT-V

Applications of ML: Load Forecasting – Energy Market forecasting– Fault identification and localization using Regression and K-NN algorithms - Renewable Uncertainty estimation - Wind Power and Solar power Uncertainty Regression and K-NN algorithms.

TEXTBOOKS:

1. Tom Mitchell, “Machine Learning”, First Edition, McGraw- Hill, 1997.
2. Ethem Alpaydin, “Introduction Machine Learning”, Edition 2.
3. M.Gopal, “Applied Machine Learning”, McGraw Hill Education (India) Private Limited, 2018
4. Andreas C. Mueller and Sarah Guido, “Introduction Machine Learning with Python”, O'Reilly Media, Inc, 2016
5. Christopher Bishop, “Pattern Recognition and Machine Learning”, Springer, 2011

SUGGESTED READING:

1. Jeeva Jose, “Introduction Machine Learning”, Khanna Book Publishing Co., 2020.
2. John Paul Mueller and Luca Massaron, “Machine Learning for Dummies”, 2016.
3. Rajeev Chopra, “Machine Learning”, Khanna Book Publishing Co., 2021
4. Ethem Alpaydin, “Machine Learning: The New AI”, The MIT Press, 2016

NPTEL/SWAYAM Course:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Introduction Machine Learning	Prof. Balaraman Ravindran	IIT Madras
2	Introduction Machine Learning	Prof. Sudeshna Sarkar	IIT Kharagpur

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2026-27 (R26)

M.E (Power Systems and Power Electronics)

SEMESTER–II

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours Per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	26EEC106	Advanced Computational Methods in Power Systems	3	-	-	3	40	60	3
2	26EEC107	DC Microgrid and Control System	3	-	-	3	40	60	3
3	26EEC108	Data Science Applications in Power Engineering	3	-	-	3	40	60	3
4	26EEE1XX	**Program Elective-III**	3	-	-	3	40	60	3
5	26EEE1XX	**Program Elective-IV**	3	-	-	3	40	60	3
	PRACTICALS								
6	26EEC109	Power Systems Computational Lab	-	-	2	-	50	-	1
7	26EEC110	Data Science Applications Lab	-	-	2	-	50	-	1
8	26EEC111	Mini Project	-	-	2	-	50	-	1
Total			**15**	**-**	**6**	**-**	**350**	**300**	**18**
	Clock Hours Per Week: 21								

L: Lecture D: Drawing CIE: Continuous Internal Evaluation T: Tutorial

P: Practical/Project Seminar/Dissertation SEE: Semester End Examination

26EEC106

ADVANCED COMPUTATIONAL METHODS IN POWER SYSTEMS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on power system analysis

COURSE OBJECTIVES: This course aims to:

1. Understand the load flow analysis of power systems.
2. Analyze the load flows under renewable penetrated power systems.
3. Attain knowledge of power system components, its operation strategies, and stability analysis.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Develop proper mathematical models for analysis of a selected problem like load flow study of Power System and Distribution Network or Fault analysis.
2. Determine Power flows with various load flow methods.
3. Obtain the power flows for distribution systems.
4. Develop power system software /implementation algorithm for fault analysis.
5. Find the fault currents by implementing algorithms for different faults.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	2
CO 2	2	2	2	1
CO 3	3	2	1	2
CO 4	2	2	1	3
CO 5	2	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Basic Power System Components and their Representation: Physical parameters – Significance of per unit - representation, Typical single line diagram of a power system. Concept of incidence matrix, formation of A and Â matrices, list of other types of incidence matrices and their limitations. Representation of Generator, Transmission lines and Transformers, Primitive and Network matrices, Ybus formation by Inspection method and its algorithm. Merits and Demerits of Y_{bus} and Z_{bus} matrices in Power System Analysis – Areas of application.

UNIT -II

Load Flow Analysis: Y_{bus} based Power System Static Load Flow Equations. Gauss-Seidel (GS) method, PV-bus treatment, Gauss-Seidel load flow algorithm. Need of Sparsity technique for 'well grown' power systems, Concept of Sparsity technique, Y_{bus} formation using Sparsity technique. GS with Sparsity technique. Merits and Demerits of GS method. Newton-Raphson (NR) load flow method and its algorithm. Merits and Demerits of NR method; Newton‟s Decoupled, Fast Decoupled equation, algorithm of Fast Decoupled (FDC) method. Merits and Demerits of the FDC method; Areas of application of the load flow study.

UNIT -III

Distribution System Load Flow Methods: Load Flow Methods-Vector-based load flow method, Backward-Forward Sweep method, and Current injection method. Load flow studies with Renewable Energy Sources –Solar and Wind Energy Sources.

UNIT -IV

Short Circuit Studies: Need of short circuit studies, Assumptions in short circuit studies, Areas of application. Formation of Z_{bus} using a step-by-step approach (Addition of a branch & Addition of a link). Modification of Z_{bus} elements for changes.

UNIT -V

Symmetrical Sequence Components: Symmetrical components transformation – Significance & approximations, formation of primitive Z_f^{abc}, V_f^{abc} , Z_f^{012} and Y_f^{012} for various types of faults, Unsymmetrical Fault Analysis: Sequence network analysis of line to ground and double line to ground fault.

TEXTBOOKS:

1. Stagg and El – Abiad, "Computer Methods in Power System Analysis", , McGraw Hill, ISE, 1986
2. M A Pai and Dr. Dheeman Chatterjee, "Computer techniques in Power System Analysis", McGraw hill.,3rd Edition.

SUGGESTED READING:

1. Hadi Sadat, "Power System Analysis", International Edition, McGraw Hill, 1999.
2. J.Arrilaga and NR Watson , "Computer Modeling of Electrical Power Systems", , John Wiley and Sons.
3. https://nptel.ac.in/courses/108104051.
4. https://nptel.ac.in/courses/101104086.

26EEC107

DC MICROGRID AND CONTROL SYSTEM

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Power Electronics, Electrical Power Systems, and Control Systems.

COURSE OBJECTIVES: This course aims to:

1. To provide a comprehensive understanding of microgrid concepts, configurations, and their role in modern power systems with distributed energy resources.
2. To analyze power electronic converters, modeling of energy sources, and dynamic behavior of microgrid systems.
3. To study the operation, control strategies, stability analysis, and applications of DC microgrid systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Explain the fundamental concepts of microgrids, distributed generation, and compare microgrids with conventional power systems.
2. Analyze the role of power electronic converters in microgrid applications and develop models for different converter configurations.
3. Model renewable energy sources, energy storage systems, and analyze the dynamic behavior of microgrid systems.
4. Evaluate microgrid operation modes, control architectures, and energy management strategies in AC and DC microgrid systems.
5. Analyze control methods, stability issues, and stabilization techniques in DC microgrid systems and identify their applications

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	3	2	3	3
CO 3	3	2	3	3
CO 4	2	2	3	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Fundamentals of Microgrids: Overview of microgrids, concept of microgrids, microgrid and distributed generation, microgrid vs conventional power system. AC and DC microgrid with distributed energy resources, AC and DC microgrid with distributed energy resources.

UNIT -II

Power Electronics and Converter Modeling in Microgrids: Power electronics for microgrid, power electronic converters in microgrid applications, power electronic converters in microgrid applications (power electronic for interfacing), power electronic converters in microgrid applications (converter modulation techniques). Modeling of converters in microgrid power system (AC/DC and DC/AC converters modeling), modeling of power converters in microgrid power system (DC/DC converter modeling and control).

UNIT -III

Modeling of Energy Sources and Microgrid Dynamics: Modeling of renewable energy resources (modeling of wind energy system), modeling of renewable energy resources (modeling of photovoltaic system), modeling of energy storage system. Microgrid dynamics and modeling, microgrid dynamics and modeling.

UNIT -IV

Microgrid Operation, Control and Architecture: Microgrid operation modes and standards, microgrid control architectures, microgrid control architectures. Intelligent microgrid operation and control, Energy management in microgrid system. DC microgrid system architecture and AC interface.

UNIT -V

DC Microgrid Dynamics, Control, Stability and Applications: DC microgrid dynamics and modeling, control of DC microgrid system. Applications of DC microgrids, stability in microgrid, stability analysis of DC microgrid. DC microgrid stabilization strategies (passive damping method), DC microgrid stabilization strategies (impedance/admittance stability criteria), DC microgrid stabilization using nonlinear techniques, general summary of DC microgrids.

TEXTBOOKS:

1. Fusheng Li, Ruisheng Li, Fengquan Zhou, Microgrid Technology and Engineering Application, Elsevier, 2015.
2. Nikos Hatziargyriou, Microgrids: Architectures and Control, John Wiley & Sons, 2014.
3. Hassan Bevrani, Bruno François, Toshifumi Ise, Microgrid Dynamics and Control, John Wiley & Sons, 2017

SUGGESTED READING:

1. S. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, Institution of Engineering and Technology, 2009.
2. Manuela Sechilariu, Fabrice Locment, Urban DC Microgrid: Intelligent Control and Power Flow Optimization, Butterworth-Heinemann, 2016.
3. Gevork B. Gharehpetian, S. Mohammad Mousavi Agah, Distributed Generation Systems: Design, Operation and Grid Integration, Butterworth-Heinemann, 2017.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute	Link
1	DC Microgrid and Control System	Prof. Avik Bhattacharya	IIT Roorkee	https://nptel.ac.in/courses/108107143

26EEC108

DATA SCIENCE APPLICATIONS IN POWER ENGINEERING

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have knowledge of linear algebra, PDE, and Power Systems.

COURSE OBJECTIVES: This course aims to:

1. Understand the data collection and data handling of real time power system problems.
2. Analyze the given data with various AI techniques.
3. Understand the role of data science in smart grid technologies.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Distinguish between Algorithmic based methods and Knowledge based Methods.
2. Able to distinguish between Artificial Neural Networks and Fuzzy Logic.
3. Able to analyze the critical power system data with AI techniques.
4. Adopt Soft Computing techniques for solving Power Engineering Problems.
5. Apply appropriate AI framework for solving Power Engineering Problems.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	2	2	2	2
CO 3	2	3	2	3
CO 4	3	2	2	3
CO 5	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Fuzzy Logic: Introduction - Classical set - Properties, Operations and relations, Fuzzy Sets-Properties, Operations and relations, Fuzzy Cartesian Product -Fuzzy Membership functions - Fuzzy Cardinalities, Fuzzy Logic Controller (FLC) - Fuzzy Logic System Components: Fuzzification, Inference Engine, Defuzzification methods.

UNIT -II

Artificial Neural Networks (ANN): Introduction Artificial Neural Networks - Definition and Fundamental concepts -Biological Neural Network - Modelling of a Neuron - Activation functions -Initialization of weights - Typical architectures - Linear Separability – AND, OR - XOR Problem - Multi layer perceptron, Forward propagation, Back propagation

UNIT –III

Data Analytics for Power Systems: Introduction - Types of data - structured, unstructured, time-series, Data sources in Power Systems – Data availability in Power System- Data Preprocessing, Data cleaning, Data normalization and scaling, Singular Value Decomposition (SVD) - Principal Component Analysis (PCA) - Application of SVD and PCA -Smart metering- Components of smart metering, Data transmission technologies - Applications of Smart metering-Data Visualization.

UNIT -IV

Deep Learning: Introduction to Deep learning, Difference between Machine Learning and Deep Learning -Role of deep learning in Data Science - McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm, Convolutional Neural Network (CNN), Building blocks of CNN, Transfer Learning, Deep Neural Networks (DNN), Deep belief Networks, Recurrent Neural Network.

UNIT -V

Applications of Data Science in Power Systems: Load flow studies - Economic load dispatch - Load Frequency Control (LFC) – Single area system and two area systems using Fuzzy and ANN, **Applications of Deep Learning:** Battery health monitoring, Fault detection, Load forecasting.

TEXTBOOKS:

1. S. Rajasekaran and G.A.V. Pai, “Neural Networks, Fuzzy Logic & Genetic Algorithms”, PHI, New Delhi, 2008.
2. T.J. Ross, “Fuzzy Logic with Fuzzy applications”, Mc Graw Hill Inc, 1997.
3. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning. Cambridge, MA, USA: MIT Press, 2016.

SUGGESTED READING:

1. Simon Haykin, “Neural Networks: A Comprehensive Foundations” Pearson Edition, 2003.
2. G.J.Klir and T.A.Folger, “Fuzzy sets, Uncertainty and Information”, PHI, Pvt.Ltd,1994.
3. Introduction to Soft computing, https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_cs54
4. Fuzzy sets, logic and systems and its applications, https://nptel.ac.in/courses/108104157

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Fuzzy Logic and Neural Networks	Prof.Dilip Kumar Pratihar	IIT Kharagpur

26EEC109

POWER SYSTEMS COMPUTATIONAL LAB

Instruction	2P Hours per week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1

Prerequisite: Students should have prior knowledge of power systems

COURSE OBJECTIVES: This course aims to:

1. Simulate and study the various aspects of power system analysis.
2. Simulate and assess the stability and control of a power system.
3. Understand the application of soft computing techniques in power systems operation and control.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Analyze the power system under various fault conditions.
2. Evaluate the economic dispatch in the power system operation.
3. Analyze load frequency control and transient stability of power systems.
4. Estimate power system states using state estimation techniques.
5. Analyze and select artificial intelligence techniques for the Power System operation and control.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	3	3
CO 2	3	2	3	3
CO 3	3	2	3	3
CO 4	3	2	3	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Formation of Z-Bus Matrix using Building Algorithm
2. Short Circuit Analysis for unsymmetrical faults
3. Load Flow Studies Using Gauss-Seidel and Newton-Raphson Method
4. Economic Load Dispatch in Power Systems
5. Single Area and Two Area Load Frequency Control

6. Transient Stability Studies
7. Solution of Swing Equation
8. DC Load Flow based Weighted Least Square Based State Estimation
9. Single Area Load Frequency Control using Fuzzy Logic Toolbox.
10. Maximization of Sin(x) using Genetic Algorithm
11. Economic Load Dispatch using Genetic Algorithm
12. Economic Load Dispatch using Particle Swarm Optimization

Note: At least **TEN** experiments should be conducted in the semester.

26EEC110

DATA SCIENCE APPLICATIONS LAB

Instruction	2P Hours per week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1

Prerequisite: Students should have prior knowledge of basic programming language, MATLAB, Power Systems and Power electronics.

COURSE OBJECTIVES: This course aims to:

1. Provide knowledge of fuzzy logic and neural networks.
2. Provide knowledge on deep learning techniques.
3. Provide knowledge of various AI techniques.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Analyze and choose suitable AI techniques for power system problems.
2. Design fuzzy logic rule-based system.
3. Understand and design neural networks for electrical engineering problems.
4. Understand basic concepts of deep learning algorithms.
5. Analysis of power electronics converters using AI Techniques.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	3	3	3
CO 2	3	3	3	3
CO 3	3	3	3	3
CO 4	3	3	3	3
CO 5	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:

1. Identification of similarities in data attributes using Pearson coefficient method
2. Dimensionality reduction using principal component analysis (PCA)
3. Speed Control of DC Motor using Fuzzy Logic Controller.
4. Energy Management of radial distribution system using ANN.

5. Fuzzy based current control of Buck-Boost converter
6. Power measurement of RL circuit using Neural Network
7. ANN based AGC – Single area system.
8. Room temperature analysis
9. Load Flow analysis using Neural Network
10. Load forecasting using ANN.
11. Power system Security using Neural Network
12. Classification of Fault using ANN

Note: At least **TEN** experiments should be conducted in the semester

26EEC111

MINI PROJECT

Instruction	2P Hours per week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1

Prerequisite: None

COURSE OBJECTIVES: This course aims to:

1. Provide an opportunity for defining a problem statement through the practice of literature survey.
2. Motivate students face the challenges in which demonstration of their competence in research techniques.
3. Provide an opportunity to contribute to the engineering arena in their own form.

COURSE OUTCOMES: After completion, the student will be able to:

CO1: Identify real-world or research-oriented problems in Electrical Engineering (PSPE focus).
CO2: Develop skills in **literature review, problem formulation, and methodology design**.
CO3: Design and implement models/simulations/experimental setups.
CO4: Plan, execute, and manage project tasks individually or in teams.
CO5: Enhance **technical communication and professional ethics**.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	2	2
CO 2	3	2	3	3
CO 3	2	1	3	2
CO 4	1	3	2	1
CO 5	2	2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

General Instructions:

1. Each student will be allotted a faculty **Supervisor** for mentoring.
2. Composition of Departmental Review Committee **[DRC]**
   Supervisor and any other **Two Faculty** Members
3. Evaluation will be carried out based on **'RUBRIC'** (which will be supplied by the dept.)
4. Report should be written as per IEEE standard format.
5. The **Outcome** of the MINI PROJECT should turn into a Paper publication/ Conference Presentation/ any other relevant

Innovation Tracks (Optional)

- Smart Grid & Renewable Integration
- AI/ML in Power Systems
- Power Electronics for EVs
- Energy Sustainability Models
- IKS-based Engineering Concepts

Time scheduling

Phase	Weeks	Activity
Phase 1	1–2	Problem Identification + Literature Survey
Phase 2	3–5	Problem Formulation + Methodology- **REVIEW-1[4th Week]**
Phase 3	6–10	Implementation (Simulation / Hardware / Analytical) **REVIEW-2[8th Week]**
Phase 4	11–12	Testing, Results & Analysis
Phase 5	13–14	Report Writing & Final Presentation **FINAL EVALUATION [12th Week]**

Guidelines for awarding CIE

Evaluation by	Max. Marks	Evaluation Criteria / Parameter
Supervisor	20	Progress and Report
	05	Leading to Outcome
Department Research Committee (DRC)	05	Relevance of the Topic
	05	PPT Preparation
	05	Presentation
	05	Leading to Outcome
	05	Report Preparation

Repertoire of the MINI- Project report:

- Title Page
- Abstract
- Introduction
- Literature Review
- Problem Statement
- Methodology
- Design / Implementation
- Results & Analysis
- Conclusion & Future Scope
- References
- Appendices

26EEE111

POWER QUALITY IMPROVEMENT TECHNIQUES

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Power Electronics

COURSE OBJECTIVES: This course aims to:

1. To understand various power quality issues such as voltage variations, waveform distortions, and harmonic standards.
2. To analyze the causes of harmonics and study techniques for their elimination using passive and active filtering methods
3. To study advanced power quality improvement techniques including hybrid filters and unified power quality conditioners.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Explain power quality concepts, types of disturbances, harmonic representation, and standards for harmonic limits.
2. Analyze the sources and causes of harmonics in power systems due to converters and various electrical loads.
3. Evaluate harmonic mitigation techniques using high power factor converters, multi-pulse converters, and passive filters.
4. Apply PWM inverter-based active filtering techniques and control strategies for power quality improvement.
5. Analyze the operation and performance of hybrid active filters and unified power quality conditioners for mitigating sag, swell, and flicker.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	3	2	3	2
CO 3	3	2	3	3
CO 4	3	2	3	3
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Concept of Power Quality and Harmonic Standards: Concept of Power Quality, frequency variations, voltage variations – sag and swell, waveform distortion – DC offset, harmonics, inter-harmonics, notching and noise, representation of harmonics, waveform, harmonic power, measures of harmonic distortion, current and voltage limits of harmonic distortions: IEEE, IEC, EN, NORSO.

UNIT -II

Causes of Harmonics: 2-pulse, 6-pulse and 12-pulse converter configurations, input current waveforms and their harmonic spectrum, input supply harmonics of AC regulator, integral cycle control, cycloconverter, transformer, rotating machines, ARC furnace, TV and battery charger.

UNIT -III

Elimination and Suppression of Harmonics using Passive Methods: Elimination/suppression of harmonics: high power factor converter, multi-pulse converters using transformer connections (delta, polygon), Passive filters: types of passive filters, single tuned and high pass filters, filter design criteria, double tuned filters, damped filters and their design.

UNIT -IV

Active Power Filters and PWM Inverter Control: PWM inverter: voltage sourced active filter, current sourced active filter, constant frequency control, constant tolerance band control, variable tolerance band control, Active power filters: compensation principle, classification of active filters by objective, system configuration, power circuit and control strategy.

UNIT -V

Hybrid Filters and Unified Power Quality Conditioner: Hybrid shunt active power filter: principle of operation, analysis and modelling, unified power quality conditioner, voltage source and current source configurations, principle of operation for sag, swell and flicker control.

TEXTBOOKS:

1. B. Singh, A. Chandra, K. Al-Haddad, Power Quality: Problems and Mitigation Techniques, 1st Edition, Wiley India, 2015.
2. J. Arrillaga, B. C. Smith, N. R. Watson, A. R. Wood, Power System Harmonic Analysis, 2nd Edition, Wiley India, 2008.
3. Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 2000

SUGGESTED READING:

1. Derek A. Paice, Power Electronic Converter Harmonics, IEEE Press.
2. G.T. Heydt, “Electric power quality”, McGraw-Hill Professional, 2007
3. Roger C.Dugan, Mark F.McGranaghan, Surya Santoso, H.Wayne Beaty, ‘Electrical Power Systems Quality’, 3rd Edition,Tata McGraw-Hill, 2012.
4. R.Sastry Vedam, M.Sarma, "Power Quality-Var Compensation in Power Systems ", CRC Press, 2009
5. **NPTEL Course Name: “**Power Quality”,**Instructor:**Prof. BhimSingh, IIT Delhi (onlinecourses.nptel.ac.in/noc23_ee63/preview)

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute	Course URL
1	Power Quality Improvement Technique	By Prof. Avik Bhattacharya	IIT Roorkee	https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_ee65

26EEE112

HIGH POWER INVERTERS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have an introductory course on Power Electronics.

COURSE OBJECTIVES: This course aims to:

1. Understand and analyse the limitations of two-level inverters and the need for multilevel inverter topologies.
2. Apply and examine various PWM techniques used in high-power inverters.
3. Explore control and performance aspects of multilevel inverters in practical applications.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Explain and analyze the operation and limitations of two-level inverters and the need for multilevel inverters.
2. Understand PWM techniques such as level-shifted, phase-shifted and space vector PWM to diode clamped multilevel inverters.
3. Compare symmetrical and asymmetrical cascaded multilevel inverters and describe modular multilevel inverter concepts including capacitor voltage balancing.
4. Discuss reduced switch count multilevel inverter topologies based on basic performance measures.
5. Compare current source and voltage source inverters with appropriate PWM techniques.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	3	2	3	3
CO 3	3	2	3	3
CO 4	2	2	3	3
CO 5	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT-1:

Introduction: Review of two-level inverters and their PWM schemes. Effect of dead-time and compensation in two-level inverters. Limitations of two-level inverters and introduction of multilevel inverters. Conventional multilevel inverter topologies.

UNIT-II

Diode clamped multilevel inverter (DCMLI**):** Three, Four and Five level DCMLIs, level shifted PWM, Neutral point voltage balance, SVM and discontinuous SVM, Elimination of common mode voltage, Active Neutral Point Clamped Inverter (ANPCI).

UNIT-III

Cascade H-bridge (CHB) multilevel inverter (MLI): Symmetrical and asymmetrical topologies, level-shifted PWM, phase-shifted PWM, hybrid PWM. Concept of coupling transformer less grid connected applications, Topologies of modular multilevel inverters (MMI).

UNIT-IV

Reduced switch count MLIs: Introduction, classification, operation of T-type, multilevel dc link, switched series-parallel source and other topologies. Comparative Performance Analysis of Reduced Switch Count MLIs

UNIT-V

PWM current source inverters: Trapezoidal modulation, selective harmonic elimination and SVM, Load-commutated inverters (LCI).

TEXTBOOKS:

1. Bin Wu, “High Power Converters and AC Drives”, 2nd Edition, Wiley-Inter science, 2017.
2. D. Grahame Holmes and Thomas A. Lipo, “Pulse Width Modulation for Power Converters: Principles and Practice”, IEEE Press, 2003.

SUGGESTED READING:

1. N. Mohan, T. M. Undeland and W.P Robins, “Power Electronics Converters, Application and Design”, 3rd Edition, John Wiley India 2003.
2. M. H. Rashid, “Power Electronics Circuits, Devices and Applications”, 3rd Edition, Prentice-Hall 2004.
3. L. Umanand, “Power Electronics Essentials and Applications”, Wiley India 2009.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	High Power Multi-Level Converters, Analysis, Design and Operational Issues	Prof. Anandarup Das	IIT, Delhi

26EEE113

INDUSTRIAL AND STRATEGIC APPLICATIONS OF SUPERCONDUCTIVITY

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on Basic Electrical Engineering.

COURSE OBJECTIVES: This course aims to

1. Understand the fundamentals of superconductivity.
2. Examine the applications of superconductivity.
3. Evaluate the emerging trends and prospects.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Develop an understanding of the fundamental principles of superconductivity, including the properties of superconducting materials, critical temperature, and Meissner effect.
2. Analyse the potential applications of superconductivity in various industries, including energy, transportation, medical imaging, and computing.
3. Evaluate the benefits and limitations of superconductivity, including the technical, economic, and societal challenges that must be addressed for widespread adoption.
4. Apply the strategic implications of superconductivity, including its potential impact on national security, global competition, and intellectual property.
5. Explore the emerging trends in superconductivity research and development and assess the potential for future breakthroughs and new applications.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	2	1
CO 2	3	2	2	2
CO 3	3	2	2	1
CO 4	2	2	1	1
CO 5	3	2	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT - I

Introduction: Physics of superconductivity: Discovery of superconductivity. Meissner state, Superconductors vs. perfect conductors, Basic Research need for superconductivity. Cryostat and Experimental Set-up for testing Superconductivity

Theories of superconductivity: London, Ginzburg-Landau, BCS, Phase diagrams, mixed state, type- I and type- II superconductors, flux flow and flux creep. Engineering relevance of superconducting parameters (Tc, Hc, Jc)

UNIT - II

Types of Superconducting Materials: Low-temperature superconductors (NbTi, Nb3Sn). Wire manufacturing, physical properties, BJT Diagram High-temperature superconductors (BSCCO, YBCO). Bulk, tapes and wires, physical properties,
Stability and AC Losses: Degradation, training, and Stability criteria. Different losses in superconductors - hysteresis, eddy current, coupling losses. Additive manufacturing of superconductors

UNIT - III

Medical and power system applications: Overview of energy and medical applications of superconductors: Introduction MRI magnets, Design Aspects of MRI Magnets, Functioning of MRI Magnets, Application in Power system: Fault current limiters- Schematic Diagram and Principle of Operation., Resistive type and Inductive type Fault current Limiters. SC Transformers, Advantages, Construction and operational Aspects. SC Cables and its Application, Superconducting Magnetic Energy Storage System (SMES) and its application for power system stability. HTS
transformers (real deployment examples)

UNIT - IV

Industrial and Strategic applications: Overview of Industrial and Strategic energy applications of superconductors, Superconducting Motors and Wind Generators, Design Aspects, Air gap Electromagnetic Field calculation, Manufacture and Performance Evaluation. Application of SC Degaussing Coils for Naval Ships, Schematic diagram and Application for SC Magnets for Maglev Trains. Space applications (NASA superconducting systems)

UNIT–V

Accelerator Fusion Magnet: Introduction, Advance applications-particle accelerators Research being carried out at International thermonuclear Experimental Reactor (ITER), France Facility for Antiproton and Ion Research in Europe GmbH" (FAIR GmbH). Quantum magnets in accelerators

TEXTBOOKS:

1. Michael Tinkham, “Introduction Superconductivity”, Second Edition.
2. Stephen J. Blundell, “Superconductivity: A Very Short Introduction”
3. Edited by Paul Seidel, “Applied Superconductivity: Handbook on Devices and Applications”
4. Edited by P. Seidel and H.W.Weber, “Superconductivity: Fundamentals and Applications”
5. Martin N. Wilson A“Superconducting Magnets” Clarendon Press Publication
6. J. R. Bumby,“Superconducting Rotating Electrical Machines” Clarendon Press
7. Peter Schmueser, Siegfried Wolff, “Superconducting Accelerator Magnets Karl-hubert Mess”.

SUGGESTED READING

1. J. Robert Schrieffer and Leon N. Cooper, "High-Temperature Superconductivity: An Introduction"
2. James F. Annett, "Superconductivity, Super fluids, and Condensates"
3. Rolf W. Grosse and Werner Kissener, "Superconductivity: Basics and Applications Magnets”.
4. YuAshida, "Superconductivity: A New Approach Based on the Bethe–Salpeter Equation in the Mean- Field Approximation".
5. Vernon L., “Applied Superconductivity: Volume 2”, Academic Press- Technology Engineering pages.

ONLINE RESOURCES

1. https://onlinecourses.nptel.ac.in/noc26_ph11/preview
2. https://onlinecourses.nptel.ac.in/noc22_ph31/preview
3. https://onlinecourses.nptel.ac.in/noc24_ph34/preview

26EEE114

ADVANCES IN UHV TRANSMISSION AND DISTRIBUTION

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Basic Electrical Engineering.

COURSE OBJECTIVES: This course aims to:

1. To understand the development of EHV/UHV transmission systems, including insulation coordination, overvoltages, and key components of modern power networks.
2. To analyze reliability aspects and high voltage testing techniques of electrical apparatus used in EHV/UHV transmission systems.
3. To study conductors, towers, substations, and advanced practices such as measurement, safety, and upgradation of transmission systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Explain the development of EHV/UHV transmission systems, including grid management, insulation coordination, overvoltages, and insulator design.
2. Analyze reliability issues in high voltage apparatus and evaluate various high voltage testing methods and laboratory practices.
3. Apply high voltage testing techniques and assess the performance of composite insulators and conductors used in EHV/UHV transmission systems.
4. Evaluate the design aspects of towers and substations, including grounding, insulation coordination, communication systems, and SCADA applications.
5. Analyze safety practices, high voltage generation and measurement techniques, and assess methods for upgradation and uprating of transmission lines

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	2
CO 2	3	2	3	2
CO 3	3	1	3	2
CO 4	2	1	3	3
CO 5	2	2	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Transmission System Development and Insulation Aspects: Transmission system development – issues, advantages of HVAC/DC transmission, introduction to grid management, transmission system development, important components of transmission system. Insulation coordination, over voltage in power systems, design/selection of insulators, importance of grading/corona rings, non-ceramic insulators performance and service experience.

UNIT -II

Reliability and High Voltage Testing of Apparatus: Failure of apparatus in the field, importance of reliability and testing, pollution flashover phenomena and modeling. Planning of high voltage laboratories, importance of high voltage testing and techniques employed, basic philosophy of HV testing, tests for various HV apparatus.

UNIT -III

High Voltage Testing Techniques and Conductors: High voltage testing techniques for various apparatus, HV testing on composite insulators, surface degradation studies on composite insulators, surface morphological techniques for composite insulators. Conductors used for EHV/UHV transmission, corona and interference on transmission lines, introduction of HTLS conductors and their advantages, mechanical considerations for HV conductors.

UNIT -IV

Towers and Substations for EHV/UHV Systems: Introduction to towers and importance of foundations, selection/design of clearances for HV towers, design optimization for UHV towers, introduction to 1100 kV HVDC. Introduction to HV substations, types of substations and comparison, insulation coordination, components in a typical substation, preventive maintenance of substation, electric and magnetic fields and mitigation techniques, importance of grounding and reducing earthing resistance, introduction to the use of fiber optic cables (OPGW), introduction to communication and SCADA.

UNIT -V

Safety, Measurement and Upgradation of Transmission Systems: Precautions and safety measures in substations, electrical hazards, minimum clearances in substations. Importance of generation of HVDC in the laboratory, importance of generation of HVAC, impulse voltage and currents in the laboratory. Measurement of high voltages, introduction to digital recorders and measurement techniques, upgradation/uprating of transmission lines and their advantages.

TEXTBOOKS:

1. Rakosh Das Begamudre, Extra High Voltage AC Transmission Engineering, New Age International (P) Ltd., New Delhi, 2000.
2. E. Kuffel, W. S. Zaengl, J. Kuffel, High Voltage Engineering Fundamentals, Newnes Publishers, 2nd Edition, 2000.
3. Ravi S. Gorur, Edward A. Cherney, Jeffrey T. Burnham, Outdoor Insulators, (Textbook).

SUGGESTED READING:

1. CIGRE Working Group SC B.3-22, Technical Requirements for Substations Exceeding 800 kV, Brochure No. 400, December 2009.
2. IEC 60826, Design Criteria of Overhead Transmission Lines, International Standard, 2003.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute	Link
1	Advances in UHV Transmission and Distribution	Prof. Subbba Reddy B	IISc Bangalore	https://onlinecourses.nptel.ac.in/noc20_ee67/preview

26EEE115

SMART GRID TECHNOLOGIES

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on conventional power grid operations and communication.

COURSE OBJECTIVES: This course aims to:

1. Understand the concept of smart grid and its advantages and the operation of smart devices such as PMU, IED etc.
2. Know smart metering techniques and wide area measurement techniques.
3. Understand the operation of the micro grid and its components and the problems associated with integration of distributed generation.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Identify the difference between smart grid & conventional grid.
2. Demonstrate the role of smart devices such as PMU, IED etc. in Smart Grid
3. Understand the role of SCADA in Smart grid controlling and data acquisition.
4. Analyze the operation and control of Micro Grid.
5. Choose the suitable modern communication technologies for the required smart grid operation

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	2	2	3	2
CO 3	2	2	3	2
CO 4	2	2	3	2
CO 5	1	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Introduction Smart Grid: Working definitions of Smart Grid, Traditional Power Grid and Smart Grid, New Technologies for Smart Grid, Drivers for Smart Grid, Smart Grid Functionalities and Key components, Key Challenges for Smart Grid, Smart Grid Initiatives in India, International policies and standards in Smart Grid

UNIT -II

SCADA: Supervisory control and data acquisition (SCADA) systems, Components of SCADA systems, SCADA applications, SCADA basic functions, SCADA application functions, Advantages of SCADA in power systems

UNIT -III

Smart Systems: Real Time Pricing, Automatic Meter Reading (AMR), Geographic Information System (GIS), Outage Management System (OMS), Home and Building Automation, Smart Substations, Vehicle Grid

Smart Devices: Smart Meters, Smart Sensors, Smart Appliances, Intelligent Electronic Devices (IED) Phase Measurement UNIT -(PMU), Remote terminal UNIT -(RTU) and their application for monitoring & protection.

UNIT -IV

Micro-Grid: Microgrid Concept, Microgrid Architecture, Issues of interconnection, Operation and Control of Microgrids, Protection of micro-grid, Integration of DG and DS in a Microgrid, Operating Problems in Micro girds, applications of micro-grid, Introduction DC Microgrids

UNIT -V

Communication Systems: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, ZigBee, GPS, Basics of CLOUD computing and its necessity in Smart Grids, Cyber Physical Attacks and Security for Smart Grid, Smart grid Logical Security Architecture, Broadband over Power line (BPL). IP based protocols.

TEXTBOOKS:

1. Ali Keyhani, “Design of smart power grid renewable energy systems”, Wiley IEEE, 2011.
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press.
3. Padiyar, K. R., & Kulkarni, A. M.” Dynamics and control of electric transmission and microgrids”. John Wiley & Sons, 2019.
4. Thomas, M. S., & McDonald, J. D.” Power system SCADA and smart grids”. CRC press, 2017.

SUGGESTED READING:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, “Smart Grid: Technology and Applications”, Wiley 2012.
2. Stuart Borlas’e, “Smart Grid:Infrastructure, Technology and solutions” CRC Press.
3. A.G.Phadke , “Synchronized Phasor Measurement and their Applications”, Springer.

NPTEL Course:

S.No.	Course Name	Instructor Name	Host Institute	NPTEL-Link
1	Smart Grid: Basics Advanced Technologies	Prof. N. P. Padhy & Prof. Premalata Jena.	IIT Roorkee	Smart Grid: Basics to Advanced Technologies - Course

26EEE116

POWER SYSTEM DYNAMICS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Power Systems and its Operation and Control.

COURSE OBJECTIVES: This course aims to:

1. Understand and analyze the various stability concepts of the power system.
2. Study the concept of modelling synchronous machines.
3. Understand the phenomenon of SSR oscillations in power systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Distinguish various stability issues in the power system.
2. Understand the modelling of synchronous machines.
3. Describe the role of Excitation, PSS and Prime Movers in improving power system performance during disturbances.
4. Analyze the small-signal stability of the power system.
5. Infer the concepts of LFOs and SSR in detail.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	2
CO 2	3	1	3	2
CO 3	3	2	3	3
CO 4	3	2	3	3
CO 5	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT – I

Synchronous Machine Modelling: Introduction, Park's Transformation, Flux Linkage Equations, Voltage Equations, Formulation of State-Space Equations, Current Formulation, Per Unit Conversion, Normalized Voltage and Torque Equations, Torque and Power, Equivalent Circuit of a Synchronous Machine, Flux Linkage State-Space Model.

UNIT – II

Stability: Definition and classification of stability, Analysis of Steady-state stability, Factors affecting Steady-state stability, Transient stability, Equal-area criterion, Factors influencing Transient stability, Numerical Methods for analyzing Transient stability, Definition of voltage stability, voltage security, voltage collapse, Factors contributing to and affecting voltage stability and minimization of voltage collapse, Analysis of voltage stability/collapse, P-V and Q-V curves.

UNIT – III

System Performance Improvement – Excitation Systems: Requirements, elements of excitation systems, types of excitation systems, modelling of excitation systems. **Power System Stabilizers:** Basic concepts in applying PSS, Structure and tuning of PSS. **Load Models:** Concept of load modelling, static and dynamic load models. **Prime Movers:** Hydraulic turbine and governing systems, steam turbine and governing system.

UNIT – IV

Small-Signal Stability: Fundamentals of stability of dynamic systems, Modal matrices, free motion of dynamic systems, mode shapes, small-signal analysis of SMIB, synchronizing and damping torque analysis, state equations for small-signal model.

UNIT – V

Sub-Synchronous Oscillations: Turbine-generator torsional characteristics, Torsional interactions with power system controls, Sub-Synchronous Resonance (SSR), countermeasures for SSR.

TEXTBOOKS:

1. P. M. Anderson & A. A. Fouad “Power System Control and Stability”, Wiley & Sons, 2003
2. P. Kundur, “Power System Stability and Control”, McGraw Hill Inc, 1994
3. K R Padiyar,” power system dynamics: stability and control”, BS Publications, 2008

SUGGESTED READING:

1. J Machowski, J Bialek& J. R W. Bumby, “Power System Dynamics and Stability”, John Wiley & Sons, 1997
2. L. Leonard Grigsby (Ed.); “Power System Stability and Control”, Second edition, CRC Press,2007
3. **NPTEL Course Name:”** Power System Dynamics, Control and Monitoring”, **Instructor:** Prof. Debapriya Das, IIT Kharagpur (onlinecourses.nptel.ac.in/noc21_ee16/preview)
4. **NPTEL Course Name:”** Power System Dynamics and Control”, **Instructor:** Prof. A. M. Kulkarni, IIT Bombay (nptel.ac.in/courses/108101004)

26EEE117

POWER ELECTRONICS FOR POWER SYSTEMS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on Power Electronics and Power System Control.

COURSE OBJECTIVES: This course aims to:

1. Introduce the concepts of reactive power compensation that can be used for interconnected power transmission and distribution systems.
2. Study the principles of operation and control of shunt, series and combined FACTS controllers.
3. Study the various types of power quality problems in distribution systems and know about the filters.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Distinguish the performance of Transmission line with and without FACTS Devices
2. Compare the SVC and STATCOM.
3. Understand the operation and control of various Static Series Compensators
4. Understand the operation and control of Unified Power Flow Controller
5. Distinguish various power quality issues and how they are mitigated by various FACTS Devices

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	3	2
CO 2	2	2	3	2
CO 3	2	2	3	2
CO 4	2	2	3	2
CO 5	1	2	2	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT-I

Reactive Power Flow Control in Power Systems: Power flow control, Constraints of maximum transmission line loading, Benefits of FACTS Transmission line compensation, Uncompensated line, Shunt compensation, Series compensation, Phase angle control, Reactive power compensation, Shunt and Series compensation principles, Reactive compensation at transmission and distribution level.

UNIT-II

Static Shunt Compensation: Static versus passive VAR compensator, Static shunt compensators, SVC and STATCOM, Operation and control of TSC, TCR and STATCOM Compensator control, Comparison between SVC and STATCOM.

UNIT-III

Static Series Compensation: TSSC, SSSC -Static voltage and phase angle regulators, TCVR and TCPAR Operation and Control, Applications, Static series compensation, GCSC, TSSC, TCSC and Static synchronous series compensators and their Control.

UNIT-IV

Combined Power Flow Controller: Circuit Arrangement, Operation and control of UPFC, Basic Principle of P and Q control, Independent real and reactive power flow control- Applications, Introduction interline power flow controller (IPFC)

UNIT-V

Power Quality Problems in Distribution Systems: Harmonics, loads that create harmonics, harmonic propagation, series and parallel resonances, mitigation of harmonics, passive filters, active filter, shunt, series, hybrid filters and their control. Voltage swells, sags, flicker, unbalance and mitigation of these problems by unified power quality conditioner (UPQC), IEEE standards on power quality.

TEXTBOOKS:

1. K R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International Publishers, 2007.
2. N.G. Hingorani, L. Gyugyi, “Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems”, IEEE Press Book, Standard Publishers and Distributors, Delhi, 2001.

SUGGESTED READING:

1. X P Zhang, C Rehtanz, B Pal, “Flexible AC Transmission Systems- Modelling and Control”, Springer Verlag, Berlin 2006.
2. K.S.Sureshkumar, S.Ashok , “FACTS Controllers & Applications”, E-book edition, Nalanda Digital Library, NIT Calicut, 2003.
3. G. T. Heydt, “Power Quality”, McGraw-Hill Professional, 2007.
4. T. J. E. Miller, “Static Reactive Power Compensation”, John Wiley and Sons, New York, 1982

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Facts Devices	Prof. Avik Bhattacharya	IIT Roorkee

26EEE118

CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of the Power System and Control System.

COURSE OBJECTIVES: This course aims to

1. Provide knowledge of electric grid configuration, power quality, and the effects of renewable energy penetration in the power network.
2. Develop the ability to model and evaluate dynamic and static renewable energy sources and storage devices.
3. Analyse and apply control mechanisms and integration strategies for grid-connected and off-grid renewable energy systems.

COURSE OUTCOMES: After the completion of this course, the student will be able to:

1. Identify and explain different renewable energy sources, their operating principles and storage technologies.
2. Develop mathematical models of dynamic and static renewable energy sources for analysis and simulation.
3. Analyse and simulate control strategies for grid-connected and off-grid renewable energy systems.
4. Evaluate control issues, challenges, protection requirements and fault ride-through capabilities in renewable energy systems.
5. Interpret and apply IEEE & IEC codes and standards for renewable energy grid integration.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	3	1
CO 2	3	2	3	2
CO 3	3	2	3	3
CO 4	3	2	3	3
CO 5	2	3	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT – I

Electric Grid and Renewable Energy Penetration: Electric grid, power quality, stability and cost; importance & effects of renewable energy penetration in the grid; boundaries of the actual grid configuration; consumption models and patterns.

UNIT – II

Dynamic Energy Conversion Technologies: Introduction, types of conventional and nonconventional dynamic generation technologies; principle of operation and analysis of reciprocating engines, gas and micro turbines; hydro and wind-based generation technologies

UNIT – III

Static Energy Conversion Technologies: Introduction, types of conventional and nonconventional static generation technologies; principle of operation and analysis of photovoltaic systems, fuel cell, and wind generation technologies (power-electronic interface); storage technologies – batteries, flywheels, supercapacitors and ultra-capacitors.

UNIT – IV

Control Issues and Challenges: Predictive controllers and adaptive controllers; load frequency and voltage control; modulation techniques; control of diesel, PV, wind and fuel cell-based generators; fault ride-through capabilities.

UNIT – V

Integration of Energy Conversion Technologies: Introduction & importance of integrated systems; interfacing requirements; IEEE & IEC codes and standards for renewable energy grid integration; Indian case study.

TEXTBOOKS:

1. G. Masters, “Renewable and Efficient Electric Power Systems”, 2nd Edition, G. Masters, IEEE-John Wiley and Sons Ltd. Publishers, 2013.
2. S. Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks”, IET Power Electronics Series, 2012.
3. Ali Keyhani Mohammad Marwali and Min Dai, “Integration and Control of Renewable Energy in Electric Power System”, 2nd Edition, John Wiley publishing company, 2010

SUGGESTED READING:

1. Chetan Singh Solanki, “Solar Photovoltaic, Fundamentals, technologies Applications”, 3rd Edition, PHI Publishers, 2019.
2. QuingChang Zhong, “Control of Power Inverters in Renewable Energy and Smart Grid Integration”, 1St Edition, IEEE-John Wiley and Sons Ltd. Publishers, 2013.
3. Bin Wu, Yongqiang Lang, Navid Zargari, “Power Conversion and Control of Wind Energy Systems”, 1st Edition,IEEE- John Wiley and Sons Ltd. Publishers, 2011.
4. Report on *"Large Scale Grid Integration of Renewable Energy Sources-Way Forward"*, Central Electricity Authority (CEA), Government of India, 2013.
5. R. Anandalakshmi and V.V. Goud, “Renewable Energy Engineering: Solar, Wind & Biomass .” NPTEL Web Course, IIT Guwahati, 2021. nptel.ac.in/courses/103103206
6. Debapriya Das “Power System Dynamics, Control & Monitoring ,” NPTEL Web Course, IIT Kharagpur, 2022. Power System Dynamics, Control and Monitoring - Course
7. Prathap Haridoss, “Non-conventional Energy Resources,” NPTEL Web Course, IIT Madras, 2024. Non-conventional energy Resources - Course
8. onlinecourses.nptel.ac.in/noc24_ee148/preview

26EEE119

DSP APPLICATIONS IN ELECTRICAL ENGINEERING

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on DSP

COURSE OBJECTIVES:

1. To understand adaptive filtering algorithms and their mathematical foundations.
2. To study convergence behavior and performance of adaptive systems.
3. To apply adaptive filtering techniques in electrical and electronic applications.

COURSE OUTCOMES: After completing the course, students will be able to:

1. Analyze power system disturbances and power quality issues using digital signal processing techniques.
2. Design and evaluate adaptive filtering algorithms for system identification and noise reduction in electrical systems.
3. Apply spectral analysis and estimation techniques for frequency and phasor estimation in electrical signals.
4. Analyze non-stationary power signals using time–frequency methods and extract relevant features for classification.
5. Implement DSP algorithms on hardware platforms for real-time electrical and electronic applications.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	1	-	2	2
CO 2	2	-	3	2
CO 3	1	-	3	2
CO 4	2	-	2	3
CO 5	1	-	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT-I

DSP in Modern Power Systems: Power quality issues: sag, swell, harmonics - Interruptions Frequency and voltage variations - Transformer inrush current: over-excitation, instrument transformer transients, Digital protection basics - Wide Area Monitoring Systems (WAMS) - Predictive analysis in smart grids

UNIT-II

Advanced Filtering Techniques & System Identification: Advanced filter fundamentals - MSE - Gradient-Based Adaptive Algorithms: LMS, NLMS, Gradient adaptive lattice algorithm - Convergence and stability analysis - RLS algorithms: GRLS, Gauss–Newton, RM, Matrix inversion lemma - Linear prediction and lattice filters (AR, ARMA) - Wiener and Kalman filters - Applications of adaptive filtering,

UNIT- III

Spectral Analysis & Estimation Techniques: Auto-correlation - power spectral density - Periodogram - nonparametric methods - Parametric methods: AR, MA, ARMA - Least squares estimation - Frequency and phasor estimation (with DC component) - Windowing and spectral leakage - Frequency-domain interpolation and multitone signals

UNIT- IV

Time-Frequency Analysis & Feature Extraction: STFT and Sliding Window DFT - Wavelet transform and S-transform - Empirical Mode Decomposition and Hilbert Transform - Gabor transform - Filter banks and multiresolution analysis - Feature extraction from power signals - Pattern recognition basics.

UNIT-V

Applications: FPGA architecture and programmable logic devices - HDL programming (VHDL/Verilog) - Design flow: synthesis, simulation, implementation - DSP hardware platforms - Applications: rectifiers, SMPS, PWM inverters, Motor control: DC and induction motors, Fault diagnosis and islanding detection

Learning Resources:

TEXTBOOKS:

1. S. Palani, *Principles of Digital Signal Processing*, 2nd Edition, Springer, 2023.
2. Alan V. Oppenheim and Ronald W. Schafer, *Discrete-Time Signal Processing*, 3rd Edition, Pearson, 2010.
3. John G. Proakis and Masoud Salehi, *Advanced Digital Signal Processing*, McGraw-Hill, 2000.

REFERENCE BOOKS:

1. Simon Haykin, *Adaptive Filter Theory*, 2nd Edition, Prentice Hall, 2001.
2. Sanjit K. Mitra, *Digital Signal Processing: A Computer-Based Approach*, 2nd Edition, McGraw-Hill, 2001.
3. Uwe Meyer-Baese, *Digital Signal Processing with Field Programmable Gate Arrays*, 4th Edition, Springer, 2014.
4. Introduction to Adaptive Signal Processing, Prof. Mrityunjoy Chakraborty, IIT Kharagpur

23EEE120

EVOLUTIONARY ALGORITHMS APPLICATIONS IN POWER ENGINEERING

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of basic optimization techniques

COURSE OBJECTIVES: This course aims to:

1. Provide a broad introduction to the field of conventional optimization problems.
2. Provide a broad introduction to the field of Genetic Algorithms and other fields of Evolutionary Computation and global optimization.
3. Teach students how to apply these methods to solve problems in complex domains.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Familiarize conventional optimization techniques.
2. Analyze the capabilities of bio-inspired systems and conventional methods for solving optimization problems.
3. Analyze how evolutionary algorithms can be explored and exploited to obtain near global optimal results.
4. Differentiate between evolutionary algorithms.
5. Apply bio-inspired algorithms Power Engineering applications.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	-	3	3
CO 2	3	-	3	3
CO 3	3	-	3	3
CO 4	3	-	3	3
CO 5	3	-	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Fundamentals of Soft Computing Techniques: Classification of optimization problems- unconstrained and Constrained optimization, Optimality conditions, Introduction to intelligent systems- soft computing techniques- Conventional Computing versus Swarm Computing - Classification of meta-heuristic techniques- Single solution based and population-based algorithms- Properties of Swarm Intelligent Systems.

UNIT -II

Genetic Algorithm (GA): Introduction GAs, Encoding, Fitness, Basic Operators- Selection, Crossover, Mutation, Different types of crossover and mutation operators, Control Parameters Estimation, Niching Methods, Genetic Algorithm versus Conventional Optimization Techniques, Flowchart of GA, Working of Binary and Real coded GA with standard test functions like Himmelblau, Booth, Sphere Functions.

UNIT -III

Particle Swarm Optimization (PSO): Introduction- Velocity updation- Position updation- Flow chart of PSO - Variants of PSO- Discrete PSO, Construction Factor Approach (CFA), Hybrid PSO (HPSO), Adaptive PSO (APSO), Evolutionary PSO (EPSO), Detailed working of PSO with Standard Test Functions like Himmelblau, Booth, Sphere Functions.

UNIT -IV

Differential Evolution (DE): Introduction- Initial Population, Mutation, and Recombination, Selection and the Overall DE, Key Operators for DE- Flow chart - Encoding, Mutation, Crossover, Working of DE with Standard Test Functions like Himmelblau, Booth, Sphere Functions.

UNIT -V

Applications to Power Systems: Load Frequency Control (LFC), Economic Dispatch (ED) and Load Forecasting , load curtailment using GA, PSO, and DE.

TEXTBOOKS:

1. Xin-She Yang, “Recent Advances in Swarm Intelligence and Evolutionary Computation”, International Edition, Springer International Publishing, Switzerland, 2015.
2. Kalyanmoy Deb, “Multi-Objective Optimization using Evolutionary Algorithms”, International Edition, John Wiley & Sons, 2001.
3. Kwang Y. Lee, Mohamed A. EI- Sharkawi, “Modern Heuristic Optimization Techniques, Theory, and applications power systems” IEEE Press Series on Power Engineering, 2008

SUGGESTED READING:

1. Eric Bonabeau, Marco Dorigo and Guy Theraulaz, “Swarm Intelligence-From natural Artificial Systems”, Oxford university Press, 1999
2. James Kennedy and Russel E Eberheart, “Swarm Intelligence”, The Morgan Kaufmann Series in Evolutionary Computation, 2001
3. N P Padhy, “Artificial Intelligence and Intelligent Systems”, Oxford University Press, 2005
4. I. Aleksandar Lazinica, “Particle Swarm Optimization”, Published by In-Tech, 2009

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute	Course Link
1	Evolutionary Computation for Single and Multi-Objective Optimization	Prof. Deepak Sharma	IIT Guwahati	https://onlinecourses.nptel.ac.in/noc21_me43/preview

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2027-28 (R26)

M.E (Power Systems and Power Electronics)

SEMESTER–III

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours Per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	26EEE1XX	**Program Elective- V**	3	-	-	3	40	60	3
2	26XXO1XX	**Open Elective**	-	-	-	3	40	60	3
3	AC-II	Audit Course-II	2	-	-	2	-	50	NC
4	26EEC112	Industrial Project /Dissertation Phase I	-	-	20	-	100	-	10
Total			**5**	**-**	**20**	**8**	**180**	**170**	**16**
	Clock Hours Per Week: 25								

L: Lecture D: Drawing CIE: Continuous Internal Evaluation T: Tutorial

P: Practical/Project Seminar/Dissertation SEE: Semester End Examination

26EEE121

DIGITAL PROTECTION OF POWER SYSTEMS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on Power systems, Switchgear and protection

COURSE OBJECTIVES: This course aims to:

1. To provide in-depth knowledge of the fundamentals of digital relays, signal processing techniques, and phasor estimation methods used in modern power system protection.
2. To develop the ability to analyze and design digital protection schemes for generators, transformers, transmission lines, and interconnected power systems.
3. To familiarize students with advanced protection concepts including microgrid protection, wide-area monitoring using PMUs, standards, and emerging trends such as AI and cyber security in power systems.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Understand fundamentals of digital relays, sampling, and phasor estimation techniques
2. Analyze digital differential protection and overcurrent relay coordination in power systems.
3. Evaluate digital distance protection methods for transmission lines.
4. Assess load shedding, islanding, and protection of AC/DC microgrids.
5. Interpret advanced protection concepts including PMU, standards, AI, and cyber security.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	2	2
CO 2	3	2	2	3
CO 3	3	2	3	3
CO 4	2	2	3	3
CO 5	2	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Fundamentals of Digital Relays and Phasor Estimation: Introduction of digital relays; fundamentals of digital relays; basic layout and elements of the digital relays with visual illustration; the concept of sampling and aliasing for digital relays; sliding window concept of digital relays; estimation of phasors using full-cycle discrete

Fourier transform (DFT); estimation of phasors using half-cycle DFT and introduction of discrete cosine transform; estimation of phasors using Walsh function technique and least error square technique; estimation of frequency in digital relays and practical considerations for selection of various algorithms; digital differential protection of generator, induction motors and busbar.

UNIT -II

Differential Protection and Overcurrent Relays: Digital differential protection of transformers; digital directional/non-directional overcurrent and earth fault relays; overcurrent relay coordination in an interconnected power system network: LINKNET structure and determination of primary/backup relay pairs; overcurrent relay coordination in an interconnected power system network: example; problems faced by digital distance relays.

UNIT -III

Digital Distance Protection Techniques: Computation of direction and impedance for digital distance relays; power swing detection and blocking technique in digital distance relays; protection of double-circuit transmission line using digital distance relays; protection of multi-terminal transmission line using digital distance relays; protection of series compensated transmission line using digital distance relays: basic components, voltage/current inversion and sub-synchronous oscillations and additional transients.

UNIT -IV

Load Shedding, Islanding and Microgrid Protection: Load shedding and frequency relaying: various load shedding techniques and frequency relays, factors to be considered and rate of frequency decline; islanding phenomena: hazards and risk of islanding and methods of islanding; loss of existing protection coordination among protective devices: recloser-fuse coordination for DG interfaced distribution network; hardware-in-loop testing of an islanding detection technique; protection of dc microgrid: review and challenges; AC microgrid protection: problems and solutions; insight into hybrid ac-dc microgrid protection; application of travelling wave (TW) and wavelet transform (WT) based algorithm.

UNIT -V

Wide Area Protection, Standards and Advanced Topics: Application of artificial intelligence (AI) in digital relaying; introduction to phasor measurement unit (PMU); introduction of IEEE C37.118 standard; wide area monitoring, control and protection using PMU; introduction to IEC 61850 standard for substation automation and relay interoperability; protection of high voltage dc transmission network; various cyber-attacks at substation/transmission level for Indian power grid network; basic concept and application of control switching.

TEXTBOOKS:

1. Bhavesh Bhalja, R. P. Maheshwari, N. G. Chothani, Protection and Switchgear, Oxford University Press, 2nd edition, New Delhi, India, 2018.
2. Oza, B. A., N. C. Nair, R. P. Mehta, et al., Power System Protection & Switchgear, Tata McGraw Hill, New Delhi, 2010.
3. Phadke, A. G. and J. S. Thorp, Computer Relaying for Power Systems, Research Study Press Ltd, John Wiley & Sons, Taunton, UK, 1988.

SUGGESTED READING:

1. Anderson, P. M., Power System Protection, IEEE Press, New York, 1999.
2. Blackburn, J. L., Applied Protective Relaying, Westinghouse Electric Corporation, New York, 1982.
3. Bhavesh Bhalja and Vijay H. Makwana, Transmission Line Protection Using Digital Technology, Springer, Singapore, 2016.

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute	Link
1	Digital Protection of Power System	Prof. Bhaveshkumar R. Bhalja	IIT Roorkee	https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_ee87

26EEE122

ADVANCED CONTROL TECHNIQUES FOR DC-DC CONVERTERS

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Students should have knowledge in Power Electronics and Design.

COURSE OBJECTIVES: This course aims to:

1. Understand and analyze modelling techniques of power converters for control applications.
2. Design and develop advanced control strategies for DC–DC converters.
3. Apply and evaluate various control techniques for improving converter performance under uncertainties.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Analyze and compare different modelling approaches of power converters,
2. Design and implement various PID controllers for DC-DC converters.
3. Develop different advanced controllers for effective control of DC-DC converters.
4. Apply robust control methods for power converters under uncertainties.
5. Design non-linear Controllers to achieve robust performance.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	2	3	3
CO 2	3	2	3	3
CO 3	3	2	3	3
CO 4	3	2	3	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT -I

Modeling of Power Converters: Types of Models- Linearized Averaged models- large signal and small signal models- Switched models- Relation between various model types- Control goals in converter operation- Review of classical control methods

UNIT -II

Advanced PID Controller: PID controller-Tuning methods of PID controller- Set point weighting, Integrator Windup- Controller degrees of freedom- Model based Design methods: Direct Synthesis (DS) method, Internal Model Control (IMC) method- Fractional Control System (FOS) -Design of Fractional PID controller- Case Study- PID controller design for DC-DC boost converter.

UNIT -III

Resonant Controller: Necessity of resonant controller- Principle of Proportional Resonant (PR) control- Design methods of PR controller- Example of PR controller design for DC-DC boost converter.

UNIT -IV

Loop-shaping design: Concept of Loop shaping- Robust controller design using the loop shaping methods: H∞ Control, Quantitative feedback theory (QFT)- Case Study- Loop shaping methods design the robust controller for DC-DC converter.

UNIT -V

Sliding Mode Controller (SMC): Nonlinear control preliminaries-Types of Uncertainty-Sliding surface design-Stability of SMC- Equivalent control concept-Integral Sliding Mode Control (ISMC) design- Case study-Application of SMC design the robust controller for DC-DC converter.

TEXTBOOKS:

1. S. Bacha, I. Munteanu, A.I. Bratcu, "Power Electronic Converters Modeling and Control with Case Studies", 1st Edition, Springer-Verlag London, 2014.
2. L. Wang, S. Chai, D. Yoo, L. Gan, K. Ng, "PID and Predictive control of Electrical Drives and Power Converters using MATLAB/Simulink", 1st Edition, Wiley Press, 2015.
3. C. Olalla, Ramon Leyva, I. Queinnec, "Robust Linear Control of DC-DC Converters: A Practical Approach the Synthesis of Robust Controllers, VDM Verlag- Dr. Muller", 1 st Edition, 2010.
4. A. Mehta, B. Naik, "Sliding Mode controllers for Power Electronic Converters", Springer Nature, 2019

SUGGESTED READING:

1. SC. Tan, Y-M. Lai, C.K. Tse, "Sliding Mode Control of Switching Power Converters: Techniques and Implementation", 1st Edition, CRC Press, 2012.
2. Hebertt Sira-Ramirez, Ramon Silva-Ortigoza, "Control Design Techniques in Power Electronic Devices", 1st Edition, Springer-Verlag London, 2006.
3. Freede Blaabjerg, "Control of Power Electronic Converters and Systems", 1st Edition, Academic Press, 2018.
4. Q- C. Zhong, T. Hornik, "Control of Power Inverters in Renewable Energy and Smart Grid Integration", 1st Edition, Wiley Press, 2013.
5. Advanced Control System Design for Aerospace Vehicles:https://nptel.ac.in/courses/101/108/101108047/

NPTEL Courses:

S.No.	NPTEL Course Name	Instructor	Host Institute
1	Advanced Control Systems	Prof. S. Mahji	IIT, Guwahati

26EEE123

ELECTRIC AND HYBRID VEHICLES

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge of Electrical Machines

COURSE OBJECTIVES: This course aims to:

1. Understand the concept Electric and Hybrid vehicles, and their advantages and disadvantages.
2. Understand the Performance Characteristics of various types of hybrid electric vehicles, Knowledge of various energy storage system of EV and EHV and energy management.
3. Develop and optimise the design of propulsion motors for EV applications and knowledge of charging technologies.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Understand the models of describing Electric and hybrid vehicles and their performance.
2. Determine the tractive effort required for EHV and EV with different vehicle parameters and optimisation of power train.
3. Design optimisation of Electric power train and implementation of charging technology.
4. Analyse the different possible ways of energy storage and battery selection.
5. Illustrate the principle of Hybrid Electric Vehicle, Battery Electric Vehicle and Plug-in EHV and able prepare. business plans.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	3	2	2
CO 2	3	3	2	2
CO 3	3	3	3	3
CO 4	3	3	3	2
CO 5	3	3	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT-I

Conventional & Electric Vehicles: Basics of Internal Combustion Engine, Global warming and Climate change, Basics of EVs, EV Advantages, Introduction Battery Electric Vehicle (BEV), Components and systems of Electric Vehicle, Performance of EVs, Govt. Policies and guidelines for implementation of electric mobility,

Trends and challenges of implementation of electric mobility and start up opportunities. Indian policy update (FAME-II, future roadmap)

UNIT-II

Hybrid Electric Vehicles: Introduction Hybrid Electric Vehicles: History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, Vehicle Mechanics, Vehicle power source characterization, , transmission characteristics using clutch and gear box, gear ratio, Transmission Efficiency, impact of modern drivetrains on energy supplies and Vehicle grid (V2G) & Grid Vehicle (G2V) fundamentals. Plug-in electric vehicles, Vehicle-to-Everything (V2X) beyond V2G[elementary treatment only]

UNIT-III

Electric and Hybrid Power Trains: Basic concept of hybrid traction, Components, and systems of EHV, introduction various hybrid drive train topologies, concept and modes of operation of Series Hybrid, Parallel Hybrid and Series-Parallel Hybrid Vehicle, , Regenerative braking fundamentals, Retrofit of Electric Power Train with Conventional vehicle run as EV.

UNIT-IV

Energy Storage and Charging Technology: Introduction Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage, , Lithium based batteries, basics of Metal Air batteries, battery sizing, Super Capacitor based energy storage, Fuel Cell driven Electric Hybrid Vehicle, Hybridization of energy storage batteries with Capacitor based energy storage devices, Different types of EV charging stations for battery charging, Wireless charging technology. Dynamic Charging.

UNIT -V

Design, Analysis, Testing & Qualification of Propulsion Motor: PM Materials (Nd FeB, SmCo, Ferrite and AlNiCo). Properties of NdFeB, SmCo and Ferrite material with respect to EV/EHV Requirements, Basic concepts of Design, Construction and analysis of water cooled/Air-cooled PM Motor for EV and HEV, Outer rotor PM Motor drive, Permanent Magnet assisted Hybrid Reluctance Motor of EV, Basics of Axial Flux PM Motor , Basic Design and construction Aspects of Induction Motors for EV and HEV, Configuration & control of PM Machines and Induction machines, Design optimization of PM Motor and Induction Motor for an EV or EHV using standard software.

TEXTBOOKS:

1. C. Mi, M. A. Masrur, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, 2011.
2. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.
3. Mehrdad Ehsani, Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals”, CRC Press, 2010.
4. K. T. Chau, “Electric Vehicle, Machines and Drives Design, Analysis And Application” International Research Centre For Electric Vehicles the University Of Hong Kong© 2015 John Wiley & Sons Singapore Pte. Ltd

SUGGESTED READING:

1. T. Denton, “Electric and Hybrid Vehicles”, Routledge, 2016
2. Hybrid Vehicles and the future of personal transportation, Allen Fuhs, CRC Press, 2011.
3. Vehicle Power Management: Modeling, Control and Optimization, Xi Zhang, Chris Mi, Springer, 2011.
4. National Electric Mobility Mission Plan 2020 Released by DHI, Govt. of India
5. Zero Emission Vehicles (ZEV) Towards a Policy Framework, NITI Aayog
6. IEC and different IS and Eclectic Mobility Standards.
7. Standard Electromagnetic software for analysis
8. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003.

NPTEL Course:

S.No.	Course Name	Instructor Name	Host Institute	NPTEL-Link
1	EV: Vehicle Dynamics and Electric Motor Drives	Prof. Amit Jain & Prof. Avinash Tripathi	IIT Delhi	EV - Vehicle Dynamics and Electric Motor Drives - Course

26EEE124

WIDE AREA MONITORING AND CONTROL

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Students should have prior knowledge on power system operation, control and analysis.

COURSE OBJECTIVES: This course aims to:

1. Explain the fundamental concepts and significance of Wide-Area Monitoring and Control in modern interconnected power systems.
2. Demonstrate the architecture, components, and communication infrastructure of Wide-Area Monitoring Systems (WAMS).
3. Develop a thorough understanding of the philosophies underlying wide-area monitoring, control, and protection strategies.

COURSE OUTCOMES: Upon successful completion of this course, students will be able to:

1. Analyze the key issues and challenges associated with the operation and stability of large-scale interconnected power systems.
2. Select and evaluate appropriate technologies for implementing wide-area monitoring and control solutions.
3. Explain the architecture, data flow, and functional components of Wide-Area Monitoring Systems.
4. Assess the real-time operating conditions, dynamic behaviour, and stability margins of wide-area power systems using synchrophasor measurements.
5. Apply systematic design methodologies to develop wide-area damping controllers, including coordinated PSS, HVDC, and FACTS-based control strategies.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	2	2
CO 2	3	2	3	2
CO 3	1	2	3	1
CO 4	3	2	3	3
CO 5	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT – I

Introduction to Wide-Area Power Systems: Trends of Interconnected Systems, Stability Problems of Interconnected Systems, WAMS Technology and Its Application in Interconnected Systems, Challenges of Wide-Area Dynamic Monitoring and Control, Classification of Disturbance in the Power Systems, Three Defense Lines in Power System Stability Control, Functions of Defense System and functions of Defense system, Power System Monitoring and Control with Wide-Area Measurements.

UNIT – II

Wide-Area Technology: Intelligent Electronic Devices (IED), Introduction, Synchronized Phasor Measurement, Phasor Measurement Unit (PMU), Hierarchy for phasor measurement systems, Communication options for PMUs, Functional requirements of PMUs and PDCs, Supervisory Control and Data Acquisition (SCADA)- Components of SCADA systems, SCADA basic functions components and basic functions.

UNIT – III

Wide-Area Monitoring System Architectures: ICT Architecture used in Wide-Area Power System Monitoring and Control, Centralized WAMS architectures, Hierarchical WAMS architectures, Hybrid WAMS architectures, Data collection and management & Issues in data fusion, Intelligent synchrophasor data fusion & Power system data fusion strategies, General framework for data assimilation.

UNIT – IV

Wide-Area Monitoring: Power system health monitoring, Disturbance and anomaly detection, Voltage and reactive power monitoring, Overview of Oscillation Monitoring Using Phasor Measurements, WAMS-Based Inter-area Mode Identification, Oscillation Mode Identification Using Phasor Measurements, Small-Signal Stability Assessment of Wide-Area Power System.

UNIT – V

Wide-Area Damping Control: Basic Framework and Operating Principle of Wide area damping control, System Modelling for wide area controller design, Coordinated Design of Local PSSs and Wide-Area Damping Controller, Structure of PSS and HVDC & Design Procedure, Robust Coordination of HVDC and FACTS Wide-Area Damping Controllers, Controller Design Formulation , Design Procedure of & Wide-Area Robust Coordinated Control.

TEXTBOOKS:

1. Monti, A., Muscas, C., & Ponci, F.” Phasor measurement units and wide area monitoring systems”, Academic Press, 2016.
2. Bevrani, H., Watanabe, M., & Mitani, Y., “Power system monitoring and control”. John Wiley & Sons, 2014.
3. Messina, A. R., “Wide area monitoring of interconnected power systems (No. 10847)”. IET, 2015.
4. Phadke, A. G., & Thorp, J. S., “Synchronized phasor measurements and their applications (Vol. 1, p. 81)”. New York: Springer, 2008.

SUGGESTED READING:

1. Rehtanz, C., Li, Y., Cao, Y., & Yang, D., “Interconnected Power Systems: Wide-area Dynamic Monitoring and Control Applications”, 2016.
2. Ma, J., “Power system wide-area stability analysis and control”. John Wiley & Sons, 2018.
3. A.M. Kulkarni, “Power System Dynamics, Control and Monitoring” NTPEL course IIT Bombay. onlinecourses.nptel.ac.in/noc22_ee18/preview
4. Smart Grid: Basics to Advanced Technologies, NPTEL nptel.ac.in/courses/108107113

26EEE125

ENERGY AUDITING AND MANAGEMENT

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: None

COURSE OBJECTIVES: This course aims to:

1. Understand the need for energy auditing.
2. Understand various loads involved based on power consumption for auditing.
3. Know about different audit instruments used in practice.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Conduct data-driven energy audits
2. Analyze energy systems using modern tools
3. Design energy optimization strategies
4. Evaluate sustainability and carbon reduction
5. Use digital platforms for energy management

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	1	2
CO 2	3	2	2	2
CO 3	2	1	1	2
CO 4	3	2	2	2
CO 5	3	3	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT -I

Energy Auditing: Need for Energy Auditing, Types and objectives, Energy Auditing methodology, Energy Auditing for Buildings, Energy Auditing form for commercial buildings, Case study - Digital Energy Audit using Smart Meters & IoT Platforms

UNIT -II

Energy Audit of Electrical Equipment: Evaluation of energy conservation opportunities and environmental management- Preparation and presentation of energy audit reports, Pumps, Capacitor banks and potential energy saving - Power quality analysis in audits

UNIT –III

Energy Conservation Aspects: Energy Conservation Needs and Objectives, Energy Conservation tips in the kitchen and other domestic House, Energy Conservation measures in office, Energy Conservation opportunities in HVAC system, Demand side Management, Needs and Objectives, Benefits of DSM, DSM design guidelines, Behavioral energy analytics

UNIT -IV

Energy Conservation in Industrial and Agricultural Sector: Instrumentation: Energy Conservation in industrial Sector, Energy saving potential in Industries –Boiler- Air compressors – Refrigeration System – Heat Exchanger – Electrical Drives – Pumps – Fans and Blowers-, Energy Conservation in Agricultural Sector, Energy Conservation opportunities in Pumps used in Agricultural Sector, Energy Conservation Tips for Agricultural applications - Agricultural solar pumping systems

UNIT -V

Applications of Computer in Energy Management: Role of computers in Energy Management, Simulation as a Design Tool, Energy and Facility Management Software, Industrial Power Management System, Application Terminologies, Power & Energy Management Tools & Equipment - AI/ML in energy forecasting, Digital twin for energy systems [Elementary treatment]

TEXTBOOKS:

1. Umesh Rathore “Energy Management”, 2nd edition, S.K.Kataria & sons
2. Anthony J. Pansini, Kenneth D. Smalling, “Guide Electric Load Management”. Pennwell Pub, 1998.
3. Howard E. Jordan, “Energy-Efficient Electric Motors and Their Applications”, Plenum Pub Corp, 1994, 2nd Edition

SUGGESTED READING:

1. Tanuj Kumar Bishat. “SCADA and Energy Management system”, 2nd Edition S.K. Kataria & sons.
2. Giovanni Petrecca, Industrial Energy Management: Principles and Applications, The Kluwer international series -207, 1999
3. NPTEL course Name: “Building Energy Systems and Auditing”, Instructor name: Prof. Shankha Pratim Bhattacharya, IIT Kharagpur (https://onlinecourses.nptel.ac.in/noc25_ar10/preview)

23CSO101

BUSINESS ANALYTICS

Open Elective – VI

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-Requisites: Basic of programming, basic mathematics**.**

COURSE OBJECTIVES: This course aims to

1. Understanding the basic concepts of business analytics and applications.
2. Study various business analytics methods including predictive, prescriptive and descriptive analytics.
3. Prepare the students to model business data using various data mining, decision making methods.

COURSE OUTCOMES: After completion of this course, students will be able to

1. Identify and describe complex business problems in terms of analytical models.
2. Apply appropriate analytical methods to solve business problems and interpret the resulting metrics and measures to achieve stated objectives.
3. Illustrate descriptive, predictive and prescriptive analytics methods and techniques.
4. Model business data using data mining, forecasting, decision tree, and clustering techniques.
5. Design and evaluate viable data-driven solutions to complex business decision-making problems.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	2	2
CO 2	3	2	3	2
CO 3	2	2	3	2
CO 4	3	2	3	3
CO 5	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Introduction to Business Analytics: Introduction to Business Analytics, need and science of data driven decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics,

Machine Learning algorithms, Generative AI , LLMs and Explainable AI (XAI) in business analytics, framework for decision making, challenges in data driven decision making and future.

UNIT - II

Descriptive Analytics: Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

UNIT - III

Forecasting Techniques: Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt's method, Holt-Winter model, Croston's forecasting method, regression model for forecasting, Auto regression models, auto-regressive moving process, ARIMA, Theil's coefficient

UNIT - IV

Decision Trees: CHAID, Classification and Regression tree, splitting criteria, Ensemble methods, Random Forest, XGBoost. Clustering: Distance and similarity measures used in clustering, Clustering algorithms, K-Means, Prescriptive Analytics- Linear Programming (LP) and LP model building.

UNIT-V

Six Sigma: Introduction, origin, 3-Sigma Vs Six-Sigma process,cost of poor quality, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

TEXTBOOKS:

1. U Dinesh Kumar, "Business Analytics", Wiley Publications, 2nd Edition, 2022
2. Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, "Business analytics Principles,Concepts, and Applications with SAS", Associate Publishers, 2015

SUGGESTED READINGS:

1. **S. Christian Albright, Wayne L. Winston**, "Business Analytics - Data Analysis and Decision Making",6th Edition, Cengage, 2020.

Online Resources:

1. Coursera – Business Analytics Specialization (University of Pennsylvania, Wharton): https://www.coursera.org/specializations/business-analytics
2. NPTEL – Business Analytics and Data Mining (IIT Roorkee): https://nptel.ac.in/courses/110107106
3. edX – Data Science and Analytics MicroMasters (MIT): https://www.edx.org/micromasters/mitx-statistics-and-data-science

26MEO101

INDUSTRIAL SAFETY

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to cover

1. Causes for industrial accidents, preventive steps to be taken, Factories Act 1948 and 5S Techniques.
2. Fundamental concepts of Maintenance Engineering.
3. About Safety in advanced manufacturing systems.
4. The basic concepts and importance of fault tracing.
5. The steps involved periodic and preventive maintenance of various industrial equipment.

COURSE OUTCOMES: Upon completion of this course, students will be able to

1. Identify causes of industrial accidents and recommend preventive measures.
2. Select appropriate tools and practices for various maintenance procedures.
3. Apply different Safety measures in advanced manufacturing systems.
4. Diagnose faults in equipment such as machine tools, IC engines, and boilers.
5. Implement periodic and preventive maintenance for industrial equipment including motors, pumps, air compressors, and machine tools.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	3	2	2	1	1
CO 2	3	3	2	2	1	1
CO 3	3	3	2	2	1	1
CO 4	3	3	2	2	1	1
CO 5	3	3	3	2	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Safety Management Concepts and Industrial Safety Practices: Industrial Safety & Legal Aspects: Industrial accidents – causes, types, consequences, and preventive measures. Mechanical and electrical hazards and their control. Fire hazards, prevention and firefighting methods. Safety color codes and safety signage. Salient provisions of the Factories Act 1948 related to health, safety, and welfare.

Safety Audit: Types of safety audits – audit methodology, preparation of audit checklists, non-conformity Reporting (NCR). Analysis and interpretation of accident records and safety reports.
5S Techniques: Introduction, objectives, and elements of 5S (Sort, set in order, Shine, Standardize, Sustain). Benefits of 5S in enhancing workplace safety, productivity, and efficiency.

UNIT - II

Fundamentals of Maintenance Engineering: Definition and objectives of maintenance engineering. Primary and secondary functions and responsibilities of the maintenance department. Types of maintenance (preventive, predictive, breakdown, corrective) and their applications. Tools and equipment used in maintenance activities. Maintenance cost and its relationship with replacement decisions and economy. Concept of service life and factors affecting the lifespan of equipment.

UNIT- III

Safety in advanced manufacturing systems: Machine safety in CNC, robotics, and Flexible Manufacturing Systems (FMS). Human–machine interaction safety. Safety in Industry 4.0 environments including cyber- physical systems, smart factories, and digital twins. Safety in additive manufacturing (powder handling and laser safety). Safety in material handling systems (conveyors, cranes, AGVs) and manufacturing processes (welding, casting, forging, machining). Electrical safety in automation and Lockout/Tagout (LOTO) procedures.

UNIT - IV

Fault Tracing: Concept and importance of fault tracing. Decision tree approach – need, structure, and applications. Sequence of fault-finding activities and systematic troubleshooting procedures. Development and representation of fault diagnosis using decision trees. Fault tracing in industrial equipment includes machine tools, pumps, air compressors, internal combustion engines, boilers, and electrical motors. Types of faults in machine tools and their general causes.

UNIT - V

Maintenance and Condition Monitoring: Periodic and Preventive Maintenance: Periodic inspection, concept and need. Cleaning, servicing, and over- hauling of mechanical components and electrical motors. Common motor faults and remedies. Preventive maintenance definition, steps, and advantages. Maintenance procedures for machine tools, pumps, air compres- sors, and DG sets. Condition monitoring and basic concepts of Proactive maintenance for Industry 4.0.

TEXTBOOKS:

1. L. M. Deshmukh, Industrial Safety Management, McGraw Hill Education, New Delhi, 1st Edition, 2010.
2. M.R. Sahoo, Industrial Safety Engineering, RK Publications, New Delhi, 1st Edition, 2015.
3. H. P. Garg, “Industrial Maintenance”, S. Chand and Company, may 1987.
4. Das Akhil Kumar, Principles of Industrial Safety Management Understanding the Ws of Safety at Work, Second edition, PHI Learning Pvt Ltd, Jan 2020

SUGGESTED READING:

1. Parth B. Shah, Industrial Safety and Maintenance Engineering, Technical publications, 2021.
2. Higgins & Morrow, “Maintenance Engineering Handbook”, McGraw-Hill Education Eighth Edition, February 2014.
3. M.P. Poonia, S.C. Sharma, Khanna Publishing House - Technology & Engineering, year 2019.

26MEO102

INTRODUCTION TO OPTIMIZATION TECHNIQUES

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Understand the LPP models.
2. Understand the Transportation and Assignment techniques.
3. Understand the procedure of Project Management along with CPM and PERT techniques.
4. Understand the concepts of queuing theory and inventory models.
5. Understand sequencing techniques.

COURSE OUTCOMES: *Upon completion of this course, students will be able to*

1. Formulate a linear programming problem (LPP).
2. Build and solve Transportation Models and Assignment Models.
3. Apply project management techniques like CPM and PERT to plan and execute project successfully.
4. Apply queuing and inventory concepts in industrial applications.
5. Apply sequencing models in industries.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	3	1	2	2
CO 2	3	1	3	1	2	2
CO 3	1	1	3	2	3	2
CO 4	2	1	3	2	2	3
CO 5	2	1	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Operations Research: Definition, Scope, Models, Linear programming problems (LPP), Formulation, Graphical Method, and Simplex Method.

UNIT - II

Transportation Models: Finding an initial feasible solution, Northwest corner method, least cost method, Vogel's approximation method, Finding the optimal solution, Special cases in transportation problems,

Unbalanced transportation problem, Degeneracy in transportation, Profit maximization in transportation.

UNIT- III

Project Management: Definition, Procedure and objectives of project management, Differences between PERT and CPM, Rules for drawing network diagram, Scheduling the activities, Fulkerson's rule, Earliest and latest times, Determination of ES and EF times in forward path, LS & LF times in backward path, Determination of critical path, Duration of the project, Free float, Independent float and total float.

UNIT - IV

Queuing Theory and Inventory: Kendols notation, Single server models, Inventory control, Deterministic inventory models, Probabilistic inventory control models.

UNIT - V

Sequencing Models: Introduction, Objectives, General Assumptions, Processing 'n' jobs through two machines, Processing 'n' jobs through three machines.

TEXTBOOKS:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008.
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi,2008.

SUGGESTED READING:

1. Hitler Libermann, Operations Research, McGraw Hill Pub, 2009.
2. Harvey M Wagner, Principles of Operations Research, Prentice Hall of India,2010.

With effect from AY 2026-27

26MEO103

COMPOSITE MATERIALS

Instruction	3 Hours per week
Duration	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Provide concepts of Composite materials and their constituents.
2. Explain the Classification of the reinforcements and matrix materials.
3. Provide Fabrication methods of metal matrix composites.
4. Explain manufacturing of Polymer matrix composites.
5. Elucidate Failure mechanisms in composite materials.

COURSE OUTCOMES: Upon completion of this course, students will be able to

1. Understand composite materials and their reinforcements.
2. Summarize micro-mechanics approach as applied to UD lamina.
3. Apply fabrication methods of metal, ceramic and carbon matrix composites.
4. Apply fabrication methods of polymer matrix composites.
5. Analyze the lamina and laminate from failure perspective.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	3	1	3	1	-	3
CO 2	3	1	3	1	-	3
CO 3	3	1	3	1	-	3
CO 4	3	1	3	1	-	3
CO 5	3	1	3	1	-	3

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT- I

Introduction: Definition Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT - II

Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements.

Mechanical Behaviour of composites: Rule of mixtures, Inverse rule of mixtures. Iso-strain and Iso-stress conditions.

UNIT- III

Processing of Metal Matrix Composites: Casting - Solid State diffusion technique, Cladding - Hot iso- static pressing. Properties and applications.

Processing of Ceramic Matrix Composites: Liquid Metal Infiltration - Liquid phase sintering.

Processing of Carbon - Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT - IV

Processing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs - hand layup method - Autoclave method - Filament winding method - Compression moulding - Reaction injection moulding. Properties and applications.

UNIT - V

Strength: Lamina Failure Criteria, strength ratio, maximum stress criteria, maximum strain criteria, interactive failure criteria and hygrothermal failure. Laminate first ply failure -insight strength.

TEXTBOOKS:

1. K.K.Chawla, "Composite Materials- Science and Engineering", 4th edition, Springer Verlag, 2019.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubrama- niam, John Wiley & Sons, NY, Indian edition, 2007..
3. R.M. Jones. Mechanics of Composite Materials. 2 nd ed. CRC press. 2018.

SUGGESTED READING:

1. Deborah D.L. Chung, "Composite Materials Science and Applications" 2nd edition, Springer Verlag, 2010.
2. Sanjay K. Mazumdar, "Composites Manufacturing- materials, product and process engineering", 1st edition, CRC press, 2002.
3. Daniel Gay, "Composite Materials Design and Applications" 3rd edition, CRC press, 2015.

With effect from AY 2026-27

26CEO101

COST MANAGEMENT OF ENGINEERING PROJECTS

(OPEN ELECTIVE – Common to All Branches)

Instruction	3 Hours per week
Duration	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to:

1. To enable the students to understand the concepts of Project management.
2. To provide knowledge on concepts of Project Planning and scheduling.
3. To create an awareness on Project Monitoring and Cost Analysis
4. To provide adequate knowledge to the students on Recourse Management Costing-Variance Analysis
5. To train the students with the concepts of Budgetary Control for cost management and to provide basic platform on Quantitative techniques for cost management.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Acquire in-depth knowledge about the concepts of project management and understand the principles of project management
2. Determine the critical path of a typical project using CPM and PERT techniques.
3. Prepare a work break down plan and perform linear scheduling using various methods.
4. Solve problems of resource scheduling and levelling using network diagrams.
5. Learn the concepts of budgetary control and apply quantitative techniques for optimizing project cost

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	1	1	--	1
CO 2	1	2	1	1
CO 3	1	1	1	1
CO 4	2	2	1	1
CO 5	--	1	1	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT- I

Project Management: Introduction to project managements, stakeholders, roles, responsibilities and functional relationships. Principles of project management, objectives and project management system. Project team, organization, roles, and responsibilities. Concepts of project planning, monitoring, staffing, scheduling and controlling.

UNIT- II

Project Planning and Scheduling: Introduction for project planning, defining activities and their interdependency, time and resource estimation. Work break down structure. Linear scheduling methods-bar charts, Line of Balance (LOB), their limitations. Principles, definitions of network-based scheduling methods: CPM, PERT. Network representation, network analysis-forward and backward passes.

UNIT- III

Project Monitoring and Cost Analysis: introduction-Cost concepts in decision making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision- Making, Time cost trade off Crashing project schedules, its impact on time on time, cost. Project direct and indirect costs.

UNIT- IV

Resources Management and Costing-Variance Analysis: Planning, Enterprise Resource Planning, Resource scheduling and levelling. Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis

Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement

UNIT- V:

Boundary Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management: Linear Programming, PERT/CPM, Transportation Assignment problems, Simulation, Learning Curve Theory.

TEXTBOOKS

1. Charles T Horngren “Cost Accounting A Managerial Emphasis”, Pearson Education; 14 edition (2012),
2. Charles T. Horngren and George Foster, “Advanced Management Accounting” Prentice-Hall; 6th Revised edition (1 February1987)
3. Robert S Kaplan Anthony A. Atkinson, “Management & Cost Accounting”, Pearson; 2 edition (18 October1996)

SUGGESTED READING:

1. K. K Chitkara, “Construction Project Management: Planning, scheduling and controlling”, Tata McGrawHill Education. (2004).
2. Kumar Neeraj Jha “Construction Project Management Theory and Practice”, Pearson Education India; 2 edition (2015).

With effect from AY 2026-27

26EGA101

ENGLISH FOR RESEARCH PAPER WRITING

(M.E/M. Tech - Common to all Branches)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Writing to express on science and technological concepts with good taste for research and development.

COURSE OBJECTIVES: This course aims to:

1. Motivate learners for academic writing and thus encourage them for continuous professional updating and up-gradation.
2. Facilitate a practical understanding of the multiple purposes of Writing Research Papers and help them infer the benefits and limitations of research in science and technology.
3. Brainstorm and develop the content, formulating a structure and illustrating the format of writing a research paper.
4. Survey and select a theme/topic for a thorough reading and to writing a research paper.
5. Understand to implement the intricacies of writing and publishing a research paper.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Improve work performance and efficiency. Illustrate the nuances of research paper writing and draw conclusions on professional usefulness.
2. Classify different types of research papers and organize the format and citation of sources.
3. Explore various formats of APA, MLA and IEEE and set up for writing a research paper.
4. Draft paragraphs and write theme-based thesis statements in a scientific manner.
5. Develop an original research paper while acquiring the knowledge of how and where to publish their papers.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	2	2
CO 2	2	2	2	1
CO 3	2	2	2	1
CO 4	2	2	2	1
CO 5	3	3	2	2

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Academic Writing: Meaning & Definition of a research paper; Purpose of a research paper - Scope, Benefits, Limitations and outcomes for professional development, An introduction to methods and Approaches of Research.

UNIT - II

Research Paper Format: Title - Abstract - Introduction - Discussion - Findings - Conclusion - Style of Indentation - Font size/Font types - Indexing - Citation of sources.

UNIT - III

Process of Writing a research paper, Writing to Draft a Format, Develop content, Adapting, Reviewing, Paraphrasing& Plagiarism Checks.

UNIT - IV

Choosing a topic - Thesis Statement - Outline - Organizing notes - Language of Research - Word order, Paragraphs - Writing first draft-Revising/Editing - The final draft and proof reading. Understanding APA, MLA, IEEE formats.

UNIT - V

Research Paper Publication Reputed Journals –Paid, Free and peer reviewed journals, National/International - ISSN No, No. of volumes, Scopus Index/UGC Journals. Getting Papers Published.

TEXTBOOKS:

1. Kothari, C. R. and Gaurav, Garg, Research Methodology Methods and Techniques", 4thEdition, New Age International Publishers, New Delhi, 2019.
2. Ellison, Carroll. "Writing Research Papers", McGraw Hill's Concise Guide, 2010.
3. Lipson, Charles. "Cite Right: A Quick Guide to Citation Styles-- MLA, APA, Chicago, the Sciences, Professions, and More", 2nd Edition, University of Chicago Press. Chicago, 2018.

SUGGESTED READING:

1. Day, Robert A. "How to Write and Publish a Scientific Paper", Cambridge University Press, 2006
2. Girden, E. R. "MLA Hand book for writers of Research Papers", 7th Edition, East West Press Pvt. Ltd, New Delhi, 2009
3. Bailey, Stephen. "Academic Writing: A Handbook for International Students", Routledge, 2018

Online Resources:

1. https://onlin://onlinecourses.nptel.ac.in/noc 18_mg13/preview
2. https://nptel.ac.in/courses/121/106/121106007/
3. https://www.classcentral.com/course/swayam-introduction-to-research-5221

Writing Tools:

1. https://owl.purdue.edu/owl_exercises/index.html - The Owl writing lab
2. https://www.turnitin.com/login_page.asp?lang=en_us – Turn tin software

With effect from AY 2026-27

26EGA102

CONSTITUTION OF INDIA

(M.E/M. Tech - Common to all Branches)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Knowledge on basics of the Constitution and the Government.

COURSE OBJECTIVES: This course aims to:

1. The history of the Indian Constitution and its role in Indian democracy.
2. Get awareness on Fundamental Rights, Duties and Directive Principles of State Policy.
3. Understand the structure and organization of Union Executive, Legislature and Judiciary.
4. Examine the powers and functions of Election Commission and State Election Commission.
5. Explore the decentralization of administration in India through Local bodies.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Understand the making of the Indian Constitution and its features.
2. Establish relations among Directive Principles of State Policy, Fundamental Rights and Fundamental Duties.
3. Have an insight into various Organs of Governance at Union level.
4. Understand powers and functions of Urban local bodies and Panchayats.
5. Grasp the role of Election Commission and other organizations in safeguarding Constitution and protecting the rights of Citizens.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	1	-	-	1
CO 2	1	1	-	1
CO 3	1	1	-	1
CO 4	1	1	-	1
CO 5	1	1	-	1

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT-I

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

UNIT-II

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

UNIT-III

Organs of Governance: Parliament: Composition, Qualifications, Powers and Functions

Union executives: President, Governor, Council of Ministers, Judiciary, appointment and transfer of judges, qualifications, powers and functions.

UNIT-IV

Local Administration: District's Administration head: Role and importance. Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, PRI: ZillaPanchayat, Elected Officials and their roles, CEO ZillaPanchayat: positions and role.

Block level: Organizational Hierarchy (Different departments) Village level: role of elected and appointed officials. Importance of grass root democracy.

UNIT-V

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

TEXTBOOKS:

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

SUGGESTED READING:

1. Bhargava, Rajeev. (ed), "Politics and Ethics of the Indian Constitution", OUP, 2008.
2. NCERT, Indian Constitution at Work, 1st Edition, Government of India, New Delhi 2006, reprinted in 2022.
3. Ravindra Sastry, V. (ed.), Indian Government & Politics, 2nd edition, Telugu Akademy, 2018.

Online Resources:

1. http://www.nptel.ac.in/courses/103107084/Script.pdf

With effect from AY 2026-27

26EGA103

STRESS MANAGEMENT BY YOGA

(M.E/M. Tech - Common to all Branches)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Knowledge on Yoga Practices.

COURSE OBJECTIVES: This course aims to:

1. Create awareness about different types of stress and the role of yoga in the management of stress.
2. Promote positive health and overall well-being (Physical, mental, emotional, social and spiritual).
3. Prevent stress related health problems by yoga practice.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Understand yoga and its benefits.
2. Enhance Physical strength and flexibility.
3. Learn to relax and focus.
4. Relieve physical and mental tension through asanas
5. Improve work performance and efficiency

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	1	-	-	-
CO 2	-	-	-	-
CO 3	1	1	-	-
CO 4	1	1	-	-
CO 5	1	2	1	1

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT - I

Meaning and definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali).

UNIT - II

Meaning and definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

UNIT - III

Concept of Stress according to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress.

UNIT - IV

Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar

UNIT – V

Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama - Kapalabhati Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.

Meditation techniques: Om Meditation - Cyclic meditation: Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT)

TEXTBOOKS:

1. Janardhan, Swami, "Yogic Asanas for Group Training - Part-I": Yogabhyasi Mandal, Nagpur.
2. Vivikananda, Swami**.** "Rajayoga or Conquering the Internal Nature", Advaita Ashrama (Publication Department), Kolkata.
3. Nagendra H.R and R. Nagaratna, “Yoga Perspective in Stress Management”, Swami Vivekananda Yoga Prakashan, Bangalore.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc16_ge04/preview
2. https://freevideolectures.com/course/3539/indian-philosophy/11

With effect from AY 2026-27

26EGA104

PERSONALITY DEVELOPMENT THROUGH LIFE'S ENLIGHTENMENT SKILLS

(M.E/M. Tech - Common to all Branches)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Awareness on Personality Development.

COURSE OBJECTIVES: This course aims to:

1. Learn to achieve the highest goal happily.
2. Become a person with stable mind, pleasing personality and determination.
3. Awake wisdom among themselves.

COURSE OUTCOMES: Upon completion of this course, students will be able to:

1. Develop their personality and achieve their highest goal of life.
2. Lead the nation and mankind to peace and prosperity.
3. Practice emotional self-regulation.
4. Develop a positive approach to work and duties.
5. Develop a versatile personality.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	1	1	-	1
CO 2	1	1	-	1
CO 3	1	1	-	1
CO 4	1	1	-	1
CO 5	1	1	-	1

1 - Slightly; 2 - Moderately; 3 - Substantially

UNIT - I

Neetisatakam – Holistic development of personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

UNIT - II

Neetisatakam – Holistic development of personality (cont'd) - Verses 52, 53, 59 (dont's) - Verses 71,73,75& 78 (do's) - Approach to day to day works and duties.

UNIT - III

Introduction to Bhagavadgeetha for Personality Development – Shrimad Bhagawad Geeta: Chapter 2– Verses 41, 47, 48 - Chapter 3 – Verses 13,21,27,35 - Chapter 6 – Verses 5,13,17,23,35 - Chapter 18 – Verses 45, 46, 48 Chapter – 6: Verses 5, 13, 17, 23, 35; Chapter – 18: Verses 45, 46, 48

UNIT - IV

Statements of basic knowledge – Shrimad Bhagawad Geeta: Chapter 2- Verses 56, 62,68 - Chapter 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawat Geeta.

UNIT - V

Role of Bahgavadgeeta in the present scenario - Chapter 2 – Verses 17 - Chapter 3 – Verses 36, 37, 42 - Chapter 4 – Verses 18, 38, 39 - Chapter 18 – Verses 37, 38, 63.

TEXTBOOKS:

1. Gopinath, P., "Bhartrihari's Three Satakam (Niti-sringar-vairagya)", Rashtriya Sanskrit Sansthanam, New Delhi, 2018.
2. Swarupananda, Swami, "Srimad Bhagavad Geeta", Advaita Ashram (Publication Dept), Kolkata, 2017.

Online Resources:

1. https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_hs174

With effect from AY 2026-27

26ECA101

VALUE EDUCATION

(Audit Course)

Instruction	2 L Hours per Week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

Prerequisite: Nill

COURSE OBJECTIVES: This course aims to
1. Understand Value Education, Self-development and National development.
2. Imbibe good human values and Morals in students.
3. Cultivate individual and National character.

COURSE OUTCOMES: After the completion of this course, the student will be able to
1. Summarize classification of values and values for self-development.
2. Identify the importance of values in personal and professional life.
3. Apply the importance of social values for better career and relationships.
4. Analyze ethical issues in modern technology
5. Discuss concept of soul and reincarnation and promote responsible citizenship

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	2	2	2
CO 2	2	2	2	2
CO 3	2	2	2	2
CO 4	2	2	2	2
CO 5	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT - I

Human Values, Ethics and Morals: Concept of Values, Human Values, Indian concept of humanism, Values for self-development, social values, Individual attitudes, Work ethics, Moral and non- moral behavior, Standards and Principles based on religion, Culture and Tradition.

UNIT - II

Value Cultivation, and Self-Management: Need for and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

UNIT - III

Spiritual Outlook and Social Values: Personality and Behaviour Development, Scientific attitude and Spiritual (soul) outlook, Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, Forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance., Happiness Vs Suffering, Love for truth, Aware of self-destructive habits, Appreciation and co-operation.

UNIT - IV

Technology, Society, and Sustainability: Ethics in emerging technologies (AI, Data, 5G, IoT); Privacy and cybersecurity, Environmental ethics and sustainable development; Social responsibility of engineers, Policy and governance.

UNIT - V

Universal Values and Global Perspectives: Mind your mind, Self-control**,** Concept of soul, Science of Reincarnation, Concepts of Dharma and Karma, The qualities of Devine and Devilish, Satwic, Rajasic and Tamasicgunas. Global citizenship, Happiness and meaningful life.

TEXTBOOKS:

1. Chakraborty, S.K. “Values & Ethics for organizations Theory and practice”, Oxford University Press, New
   Delhi, 1998.
2. Jaya Dayal Goyandaka, “Srimad Bhagavad Gita”, with Sanskrit Text, Word meaning and Prose meaning, Gita Press, Gorakhpur, 2017.

REFERENCE BOOKS:

1. George Reynolds, Ethics in Information Technology, 6th Edition, Cengage Learning, 2018
2. Melanie Mitchell, Artificial Intelligence: A Guide for Thinking Humans, 1st Edition, Farrar, Straus and Giroux, 2019

With effect from AY 2026-27

26CEA101

DISASTER MITIGATION AND MANAGEMENT

(Audit Course I and II - Common to all branches)

Instruction	2L Hours per week
Duration	2 Hours
SEE	50 Marks
CIE	0 Marks
Credits	0

COURSE OBJECTIVES: To enable the student

1. To equip the students with the basic knowledge of hazards, disasters, risks and vulnerabilities, including natural, climatic and human-induced factors and associated impacts
2. To impart knowledge in students about the nature, causes, consequences and mitigation measures of the various natural disasters
3. To enable the students to understand risks, vulnerabilities and human errors associated with human-induced disasters
4. To enable the students to understand and assimilate the impacts of any disaster on the affected area, depending on its position/ location, environmental conditions, demographic, etc.
5. To equip the students with the knowledge of the chronological phases in a disaster management cycle and to create awareness about the disaster management framework and legislations in the context of national and global conventions

COURSE OUTCOMES: At the end of the course, students will be able to

1. Ability to analyse and critically examine existing programs in disaster management regarding vulnerability, risk and capacity at different levels
2. Ability to understand and choose the appropriate activities and tools, and set up priorities to build a coherent and adapted disaster management plan
3. Ability to understand various mechanisms and consequences of human-induced disasters for the participatory role of engineers in disaster management
4. To understand the impact on various elements affected by the disaster and to suggest and apply appropriate measures for the same
5. Develop an awareness of the chronological phases of disaster preparedness, response and relief operations for formulating effective disaster management plans and the ability to understand various participatory approaches/strategies and their application in disaster management

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	3	2	1
CO 2	3	3	2	2
CO 3	2	3	3	2

CO 4	3	3	2	3
CO 5	3	2	2	3

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT- I

Introduction: Basic definitions- Hazard, Disaster, Vulnerability, Risk, Resilience, Mitigation, Management; classification of types of disaster-Natural and manmade; International Decade for natural disaster reduction (IDNDR); International strategy for disaster reduction (ISDR), National disaster management authority (NDMA).

UNIT- II

Natural Disasters: Hydro meteorological disasters: Causes, Early warning systems- monitoring and management, structural and non-structural measures for floods, drought and Tropical cyclones; Geographical based disasters: Tsunami generation, causes, zoning, Early warning systems- monitoring and management, structural and non-structural mitigation measures for earthquakes, tsunami, landslides, avalanches and forest fires. Case studies related to various hydro-meteorological and geographical based disasters.

UNIT- III

Human induced hazards: Chemical disaster- Causes, impacts and mitigation measures for chemical accidents, Risks and control measures in a chemical industry, chemical disaster management; Case studies related to various chemical industrial hazards eg.: Bhopal gas tragedy; Management of chemical terrorism disasters and biological disasters; Radiological Emergencies and case studies; Case studies related to major power break downs, fire accidents, traffic accidents, oil spills and stampedes, disasters due to double cellar construction in multistoried buildings.

UNIT- IV

Disaster Impacts: Disaster impacts- environmental, physical, social, ecological, economic, political, etc.; health, psycho-social issues; demographic aspects- gender, age, special needs; hazard locations; global and national disaster trends; climate change and urban disasters.

UNIT- V

Concept of Disaster Policies and legislation for disaster risk reduction

Management: Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; risk analysis, vulnerability and capacity assessment; post-disaster environmental response water, sanitation, food safety, waste management, disease control; Roles and responsibilities of government, community, local in situations, NGOs and other stakeholders;, DRR programmers in India and the activities of National Disaster Management Authority.

TEXTBOOKS:

1. Pradeep Sahni*," Disaster Risk Reduction in South Asia*", Prentice Hall, 2003.
2. B. K. Singh,*" Handbook of Disaster Management*: *techniques &Guidelines*", Rajat Publication, 2008.
3. Ministry of Home Affairs". *Government of India, "National disaster management plan, Part I and II",*
4. K. K. Ghosh," *Disaster Management",* APH Publishing Corporation, 2006.

Suggested Reading:

1. http://www.indiaenvironmentportal.org.in/files/file/disaster_management_india1.pdf
2. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs)
3. Hazards, Disasters and your community: A booklet for students and the community, Ministry of home affairs.

With effect from AY 2026-27

26ADA101

PEDAGOGY STUDIES

(**Audit Course – 1 and 2**)

Instruction	2 Hours per week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

COURSE OBJECTIVES:

1. To present the basic concepts of design and policies of pedagogy studies.
2. To provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices.
3. To familiarize various theories of learning and their connection to teaching practice.
4. To create awareness about the practices followed by DFID, other agencies and other researchers.
5. To provide understanding of critical evidence gaps that guide the professional development.

COURSE OUTCOMES: Upon completing this course, students will be able to:

1. Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.
2. Examine the effectiveness of pedagogical practices.
3. Understand the concept, characteristics and types of educational research and perspectives of research.
4. Describe the role of classroom practices, curriculum and barriers to learning.
5. Understand Research gaps and learn the future directions.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	1	1	1	1
CO 2	1	1	1	1
CO 3	2	2	2	2
CO 4	1	1	1	1
CO 5	2	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT I

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

UNIT II

Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III

Evidence on the Effectiveness of Pedagogical Practices: Methodology for the in-depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and pedagogic strategies.

UNIT IV

Professional Development: alignment with classroom practices and follow up support - Support from the head teacher and the community – Curriculum and assessment - Barriers to learning: Limited resources and large class sizes.

UNIT-V

Research Gaps and Future Directions: Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

TEXTBOOKS:

1. Ackers J, Hardman F, "Classroom Interaction in Kenyan Primary Schools, Compare", 31 (2): 245 – 261, 2001.
2. Agarwal M, "Curricular Reform in Schools: The importance of evaluation", Journal of Curriculum Studies, 36 (3): 361 – 379, 2004.

With effect from AY 2026-27

26EEA101

SANSKRIT FOR COMPUTATIONAL THINKING AND ENGINEERING APPLICATIONS

Instruction	2 Hours per week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	-
Credits	0

COURSE OBJECTIVES:

1. To introduce Sanskrit as a structured language useful for logical thinking and algorithm design
2. To connect Sanskrit concepts with modern engineering domains (AI, circuits, structures, systems)
3. To develop computational and analytical skills using Sanskrit-based principles
4. To enable students to explore interdisciplinary applications for research and innovation

COURSE OUTCOMES: After completion, students will be able to:

1. Apply structured Sanskrit rules to improve logical and algorithmic thinking
2. Relate concepts from Sanskrit texts to modern Engineering principles
3. Develop simple computational models inspired by Sanskrit grammar/logics
4. Use Sanskrit-based frameworks in AI, coding logic, or system design
5. Identify interdisciplinary research opportunities combining Sanskrit & Engineering

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	2	1	2	1
CO 2	2	1	2	2
CO 3	3	1	2	3
CO 4	2	2	2	2
CO 5	3	2	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

UNIT–I

Sanskrit as a Structured Language: Sanskrit as rule-based system -Basics: alphabets, word formation (only essentials) -Sandhi as **data compression analogy** -Samasa as **modular design / block abstraction**-Simple sentence formation (very minimal grammar)

UNIT–II

Sanskrit & Computational Thinking: Paninian grammar → rule engine / compiler design -Shiva Sutras → encoding system- Binary concepts in Pingala (Chandas → digital logic) -Recursion & patterns in Sanskrit structures

UNIT–III

Sanskrit in Core Engineering Domains

Civil / Mechanical: Sulba Sutras → geometry, measurements -Ancient construction logic → modular design

Electrical / ECE: Concept of energy (Agni, Surya) → symbolic + physical mapping -Wave & sound (Nada → signal analogy)

Systems Thinking: Interconnectedness → system design philosophy

UNIT–IV

Sanskrit & Modern Technology: Sanskrit & Artificial Intelligence (knowledge representation) -Natural Language Processing (NLP) -Formal languages & syntax -Command-based structures → programming analogy

UNIT–V

Mini Applications & Case Studies: Case study: Sanskrit → Algorithm (simple flowchart) -Chandas → binary pattern generation-Design a simple rule-based system using Sanskrit logic -Mini presentation / activity

TEXTBOOKS:

1. **Kapil Kapoor** – Language, Linguistics and Literature- Indian Perspective; Academic Foundation, New Delhi; 1994 (1st Edition); **ISBN:** 978-8171880577
2. **Frits Staal**: *A Reader on the Sanskrit Grammarians;* MIT Press / Motilal Banarsidass ; 1972 (Original); **ISBN:** 978-0262191340
3. **George Gheverghese Joseph:** The Crest of the Peacock"; Princeton University Press; 2000 (2nd Edition; widely used); **ISBN:** 978-0691135267
4. B.V. Subbarayappa: "Indian Scientific Heritage" – National Institute of Advanced Studies (NIAS), Bangalore; 2006 **ISBN:** 978-8185015026
5. – M. Krishnamachariar : "History of Sanskrit Literature"; Motilal Banarsidass Publishers; Reprint 1993 (Original: 1937, TTD Press); **ISBN:** 978-8120802841

SUGGESTED READING:

1. Pingala. *Chandah Shastra* (various editions, Nirnaya Sagar Press / Chowkhamba)
2. Bharati, A., et al. *Natural Language Processing: A Paninian Perspective*, PHI, 1995
3. Selected IEEE / Springer Papers on Sanskrit & AI

With effect from the AY 2026-27

26EEC112

INDUSTRIAL PROJECT/DISSERTATION PHASE-1

Instruction	20P Hours per week
Duration of SEE	-
SEE	-
CIE	100 Marks
Credits	10

Prerequisite: Students should have prior Domain-specific knowledge, Research Methodology

COURSE OBJECTIVES: This course aims to

- Enable students to identify real-world / industrial / research problems in Power Systems & Power Electronics.
- Develop ability to perform critical literature survey and gap analysis.
- Train students in research methodology, modelling, and simulation design.
- Encourage industry interaction and practical exposure.
- Build technical writing, documentation, and presentation skills.

COURSE OUTCOMES: After the completion of this course, the student will be able to

- CO1: Identify and define a research problem in advanced Electrical Engineering domains.
- CO2: Perform comprehensive literature review and identify research gaps.
- CO3: Develop a structured methodology/design approach for the problem.
- CO4: Analyze feasibility using simulation / analytical / experimental methods.
- CO5: Present and document the work in a professional technical format.

CO-PO Articulation Matrix:

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	2	2
CO 2	3	2	2	2
CO 3	3	1	3	2
CO 4	3	1	2	3
CO 5	1	3	2	2

1 - Slightly; 2 - Moderately; 3 – Substantially

General Instructions:

- Project can be **Industry-based or Research-based** /extension of **MINI Project** of II Sem
- Dual supervision allowed (Industry + Faculty)

- Weekly Progress log [Project Diary] mandatory
- Topic freeze within **2 weeks**
- No plagiarism—strict rejection policy
- Regular reviews compulsory
- Documentation must follow **standard format (IEEE/Journal)**
- The **Outcome** of the **INDUSTRIAL PROJECT/DISSERTATION PHASE-1** should turn into a Paper publication/ Conference Presentation/ any other relevant
- Composition of Departmental Review Committee **[DRC]**
  Supervisor and any other **Two Faculty** Members
- Evaluation will be carried out based on **'RUBRIC'** (which will be supplied by the dept.)

Innovation Tracks (Optional)

- Smart Grid & Renewable Integration
- AI/ML in Power Systems
- Power Electronics for EVs
- Energy Sustainability Models
- IKS-based Engineering Concepts

Time scheduling

Phase	**Weeks**	**Activity**
Phase 1	1–2	Topic Selection + Problem Definition
Phase 2	3–5	Literature Survey + Gap Identification **REVIEW-1 [4th Week]**
Phase 3	6–8	Methodology / Design Development
Phase 4	9–11	Simulation / Modelling / Feasibility **REVIEW-2 [8th Week]**
Phase 5	12–14	Seminar + Report Submission **FINAL EVALUATION [12th Week]**

Guidelines for the awarding of CIE

Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Supervisor	20	Problem Definition & Objectives
	15	Literature Review & PPT Preparation
	15	Report Preparation & Leading to Outcome
DRC	10	Relevance of the Topic
	20	Work Presentation & Response to queries
	10	Leading to Outcome
	10	Well-structured Report

Evaluation Mechanism

- **Supervisor:** Continuous monitoring (weekly progress)
- **Departmental Review Committee [DRC]:** Seminar + Viva [Interim & Final Reviews]

Repertoire of the Project report:

- Title Page
- Abstract
- Introduction
- Literature Review
- Problem Statement
- Methodology
- Design / Implementation
- Results & Analysis
- Conclusion & Future Scope
- References
- Appendices

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

In line with AICTE Model Curriculum with effect from AY 2027-28 (R26)

M.E (Power Systems and Power Electronics)

SEMESTER–IV

S.no	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours Per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
	THEORY								
1	26EEC113	Industrial Project /Dissertation Phase II	-	-	32	Viva - Voce	100	100	16
Total			**-**	**-**	**32**	**-**	**100**	**100**	**16**
	Clock Hours Per Week: 32								

L: Lecture D: Drawing CIE: Continuous Internal Evaluation T: Tutorial

P: Practical/Project Seminar/Dissertation SEE: Semester End Examination

With effect from the AY 2026-27

26EEC113

INDUSTRIAL PROJECT/DISSERTATION PHASE-II

Instruction	32 P Hours per week
Duration of SEE	-
SEE	100 Marks
CIE	100 Marks
Credits	16

Prerequisite: Students should have prior Domain-specific knowledge, Research Methodology

COURSE OBJECTIVES: This course aims to

- Enable students to implement and validate proposed solutions to complex engineering problems.
- Develop capability to analyze results critically and derive meaningful conclusions.
- Encourage innovation, research contribution, and real-world applicability.
- Train students in thesis writing, publication, and professional ethics.
- Prepare students to defend their work with clarity and confidence.

COURSE OUTCOMES: After the completion of this course, the student will be able to

CO1: Implement the proposed methodology using appropriate tools/experimental setups.
CO2: Analyze, validate, and interpret results against objectives or benchmarks.
CO3: Demonstrate innovation and contribution to solving engineering problems.
CO4: Prepare a comprehensive thesis following standard formats and ethics.
CO5: Present, defend, and disseminate research through publications/patents.

CO-PO Articulation Matrix

CO \ PO	PO 1	PO 2	PO 3	PO 4
CO 1	3	1	3	3
CO 2	3	2	3	3
CO 3	3	1	3	3
CO 4	1	3	2	1
CO 5	3	3	3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

General Instructions:

Students shall **execute, validate, and complete** the project initiated in Phase-I through:

- Implementation (hardware/software/modeling)
- Experimental validation / simulation
- Performance comparison with existing techniques

- Documentation and dissertation [Thesis report (IEEE / standard format]

Final Outcome must demonstrate:

- Technical depth
- Practical relevance
- Research contribution and **any one** of the following
- Journal/Conference Paper [Published / Accepted]
- Patent Draft
- Open-source contribution
- Industrial prototype/demo

Time scheduling:

Phase	**Weeks**	**Focus**
Phase 1	1–3	Implementation Start
Phase 2	4–7	Full Development / Experimentation **REVIEW-1[3rd Week]**
Phase 3	8–10	Testing & Validation **REVIEW-2[6th Week]**
Phase 4	11–12	Result Analysis & Optimization **PRE-VIVA in the presence of supervisor [11th Week]**
Phase 5	13–14	Thesis + Publication **FINAL DEFENCE [14th Week]**

Guidelines for CIE:

Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
DRC	15	Review 1
	15	Review 2
	10	Pre VIVA VOCE
	10	Quality of work which may lead to publications
	15	Submission of Thesis in standard format
Supervisor	10	Regularity and Punctuality
	10	Work Progress
	10	Quality of work which may lead to publications
	10	Analytical / Programming / Experimental Skills
	10	Thesis Preparation

Guidelines for SEE:

Evaluation by	**Max. Marks**	**Evaluation Criteria / Parameter**
Both External and Internal Examiners together	20	Power Point Presentation
Both External and Internal Examiners together	30	Quality of Thesis Evaluation
Both External and Internal Examiners together	10	Publication / Patent / Prototype / Product
Both External and Internal Examiners together	20	Quality of the Project: Innovations, Applications, Live Research Projects, Scope for Future Study, Application to Society
Both External and Internal Examiners together	20	Viva-Voce