FINAL YEAR COURSE STRUCTURE (R23)

&

DETAILED SYLLABUS

ELECTRICAL & ELECTRONICS ENGINEERING

For
B.Tech., Four Year Degree Course
(Applicable for the batches admitted from 2023-24)

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
Approved by AICTE & Permanently Affiliated to JNTUGV, Vizianagaram
Accredited by NAAC with "A" Grade and NBA (ECE, CSE, EEE & ME)
Jonnada (Village), Denkada (Mandal), Vizianagaram Dist. – 535 005
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Department of Electrical and Electronics Engineering

B. Tech IV-Year Course Structure – R23 Regulation

IV YEAR – I SEMESTER							
S. No.	**Course code**	**Subjects**	**Category**	**L**	**T**	**P**	**Credits**
1	R23EEE-PC4101	Switchgear and Protection	PC	3	0	0	3
2	R20BSH-HM4101	Managerial Skills for Engineers	HM	2	0	0	2
3		**Professional Elective-IV**		3	0	0	3
	R23EEE-PE4101.1	Advanced Digital Design Using Verilog	PE				
	R23EEE-PE4101.2	Robotics and Automation	PE				
	R23EEE-PE4101.3	Power System Operation and Control	PE				
	R23EEE-PE4101.4	Industrial Drives	PE				
4		**Professional Elective-V**		3	0	0	3
	R23EEE-PE4102.1	FPGA based Control Design	PE				
	R23EEE-PE4102.2	Intelligent Control Techniques	PE				
	R23EEE-PE4102.3	Distribution System Planning and Automation	PE				
	R23EEE-PE4102.4	Hybrid Electric Vehicles	PE				
5		**Open Elective-III**	OE	3	0	0	3
6		**Open Elective-IV**	OE	3	0	0	3
7	R23EEE-SC4101	1. Embedded ARM Programming 2. FPGA Controller for Power Converters 3. Photovoltaic System Design 4. Electric Vehicle Technology 5. PCB Design 6. CAD for Electrical Engineering	SC	1	0	2	2
8	R23BSH-MC4101	Technical Paper Writing & IPR	MC	2	0	0	0
9	R23EEE-MC4101	Power Systems & Simulation Lab	MC	0	0	3	0
10	R23EEE-SI4101	Evaluation of Industry Internship	SI	0	0	0	2
		Total		**20**	**0**	**5**	**21**

IV YEAR – II SEMESTER							
S. No.	**Course code**	**Subjects**	**Category**	**L**	**T**	**P**	**Credits**
1	R23EEE-PR4201	Full Semester Internship and Project Work	PR	0	0	24	12
		Total					**12**

Open Electives offered by EEE

S.No.	Course code	Subjects	L:T:P	Credits
1	R26EEE-OE001	Renewable Energy Sources	3:0:0	3
2	R26EEE-OE002	Energy Conservation and Management	3:0:0	3
3	R26EEE-OE003	Electrical Safety & Standards	3:0:0	3
4	R26EEE-OE004	Utilization of Electrical Energy	3:0:0	3
			Total	**12**

Honors Degree offered by EEE

Subject Name		**L:T:P**	**Credits**
Course-1	1. Renewable Energy Systems & Sources 2. Electric Vehicle Technology and Mobility 3. Embedded System Design	3:0:0	3
Course-2	1. Flexible AC Transmission Systems 2. Modelling and Analysis of Electrical Machines 3. VLSI Design Technology	3:0:0	3
Course-3	1. Advanced Power System Protection 2. Modeling and Analysis of Power Semiconductor Devices and Converters 3. Industrial Electronics	3:0:0	3
Course-4	1. Distributed Generation and Micro Grid 2. Grid Interface of Electric Vehicles 3. Advanced Microcontroller based Systems	3:0:0	3
Course-5	MOOCS-1	-	3
Course-6	MOOCS-2	-	3
		Total Credits	**18**

Minors Degree offered by EEE

Subject Name		L:T:P	Credits
Course-1	Fundamentals of Special Electrical Machines	3:0:0	3
Course-2	Fundamentals of Power Systems	3:0:0	3
Course-3	Fundamentals of Electrical Measurements and Instrumentation	3:0:0	3
Course-4	Fundamentals of Electrical Measurements and Instrumentation Lab	0:0:3	1.5
Course-5	Fundamentals of Power Electronics	3:0:0	3
Course-6	Fundamentals of Power Electronics Lab	0:0:3	1.5
Course-7	MOOCS	-	3
		Total Credits	**18**

IV-Year, I-Semester Syllabus

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PC4101	Switchgear and Protection	3:0:0	3

Course Objectives:

- To provide knowledge on the arcing phenomenon and explain the construction and operation of various types of circuit breakers used in power systems.
- To study the working principles, characteristics, and types of electromagnetic protection relays used in electrical networks.
- To gain knowledge of protection schemes for electrical machines like generators and transformers under fault conditions.
- To understand the feeder and bus bar protection systems using modern protection schemes.
- To understand the operation of static relays and identify the various methods of Protection against over voltages

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

1. To analyze the arcing phenomenon characteristics with Rate of Rise of Restriking Voltage (L3)
2. To analyze the characteristics and operational behavior of electromagnetic protection relays, and evaluate their suitability for different protection scenarios. (L4)
3. To apply effective protection schemes for generators and transformers under fault conditions, including differential, earth fault, and overcurrent protection techniques. (L3)
4. To understand the principles and configurations of feeder and bus bar protection systems using advanced methods such as unit and distance protection. (L2)
5. To explain the working of static relays and describe various methods for protecting electrical systems against over voltages (L2).

UNIT – I

Circuit Breakers: Physics of arcing phenomenon, Elementary Principles of Arc Interruption, Restriking Voltage and Recovery Voltage - Restriking Phenomenon, RRRV, Average and Max. RRRV, Current Chopping and Resistance Switching - Description and Operation of Following Types of Circuit Breakers: Oil Circuit Breakers, Air Blast Circuit Breakers, Vacuum and SF6 Circuit Breakers–selection of circuit breakers, Ratings of circuit breakers, HVDC circuit breaker.

UNIT – II

Electromagnetic Protection Relays: Balanced beam type attracted armature relay - induction disc and induction cup relays–Torque equation - Relays classification–Instantaneous– DMT and IDMT types– Applications of relays: Over current and under voltage relays– Directional relays– Differential relays and percentage differential relays– Universal torque equation– Distance relays: Impedance– Reactance– Mho and offset mho relays– Negative sequence and under frequency relays.

UNIT – III

Generator and Transformer Protection: Protection of generators against stator faults– Rotor faults and abnormal conditions– restricted earth fault and inter turn fault protection– Numerical examples. Transformer Protection: Percentage differential protection– Transformer overheating - Protection against Magnetizing Inrush Current – Buchholz relay protection– Earth fault relays – Protection of earthing transformers – over flexing protection - Numerical examples.

UNIT – IV

Feeder and Busbar Protection: Protection of lines: Over current Protection schemes – PSM, TMS- phase Comparison Carrier Current Protection- carrier aided distance protection- Unit protection - Numerical examples -Carrier current and three zone distance relay using impedance relays–Protection of bus bars by using Differential protection- frame leakage protection.

UNIT – V

Advanced Relay systems and Protection against over voltages: Static relay components– Static over current relays– Static distance relay– Numerical over current relay. Generation of over voltages in power systems**-** Protection against lightning over voltages– Valve type and zinc oxide lighting arresters – Grounded and ungrounded neutral systems–Methods of neutral grounding: Solid–resistance– Reactance–Arcing grounds- Zones of protection

Textbooks:

1. Power System Protection and Switchgear, Badri Ram, D.N Viswakarma, TMH Publications, 2011.
2. VK Metha," Principles of Power Systems" S. Chand, 2005.
3. Switchgear and Protection, Sunil S Rao, Khanna Publishers, 1992

Reference Books:

1. Electrical Power Systems, C.L.Wadhwa, New Age international (P) Limited, Publishers, 2012.
2. Transmission network Protection, Y.G. Paithankar ,Taylor and Francis,2009.
3. Power system protection and switch gear, Bhuvanesh Oza, TMH, 2010.
4. Bhavesh Bhalja, R.P. Maheshwari, Nilesh G. Chotani, 'Protection and Switchgear' Oxford University Press, 2011.

Web Links:

1. https://nptel.ac.in/courses/108107167
2. https://www.electrical4u.com/

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PE4101.1	Advanced Digital Design Using Verilog	3:0:0	3

Course Objectives:

- Develop advanced proficiency in digital system design using Verilog HDL.
- Design and model complex digital systems at behavioral and RTL levels.
- Understand simulation, verification, synthesis, and implementation flow.
- Explore timing, optimization, and debugging in Verilog-based design.

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

1. Design complex digital circuits using Verilog at behavioral and RTL levels.
2. Simulate and verify Verilog models using test benches.
3. Synthesize and implement Verilog designs for FPGAs/ASICs.
4. Analyze timing and optimize performance of digital circuits.
5. Integrate components into larger digital systems like processors or controllers.

UNIT-I

Verilog Review and Design Methodologies: Overview of Verilog HDL (review of basic syntax, modules, ports); Simulation vs. synthesis; Design abstraction levels: behavioral, RTL; gate; Top-down vs. bottom-up design approaches

UNIT-II

Behavioral and RTL Modeling: Behavioral modeling; A brief look at data types for behavioral modeling; Boolean-Equation – Based behavioral models of combinational logic; Propagation delay and continuous assignments; Latches and Level – Sensitive circuits in Verilog; Cyclic behavioral models of Flip-Flops and Latches; Cyclic behavior and edge detection; A comparison of styles for behavioral modeling; Behavioral models of multiplexers, encoders, and decoders

UNIT-III

Testbenches and Verification: Writing effective testbenches; Stimulus generation and output monitoring; Self-checking testbenches; Delay models (#delay) and timing control; Introduction to assertion-based verification and System Verilog

UNIT-IV

Synthesis and Optimization: Synthesizable vs non-synthesizable Verilog constructs; FSM encoding styles: binary, one-hot, gray; Pipelining and parallelism; Design partitioning, resource sharing; Optimization for area, speed, and power

UNIT-V

Timing and Constraints: Clocking and resets (asynchronous vs synchronous resets); Setup and hold time concepts; Clock domain crossing issues; Static Timing Analysis (STA) basics; Timing constraints: SDC format

Textbooks:

1. Michael D. Celetti: Advanced Digital Design with the Verilog HDL, PHI, 2013
2. Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson

Reference Books:

1. Stephen Brown and Zvonko Vranesic, Fundamentals of Digital Logic with Verilog Design, McGraw Hill
2. Douglas L. Perry, Verilog HDL, McGraw Hill
3. Clifford E. Cummings, Verilog Coding Styles and Synthesis Guidelines (IEEE Papers and Notes)

Web Links:

1. https://onlinecourses.nptel.ac.in/noc24_cs61/preview
2. https://nptel.ac.in/courses/106103358
3. https://onlinecourses.nptel.ac.in/noc21_ee39/preview

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PE4101.2	Robotics and Automation	3:0:0	3

Course Objectives:

- To introduce the fundamentals of robot kinematics and classification, including forward and inverse kinematics
- To analyze the velocity and acceleration kinematics and understand robot dynamics using standard formulations.
- To apply various path and trajectory planning algorithms in configuration space.
- To model, and control robotic manipulators using classical and modern control techniques.
- To develop and test robotic applications using the Robot Operating System (ROS)

Course Outcomes: After completion of the course, the student will be able to:

- Explain the principles of transformation, rigid motion, and Denavit-Hartenberg parameters
- Apply the dynamic equations of motion for robots using Euler-Lagrange and Newton-Euler methods
- Develop path and trajectory planning techniques for point-to-point and continuous motion
- Apply principles of robot joint modeling and trajectory-following control strategies
- Utilize Robot Operating System (ROS) for developing and debugging robotic applications involving motion planning and control

UNIT-I

Introduction and Position Kinematics: Types of Robots and applications, Serial Robots, Transformations, Rigid Motions, Forward Kinematics: Denavit-Hartenberg Convention, Inverse Kinematics.

UNIT-II

Velocity Kinematics – The Jacobian: Angular and Linear Velocity: Singularities, Accelerations.
Robot Dynamics: Equations of Motion, Kinetic and Potential Energy, Euler-Lagrange Equations, Recursive Newton-Euler Formulation.

UNIT-III

Path and Trajectory Planning**:** Path vs. Trajectory, The Configuration Space, Path Planning in Configuration Space, Probabilistic Roadmap Planner, Potential Fields, Trajectory Planning, Point to Point Motion, Paths Specified by Via Points,
Sensors and Actuators: Joint Actuating Systems, Drives, Proprioceptive Sensors, Exteroceptive Sensors

UNIT-IV

Robot Control: Modelling Robot joint as a Second-order linear system, Control-law partitioning, trajectory-following control, disturbance rejection, Nonlinear and time- varying systems, multi-input, multi-output control systems, control of manipulators, practical considerations

UNIT-V

Robot Operating System (ROS): Basic ROS concepts, Writing RoS Programs, Log Messages, Graph Resource Name, Launch Files, Parameters, Services, Recording and Replaying Services

Textbooks:

1. Saeed B. Niku, Introduction to Robotics Analysis, Application, Pearson Education Asia, 1st Edition, 2001.
2. Vijay Madisetti and Arshdeep Bahga, Internet of Things - A Hands-on Approach, First Edition, University Press,1st Edition, 2015.

References:

1. "Robotics: Modelling, Planning and Control" by Bruno Siciliano and Lorenzo Sciavicco, 2nd Edition, 2001.
2. "Introduction to Autonomous Robots" by Nikolaus Correll, Bradley Hayes, and Adam Klaptocz, 2020.
3. "Robotics and Control" by M.V. Subramanyam, 2nd Edition, 2018.
4. "Robot Mechanisms and Mechanical Devices Illustrated" by Paul E. Sandin, 2003.
5. "Industrial Robotics: Technology, Programming, and Applications" by Mikell P. Groover and Mitchell Weiss, 1st Edition, 1986.

Web Links:

1 https://onlinecourses.nptel.ac.in/noc21_de13/preview

2 https://onlinecourses.nptel.ac.in/noc21_ee32/preview

3 https://onlinecourses.nptel.ac.in/noc21_ee32/preview

4 https://onlinecourses.nptel.ac.in/noc21_de13/preview

5 https://onlinecourses.nptel.ac.in/noc21_de13/preview

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PE4101.3	Power System Operation and Control	3:0:0	3

Course Objectives:

- To optimal dispatch of generation with and without losses.
- To study the optimal scheduling of hydro thermal systems and unit commitment
- To study the load frequency control for single area system with and without controllers
- To study the Economic dispatch control and load frequency control in two area systems
- To explain the reactive power control and compensation of transmission lines.

Course Outcomes: After completion of the course, the student will be able to:

1. Apply the operating principles of economic scheduling to minimize the overall cost of generation
2. Analyze the optimal allocation of hydro-thermal system and unit commitment schedules to ensure optimal operation
3. Apply the concepts to develop mathematical models for load frequency control in power systems
4. Examine the Economic dispatch control and load frequency control in two area systems
5. Describe the methods for reactive power control and its importance in maintaining system stability

UNIT – I

Economic Operation: Power scenario in Indian grid - National and Regional load dispatching centers - requirements of good power system, heat rate curve - cost curve - incremental fuel and production costs, input-output characteristics. Optimum generation allocation with and without line losses, general transmission line loss formula

UNIT–II

Hydrothermal Scheduling and Unit Commitment: Optimal scheduling of hydrothermal System: Scheduling problems-short term hydrothermal scheduling problem. Statement of Unit Commitment (UC) problem; constraints in UC, UC solution methods: Priority-list methods, forward dynamic programming approach

UNIT – III

Load Frequency Control-I: Necessity of keeping frequency constant, basics of speed governing system and modelling, block diagram representation of steam turbines and approximate linear Models, generator- load modelling. Definitions of control area - Single area control - Block diagram representation of an isolated power system - Steady state analysis - Dynamic response - Uncontrolled case.

UNIT – IV

Load Frequency Control-II: Proportional plus integral control of single area and its block diagram representation, steady state response - Load frequency control and economic dispatch control. Load frequency control of two-area system - Uncontrolled case and controlled case, Tie-Line bias control

UNIT – V

Reactive Power Control: Overview of reactive power Control - Reactive Power Compensation in Transmission Systems - Advantages and Disadvantages of Different Types of Compensating Equipment for Transmission Systems; Load Compensation - Specifications of Load Compensator, Uncompensated and Compensated Transmission Lines: Shunt and Series Compensation.

Text books:

1. Modern Power System Analysis,D.P.Kothari and I.J.Nagrath, Tata McGraw HillPublishing Company Ltd., 3rd Edition, 2003, Ninth Reprint 2007.
2. Electric Energy System Theory: An Introduction, OlleIngemar Elgerd, Tata McGrawHill, 2nd Edition, 1982.
3. Power System Stability and Control, P Kundur, Tata McGraw Hill, 1994, 5th Reprint,2008

Reference books:

1. Power System Analysis and Design, J. Duncan Glover and M.S.Sharma, Thomson, 3rd Edition, 2008.
2. Allen.J.Wood and Bruce F.Wollenberg, 'Power Generation, Operation and Control',3rd/e, John Wiley & Sons, Inc., 2013.

Web LInks

1. https://nptel.ac.in/courses/108101040/
2. http://nptel.ac.in/courses/108104052/

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PE4101.4	Industrial Drives	3:0:0	3

Course Objectives:

- To introduce students to the fundamental concepts of electric drives.
- To enable students to analyze the operation and characteristics of DC motor drives.
- To enable students to analyze the operation of Induction and Synchronous motor drives.
- To compare the performance of Vector Control and Direct Torque Control for induction motors
- To introduce the principles and methods of sensor-less control for electric drives.

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

1. Analyze the mechanical dynamics and stability of Industrial drives.
2. Analyze the operation of DC motor drives using half-controlled and fully-controlled rectifiers and converters.
3. Analyze the common control strategies for both Induction and Synchronous motor drives.
4. Analyze the implementation of Vector Control and Direct Torque Control for induction motors.
5. Analyze sensor-less speed control methods used for scalar and vector-controlled drives.

UNIT-I

Principles, Dynamics, and Power Rating Selection– Need of electric drives, basic parts, present scenario of electric drives, Mechanical Dynamics in an Electric Drive - Speed-torque characteristics of some common motors and loads, multi-quadrant operation, equivalent values of drive parameters, stability of an electric drive, Selection of Motor Power Rating – Thermal model of motor for heating and cooling, classes of motor duty, determination of motor rating.

UNIT-II

DC Motor Drive Using Phase Controlled Rectifier – DC motor drive using half controlled and fully controlled single phase and three phase rectifiers, continuous and discontinuous conduction modes of operation, 4-quadrant operation using dual converter, Operating limits of a separately excited DC motor drive.

UNIT-III

Induction Motor Drive – Steady state equivalent circuit and phasor diagram with variable frequency supply, v/f control and constant air gap flux control of induction motor drive, field weakening operation of induction motor drive.

Synchronous Motor Drive – Synchronous motor drive with Variable Voltage Variable Frequency supply, synchronous motor drive using a voltage source inverter, synchronous motor drive using load commutated thyristor inverter, control of synchronous machine using cycloconverter.

UNIT-IV

Vector Control: Indirect rotor flux oriented vector control scheme implementation– tuning - Dynamic simulation.Parameter sensitivity and compensation of vector controlled induction motors-Selection of Fluxlevel - Flux weakening operation - Speed controller design,comparison of DTC and FOC.

UNIT-V

Sensor less Control: Principles for speed sensor less control - Sensor less methods for scalar control, Sensor less methods for vector control, Introduction to observer based techniques.

TEXT BOOKS:

1. Sen, Paresh Chandra. Principles of Electric Machines and Power Electronics, International Adaptation. John Wiley & Sons, 2021.
2. Mohan, Ned, Tore M. Undeland, and William P. Robbins. Power electronics: converters, applications, and design. John wiley & sons, 2003.
3. Bose, Bimal K. "Power electronics and AC drives." Englewood Cliffs (1986).

REFERENCE BOOKS:

1. Krishnan, Ramu. "Electric motor drives: modeling, analysis, and control." (No Title) (2001).
2. Vas, Peter. Sensorless vector and direct torque control. Oxford university press, 1998.

Web Links:

1. https://onlinecourses.swayam2.ac.in/nou24_ee02/preview
2. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PE4102.1	FPGA based Control Design	3:0:0	3

Course Objectives:

1. To know about FPGA architecture features and fabrics and basics of VLSI technology
2. To learn about FPGA-based system design and VLSI technology, focusing on digital design principles.
3. To learn about logic implementation and design aspects of FPGA
4. To understand about performance analysis of sequential machines
5. To learn about architectures and multi-FPGA large scale systems

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

1. Understand about features of FPGA and its fabrics
2. Design of FPGA based systems and develop single and multi-FPGA systems
3. Apply the basic concepts to design various combinational logic gates using FPGAs
4. Develop sequential logic machines and analyze the performance
5. Analyze and compare different system architectures.

UNIT-I

FPGA ARCHITECTURE AND FABRICS: Programmable Logic Devices-Types-PLA, PAL, FPGA-architectures, SRAM-based FPGAs, Permanently Programmed FPGAs, Chip I/O. Circuit Design of FPGA Fabrics. Architecture of FPGA Fabrics.

UNIT-II

FPGA-BASED SYSTEMS AND VLSI TECHNOLOGY: Introduction, Basic Concepts, Digital Design and FPGAs. FPGA-based system design. Manufacturing Processes, Deriving Transistor Characteristics, CMOS Logic Gates, Wires, Registers and RAM, Packages and Pads.

UNIT-III

COMBINATIONAL LOGIC: The Logic Design Process. Hardware Description Languages, combinational network delay. Power and energy optimization, arithmetic logic, logic implementation for FPGAs. Physical Design for FPGAs. The Logic Design Process.

UNIT–IV

SEQUENTIAL MACHINES: The sequential machine design process. Sequential design styles. Rules for Clocking. Performance Analysis. Power Optimization

UNIT-V

LARGE SCALE SYSTEMS: Architectures and Large-Scale Systems, Behavioral Design, Design Methodologies. Design Example. Buses, Platform FPGAs, Multi-FPGA Systems, Novel Architectures.

Textbooks:

1. FPGA Based System Design, Wayne Wolf, Prentice Hall, 2004..
2. Modern VLSI Design, Wayne Wolf, Pearson Education 2002..

Reference Books:

1. Advanced Digital Design with verilog HDL, Michael D Ciletti, Pearson Education 2005.
2. Verilog HDL, Samir Palnitkar, Pearson Education 2005.
3. A Verilog HDL Primer, J Bhaskar, 2nd edition, B S Publications, 2007.
4. VHDL for Programmable Logic, Kevin Skahill Pearson Education, 2004.

Web Links:

1. https://nptel.ac.in/courses/117108040

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PE4102.2	Intelligent Control Techniques	3:0:0	3

Course Objectives:

- Understand the basics of intelligent control techniques and their applications.
- Design and implement fuzzy logic controllers.
- Develop and train neural networks for control applications.
- Apply genetic algorithms to optimize control system parameters.
- Explore hybrid control systems combining multiple intelligent techniques.

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

1. Understand the fundamental concepts of intelligent control systems
2. Design and implement fuzzy logic controllers (FLCs)
3. Apply neural networks for control system design
4. Use genetic algorithms for optimization in control systems
5. Analyze and design hybrid intelligent control systems.

UNIT-I

Introduction to Intelligent Control: Introduction to traditional control vs. intelligent control, Characteristics of intelligent control systems, Basic elements and structure of an intelligent control system, State-space modelling, Applications: DC motor modelling, Temperature control system

UNIT-II

Fuzzy Logic Control: Introduction to fuzzy sets, fuzzy logic, membership function, and fuzzy operations, Fuzzy inference systems: Mamdani and Sugeno models, Design of fuzzy logic controllers (FLC), Applications of fuzzy logic in real-world control systems, Case study: Fuzzy control for temperature regulation, washing machine, motor speed control.

UNIT-III

Neural Networks in Control: Introduction to artificial neural networks (ANN), Architecture of neural networks: Perceptron, multi-layer perceptrons (MLP), Training algorithms: Back propagation, gradient descent, weight update iterations, neural network-based controllers, Applications: System identification, pattern recognition, Solar PV power forecasting, State-of-charge prediction in EV batteries.

UNIT–IV

Genetic Algorithms in Control: Introduction to evolutionary algorithms and genetic algorithms, Representation, selection, crossover, and mutation, Genetic algorithms for parameter optimization, GA Iterations, Hybrid GA-based control systems, Applications: Tuning PID controllers using genetic algorithms, optimization in energy systems.

UNIT-V

Hybrid Control Systems: Concept of hybrid control: Combining multiple intelligent techniques, Fuzzy-logic and neural network hybrid systems, Fuzzy-logic and genetic algorithm hybrid systems, ANFIS Hybrid Learning iterations, Applications: Adaptive control of drone flight path, Self-learning EV motor drive, and Grid-tied inverter with hybrid control.

Textbooks:

1. "Fuzzy Control Systems" by Witold Pedrycz and Andrzej Skowron.

2. "Neural Networks for Control" by Lipo Wang.
3. "Genetic Algorithms in Search, Optimization, and Machine Learning" by David E. Goldberg.

Reference Books:

1. "Intelligent Control Systems with MATLAB" by D. P. Atherton.
2. "Artificial Intelligence: A Modern Approach" by Stuart Russell and Peter Norvig.
3. "Introduction to Genetic Algorithms" by S. N. Sivanandam and S. N. Deepa.

Software Tools:

- MATLAB/Simulink (for simulation of fuzzy logic, neural networks, and genetic algorithms).
- Python libraries such as TensorFlow and PyTorch for neural networks.

Web Links:

1. https://www.mathworks.com/products/matlab.html
2. https://www.tensorflow.org/
3. https://scikit-learn.org/

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PE4102.3	Distribution System Planning and Automation	3:0:0	3

Course objectives:

- To understand the fundamental concepts and need for distribution system planning.
- To familiarize components and layout of sub-transmission systems and distribution substations.
- To calculate voltage drops and power losses in various feeder arrangements.
- To learn the objectives, functions, and benefits of distribution automation in modern power networks.
- **Study** different communication protocols and data acquisition methods used in SCADA-based systems.

Course Outcomes: At the end of the Course the student shall be able to

1. Explain the concepts of distribution system planning and automation
2. Explain substation layout and its influence on service area coverage
3. Analyze distribution network performance by voltage drop and power loss calculations
4. Analyze the communication requirements and RTU functionality for effective implementation of distribution automation
5. Analyze the role of SCADA in monitoring and controlling distribution network operations

UNIT-I

Distribution Systems Planning:

Introduction, Distribution system planning, Factors affecting system planning, Present distribution planning techniques, Distribution system planning in the future, Future nature of distribution planning, Central role of the computer in distribution planning, Impact of Dispersed Storage and Generation , Load characteristics, Load forecasting, Long term forecasting, Technological forecasting..

UNIT-II

Design of Sub transmission Lines and Distribution substations:

Sub-transmission, Distribution substations, Sub-station bus schemes, Sub-station location, Rating of distribution substation, Substation service area with 'n' primary feeders, Comparison of four and six feeder patterns

UNIT-III

Design Considerations of Primary and Secondary Systems:

Radial type and loop type primary feeders, Primary network, Primary feeder voltage levels, Primary feeder loading, Radial feeders with uniformly distributed load and non-uniformly distributed loads, Secondary voltage levels, Secondary banking, and Secondary networks-Secondary mains Voltage drops and power loss calculations- three phase balanced primary lines, non-three phase primary lines.

UNIT-IV

Distribution Automation:

Problems of existing Distribution System, Need for Distribution Automation, Characteristics of Distribution System, Distribution Automation (Objectives, Functions, Benefits), Communication Requirements for DA, Remote Terminal Unit (RTU) ,Network reconfiguration, Improvement in Voltage Profile, Capacitor Placement in Distribution System for Reactive Power Compensation

UNIT-V

SCADA SYSTEM

Introduction, Block Diagram, Components of SCADA, Functions of SCADA, and SCADA applied to Distribution Automation, Advantages of DA through SCADA, Requirements and Feasibility, DA Integration Mechanisms, Communication Protocols in SCADA Systems.

Text Books:

1. Dr M K Khedkar and Dr G M Dhole, "A Textbook of Electric Power Distribution automation", University Science Press, 1st Edition 2011.
2. Turan Gonen , "Electric Power Distribution system Engineering", CRC press, 3rd edition, 2014

Reference Books:

1. . A.S. Pabla, "Electric Power Distribution " Tata Mc Graw-hill Publishing Company, 6 th edition, 2011
2. Control and Automation of Electrical Power Distribution systems by James North cote and Robert Wilson, CRC press, 1st edition 2006.

Web Links:

1 https://onlinecourses.nptel.ac.in/noc22_ee35

2 NPTEL :: Electrical Engineering – Energy Management Systems and SCADA

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–PE4102.4	Hybrid Electric Vehicles	3:0:0	3

Course Objectives:

- To understand the advantages of electric and hybrid electric vehicles.
- To know various architectures of hybrid electric vehicles.
- To learn the power management of plug-in electric vehicles.
- To familiarize the different management strategies electric vehicles.
- To know different batteries and other storage systems

Course Outcomes: After completion of the course, the student will be able to

1. Understand the concept of electric vehicles and hybrid electric vehicles
2. Explain the different configurations of hybrid electric vehicles
3. Apply the power management used in hybrid electric vehicles
4. Classify the different energy management strategies in electric vehicles
5. Explain different batteries and other energy storage systems

UNIT– I

Introduction: Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; History of hybrid vehicles, advantages and applications of Electric and Hybrid Electric Vehicles, principle of magnetic levitation, different Motors suitable for of Electric and Hybrid Electric Vehicles.

UNIT–II

Hybridization of Automobile: Architectures of Hybrid Electric Vehicles (HEVs), series and parallel HEVs, complex HEVs. Plug-in hybrid electric vehicle (PHEV), constituents of PHEV, comparison of HEV and PHEV; Fuel Cell vehicles and its constituents.

UNIT–III

Plug-in Hybrid Electric Vehicle: PHEV Architectures, equivalent electric range of blended PHEVs; Fuel economy of PHEVs, power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, PHEV battery charging, drive train structure, grid to vehicle.

UNIT–IV

Energy Management Strategies: Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, Classification of different energy management strategies, Comparison of different energy management strategies, Implementation issues of energy management strategies

UNIT– V

Battery and Storage Systems: Energy Storage Parameters; Lead–Acid Batteries; Lithium- ion batteries-Ultra capacitors; Flywheels – Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage – Storage Heat; Energy Storage as an Economic Resource

TEXT BOOKS

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
3. S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”, Springer, 2015.

REFERENCE BOOKS:

1. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. H. Partab: Modern Electric Traction – DhanpatRai& Co, 2007.
4. C. Mi, M. A. Masrur and D. W. Gao, “Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives”, John Wiley & Sons, 2011.

WEBLINKS:

1. https://onlinecourses.nptel.ac.in/noc22_ee53/preview

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–SC4101.1	Embedded ARM Programming	1:0:2	2

Course Objectives:

- To understand the ARM Cortex-M3 architecture and LPC1769 microcontroller peripherals.
- To use port pins as input or output depending on the need with specific pin mode of operation
- To Understand how to use timers for different purposes
- To interface peripherals like PWM,ADC and DAC effectively
- To establish serial communication using UART and SPI protocols for data exchange.

Course Outcomes

1. Analyze the use of GPIO pins for input and output operations including polling and interrupt handling.
2. Configure internal and external oscillators and generate precise time delays using software and timer peripherals.
3. Implement logic-based digital systems and waveform generation using DIP switches, timers, and PWM modules.
4. Apply the ADC and DAC modules in the LPC1769 for analog-to-digital and digital-to-analog conversion.
5. Implement serial communication using UART and SPI protocols for data exchange.

Description: Overview of ARM Cortex-M3 Architecture, LPC1769 Features, Pin Configuration and Block Diagram, Understanding GPIO Registers, Input/Output configuration, LPC1769 Timers overview, interrupt generation on match, stop or reset timer on match, Nested Vector Interrupt Controller (NVIC), PWM operation, configuring for single edge or double edge, LPC1769 ADC Block and Register Structure, UART register configuration, SPI Basics and Register Configuration.

Conduct the following Experiments on LPC1769 ARM CORTEX M3 micro controller board with MCU Toolchain of Keil

1. Implement LED blinking with the help of GPIO pins using pooling and interrupt method.
2. Configure Clock source of controller with internal RC oscillator, Main Oscillator and generate a square wave of 1Hz using delay routine
3. Implement the logic gates using GPIO pins
4. Read 4-bit DIP switch and load correspond ON and OFF values from arrays and generate pulse width waveform accordingly using single Timer peripheral.
5. Read 4-bit DIP switch and load correspond ON and OFF values from arrays and generate pulse width waveform accordingly by using two timers with interrupt.
6. Using Internal PWM module of the ARM controller generate PWM output in single-edge controlled mode.

7. Using Internal PWM module of the ARM controller generate PWM output in double-edge controlled mode

8. Determine the digital output for given analog input using internal ADC of ARM Controller.

9. Interface DAC and Generate Triangular and Square Wave forms.

10. Interface a stepper motor and rotate in clockwise and anti clock wise direction.

11. Transmit the ADC's digital output values over internal UART of ARM Controller.

12. Develop a program to initialize SPI in master mode and continuously transmit a fixed 8-bit data to a slave device

TEXTBOOKS:

1) Embedded Systems Fundamentals with ARM cortex-M based microcontrollers: A practical Approach, Alexander G. Dean.
2) A Beginner's guide to designing embedded system applications on ARM cortex-M microcontrollers, Ariel Lutenberg, Pablo Gomez, Eric Pernia.

REFERENCE BOOKS:

1) LPC1769 Reference Manual (User)

Web LINK:

- https://onlinecourses.nptel.ac.in/noc22_cs93

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–SC4101.2	FPGA Controller for Power Converters	1:0:2	2

Course Objectives:

- To introduce the fundamentals of FPGA architecture and its role in real-time digital control.
- To develop proficiency in VHDL/Verilog programming for signal processing and control logic.
- To understand the control principles of DC-DC converters, inverters and multi-level inverter using digital platforms.
- To impart practical skills in implementing closed-loop control systems using FPGA.
- To expose students to hardware interfacing, PWM generation, and real-time signal processing.
- To encourage students to design, simulate, and validate FPGA-based converter control projects.

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

1. Describe the structure and functioning of FPGAs for control applications.
2. Write and simulate VHDL/Verilog code for PWM generation and digital control.
3. Develop closed-loop control systems for converters (buck, boost, inverter) using FPGA.
4. Interface ADCs and sensors with FPGA for real-time feedback control.
5. Analyze performance of FPGA-based converter systems using simulation and testing.

Module 1: Introduction to Power Converters and FPGA

- Overview of Power Electronic Converters: DC-DC, DC-AC, AC-DC, AC-AC
- Basic concepts of FPGA: Architecture, CLBs, I/O blocks, LUTs
- FPGA vs Microcontrollers for power electronics

Module 2: FPGA Design Tools and Workflow

- Introduction to VHDL/Verilog
- Xilinx Vivado / Intel Quartus overview
- Simulation & synthesis process
- Test bench creation and waveform analysis

Module 3: PWM Generation using FPGA

- Basics of PWM, SPWM, SVPWM
- VHDL implementation of PWM
- Duty cycle control logic
- Multi-channel PWM for converter applications

Module 4: Closed-Loop Control using FPGA

- Introduction to PI/PID control theory
- Implementing digital control algorithms in VHDL
- Voltage and current feedback loop design
- Real-time data acquisition from sensors via ADCs

Module 5: FPGA Control of DC-DC Converters

- Control of buck, boost, buck-boost converters
- Modeling and simulation of DC-DC converters
- FPGA-based real-time control implementation
- Case study: MPPT for solar using boost converter

Textbooks:

1. Digital Design- Authors: M. Morris Mano and Michael D. Ciletti
2. FPGA Prototyping by VHDL Examples-Author: Pong P. Chu
3. Power Electronics: Converters, Applications, and Design- Author: Ned Mohan, Tore M. Undeland, William P. Robbins
4. Power Electronics: Devices, Circuits, and Applications- Author: Muhammad H. Rashid

Reference Books:

1. Designing with FPGAs and CPLDs- Author: Bob Zeidman
2. Advanced FPGA Design: Architecture, Implementation, and Optimization-Author: Steve Kilts.
3. Xilinx and Intel (Altera) FPGA User Manuals & Application Notes.
4. Digital Control of Electrical Drives with Embedded System-Author: Shaahin Filizadeh

Web Links:

1. https://archive.org/details/digital-design-5th-edition-m-morris-mano-and-michael-d-ciletti
2. https://archive.org/details/fpgabasedsystemd0000wolf
3. https://archive.org/details/fpgabasedsystemd0000wolf
4. https://archive.org/details/powerelectronics0000rash

Course Code	Course Title	Hrs./Week L: T: P	Credits
R23EEE-SC4101.3	Photovoltaic System Design	1:0:2	2

Course Objectives:

- To identify solar panel systems, their components and connections for various loads
- To Perform site selection, Installation, maintenance, and safe operation of solar PV systems
- To identify various characteristics of solar battery
- To select various equipment's for solar PV system
- To calculate the losses in Grid-Connected PV System

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

1. Identify solar panel systems, their components, and technical specifications, as well as calculating the required number of panels and connections for various loads.
2. Perform site selection, Installation, maintenance, and safe operation of solar PV systems
3. Set the tilt angle of solar panels for maximum efficiency and identify the characteristics of various solar battery types
4. Select the various HT switch gear equipment
5. Calculate the losses in Grid-Connected PV System

List of Experiments

1. Study different types of Solar Power Plants.
2. Calculation of PV module tilt angle and shadow analysis
3. Selection of PV module technology and calculation of energy output
4. I-V characteristics of solar cell
5. Sizing of solar inverter for roof top and grid connected projects
6. Connection of PV Module(Series and Parallel Circuit)
7. Selection and Sizing of HT switchgear for Solar power plant
8. Selection and sizing of AC and DC Cables
9. Design substation and switchyard for Solar power plant
10. Smart Grid/Net Metering in Solar power plant
11. Performance analysis of a solar power plant
12. Determination of Cable size and losses in a Grid connected PV system

TEXT BOOK:

1. Chetan Singh Solanki ,Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, PHI Learning Publications, 3rd Edition, 2015
2. SAM Ver. 2.0 User guide - https://www.nrel.gov/docs/fy08osti/43704.pdf

REFERENCES:

1. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, PHI Learning Publications, 3rd Edition, 2015
2. Roger A. Messenger and Jerry Ventre, 'Photovoltaic Systems Engineering', Taylor and Francis Group Publications, 3rd Edition, 2010(CRC Press Reprint – 2018)
3. Soteris A. Kalogirou, Solar Energy Engineering: Processes and Systems, Academic Press, (Elsevier) 2nd edition, 2014.

Online Learning Resources:

https://onlinecourses.nptel.ac.in/noc22_ee71/preview

Course Code	Course Title	Hrs./Week L: T: P	Credits
R23EEE-SC4101.4	Electric Vehicle Technology	1:0:2	2

Course objectives:

- Understand the fundamental concepts, architecture, and design calculations of electric vehicles.
- Analyze and simulate power electronic converters and inverter systems used in EV applications.
- Model and evaluate electric drive systems (BLDC/PMSM) and their control strategies using MATLAB/SIMULINK.
- Develop and simulate battery systems, including charging techniques, SoC estimation, and cell balancing methods.
- Design and analyze integrated EV subsystems such as BMS, EV chargers, and grid-interactive systems (V2G/G2V)

Course outcomes: After completion of this course, student will be able to

1. Apply fundamental knowledge to perform design calculations and basic modeling of electric vehicle systems
2. Analyze and simulate power converters and inverter-based systems for EV applications.
3. Design and implement control strategies for electric drives (BLDC/PMSM) in simulation environment.
4. Evaluate battery performance, SoC, and implement charging/discharging and cell balancing techniques.
5. Develop and simulate integrated EV systems such as BMS, EV chargers, and bidirectional power flow (V2G/G2V).

Pre-requisites:

Introduction, components of electric vehicles, classification of electric vehicles, fundamentals of batteries and their design calculations for EV, PWM techniques, converters, inverters, state-of-charge for battery, battery management system, motors in electric vehicles, charging technologies-V2G, G2V.

List of Experiments

1. Introduction to electric vehicle technology, fundamentals and the design calculations for EV.
2. Simulation of three – phase VSI with SPWM technique for grid integration in EV using MATLAB/SIMULINK.
3. Design of bidirectional battery circuit using Buck / Boost converter using MATLAB/SIMULINK.
4. Modeling and Simulation to calculate electric vehicle speed from motor torque
6. Speed control of electric vehicle using BLDC or PMSM in MATLAB/SIMULINK.
7. Simulation of regenerative braking system in PMSM for EV in MATLAB/SIMULINK.
8. Battery Charging from Solar PV using Buck Converter with MPPT /MATLAB Simulation.
9. Battery controller based on SoC for charging and discharging of battery in EV using MATLAB/SIMULINK.
10. Modeling and Simulation of passive cell balancing for lithium-ion batteries using MATLAB/SIMULINK.

11. Simulation of active cell balancing using fly back converter for Lithium Ion battery in MATLAB/SIMULINK for EV.
12. Modeling and Simulation of Battery Management System (BMS) using MATLAB/SIMULINK.
13. Modeling and Simulation of EV Charger (Battery Charger) using MATLAB/SIMULINK.
14. Simulation of bidirectional V2G, G2V Operation in Electric Vehicle charger using single phase model.

Course Code	Course Title	Hrs./Week L: T: P	Credits
R23EEE-SC4101.5	PCB Design	1:0:2	2

Course Objectives:

- To design and fabricate PCB for prototyping as well as in Industrial Production environment.
- To learn the Power Supply Modules
- To study the different types of Rectifiers to design the circuit
- To know the Security Systems
- To Know the Design of an electronic printed circuit board for a specific application

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

1. Determine appropriate components to make circuits.
2. Acquire the basic level knowledge required to understand PCBs
3. Understand a single layer and multilayer PCB
4. Design of the Security Systems
5. Design of an electronic printed circuit board for a specific application

List of Experiments:

1. Introduction to Proteus and EDA Tool Software
2. Design of a ±5V, ±9V, ±12V, and ±15V Power supply
3. Schematic Creation and simulation of an electronic circuit
4. Design and simulation of a Half and Full Wave Rectifier
5. Design of a PCB layout of Low pass filter
6. Design of a PCB layout of CE Amplifier
7. Design and Simulation of Simple 7 Segment Circuit
8. Design of simple water level indicator
9. Design of a Laser Light Security Alarm
10. Design of touch less doorbell using proximity sensor
11. Design of simple over temperate detector
12. Design of time delay generator using NE555
13. Design of traffic light control for 4 way using Arduino
14. Gate driver circuit for MOSFET
15. Design led strip for 9-watt capacity

TEXT BOOK:

1. Simon Monk, “Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards (Electronics)” 2017

REFERENCE BOOK:

1. S. Yogesh, “OSCAD: An Open Source EDA Tool for Circuit Design, Simulation,
2. Analysis and PCB Design”, Shroff Publishers & Distributors Pvt. Ltd, 2013.

WEB RESOURCE:

1. https://www.udemy.com/course/circuit-design-simulation-and-pcb-manufacturing-bundle
2. https://www.allaboutcircuits.com/technical-articles/pcb-thermal-management-techniques/
3. PCB Fabrication at home(video): https://www.youtube.com/watch?v=mv7Y0A9YeUc, https://www.youtube.com/watch?v=imQTCW1yWkg

Course Code	Course Title	Hrs./Week L: T: P	Credits
R23EEE-SC4101.6	CAD for Electrical Engineering	1:0:2	2

Course Objectives:

- Develop proficiency in engineering drawing techniques using drawing instruments and CAD tools for electrical engineering applications.
- Understand and represent standard electrical symbols, wiring layouts, machine windings, substations, and power system components accurately.
- Interpret and prepare electrical engineering drawings as per standard practices and specifications.
- Enhance visualization, drafting, and design skills required for electrical installations, machines, and power system networks.
- Apply engineering drawing principles to communicate technical information effectively in electrical engineering projects.

Course Outcomes: After completing this laboratory course, students will be able to:

1. Draw basic geometrical shapes, curves, and standard electrical symbols using engineering drawing conventions.
2. Prepare electrical wiring diagrams, layouts, and control circuits for domestic and industrial applications.
3. Draw and interpret electrical machine constructional details, winding diagrams, and starter circuits.
4. Illustrate transmission towers, power system single-line diagrams, and substation layouts accurately.
5. Apply drafting standards and visualization skills to communicate electrical engineering designs effectively.

List of Experiments

1. To draw the Basic shapes like lines, arcs, curves, shape filling.
2. To draw the Basic Electrical symbols.
3. To draw house wiring diagram and layout.
4. To draw the Electrical machine winding diagram.
5. To draw Transmission tower.
6. To draw construction feature of D.C motor.
7. To draw 3-point and 4-point D.C starters.
8. To draw lamps used in illumination.
9. To draw single line diagram of power system.
10. To draw Simple power and control circuit diagrams.
11. To draw the single line diagram of 33kV/11kV substation.
12. To draw the single line diagram of 11kV/415V substation.
13. To draw the transmission tower diagram for the given dimensions.

TEXT BOOK:

1. K. V. Natarajan, A Textbook of Electrical Engineering Drawing, Dhanpat Rai Publications.
2. Surjit Singh, Electrical Engineering Drawing, Dhanpat Rai & Co.

3. S. K. Bhattacharya, Electrical Engineering Drawing and Design, New Central Book Agency.
4. P. S. Gill, Electrical Drawing and Estimating, S. K. Kataria & Sons.
5. N. D. Bhatt, Engineering Drawing, Charotar Publishing House.

REFERENCES:

1. Warren J. Luzadder and Jon M. Duff, Fundamentals of Engineering Drawing.
2. Thomas E. French and Charles J. Vierck, Engineering Drawing and Graphic Technology.
3. N. D. Bhatt and V. M. Panchal, Engineering Drawing.
4. Bureau of Indian Standards (BIS) – Electrical Symbols Standards.
5. National Electrical Code (NEC) – Electrical Drawing Symbols and Wiring Practices.

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–MC4101	Power Systems & Simulation Lab	0:0:3	0

Course Objectives:

- To evaluate the Sequence Impedance of Transformer and Alternator.
- To determine ABCD Parameters of Transmission line.
- To analyze Load Flow Studies of Power System Network.
- To analyze performance characteristics of relays
- To detect the fault locations in underground cables

Course Outcomes: After completion of the course, the student will be able to

1. Determine the Sequence Impedance of Alternator and Transformer
2. Determine the Transmission Line Parameters
3. Design & Simulation of Load Flow Studies of Power System Network
4. Analyze performance characteristics of relays
5. Detect the fault locations in underground cables

List of Experiments

1. Sequence Impedances of 3 Phase Transformer.
2. Sequence Impedances of 3 Phase Alternator by Fault Analysis.
3. Sequence Impedances of 3 Phase Alternator by Direct method.
4. ABCD parameters of Transmission line.
5. Load flow studies using Gauss-Seidel method
6. Load Flow Studies using N-R method.
7. Determination of equivalent circuit of 3-winding Transformer.
8. Identification of fault locations in underground cables using Varley loop test.
9. Transient analysis of Single Machine Connected to Infinite Bus (SMIB).
10. Study of Bucholz relay for major and minor faults.
11. Study of IDMT Electro mechanical over current relay.
12. Study of Under voltage and over voltage Numerical relay.

Open Electives offered by EEE

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–OE0001	Renewable Energy Sources	3:0:0	3

Course Objectives:

- To study the solar radiation data, extraterrestrial radiation, radiation on earth's surface.
- To study solar thermal collectors.
- To study maximum power point techniques in solar Photovoltaic Systems
- To study wind energy conversion systems, Betz coefficient, tip speed ratio and geothermal systems.
- To study basic principle and working of tidal, biomass and fuel cell

Course Outcomes: After completion of the course, the student will be able to:

1. Understand the basic concepts of solar radiation, its data on earth's surface(L2)
2. Explain the different types of solar thermal energy collectors(L2)
3. Develop the maximum power point techniques in solar Photovoltaic Systems(L3)
4. Understand the Wind energy conversion systems and the various geothermal resources(L2)
5. Explain the methods of generation of electricity from tidal and chemical resources(L2)

UNIT–I: Fundamentals of Energy Systems and Solar energy

Energy conservation principle – Energy scenario (world and India) – various forms of renewable energy - Solar radiation: Outside earth's atmosphere – Earth surface – Analysis of solar radiation data – Geometry – Radiation on flat and tilted surfaces – Numerical problems.

UNIT–II: Solar Thermal Systems

Liquid flat plate collectors: Performance analysis –Transmissivity– Absorptivity product collector efficiency factor – Collector heat removal factor – Numerical problems. Introduction to solar air heaters – Concentrating collectors, solar pond and solar still – solar thermal plants.

UNIT–III: Solar Photovoltaic Systems

Solar photovoltaic cell, module, array – construction – Efficiency of solar cells – Developing technologies – Equivalent circuit of solar cell – Series resistance – Shunt resistance – Cell I-V characteristics and P-V characteristics. Applications and systems – Balance of system components – System design: storage sizing – PV system sizing – Maximum power point techniques: Perturb and observe (P&O) technique – Hill climbing technique.

UNIT–IV: Wind Energy and Geothermal Energy

Sources of wind energy - Wind patterns – Types of turbines –Horizontal axis and vertical axis machines - Kinetic energy of wind – Betz coefficient – Tip–speed ratio – Efficiency – Power output of wind turbine – Selection of generator (synchronous, induction) – Maximum power point tracking – wind farms.

Geothermal: Classification – Dry rock and hot acquifer – Energy analysis – Geothermal based electric power generation

UNIT–V: Tidal Power, Biomass and Fuel Cells

Tidal power – Basics – Kinetic energy equation – Turbines for tidal power – Numerical problems – Wave power – Basics – Kinetic energy equation – Wave power devices.

Biomass Energy: Fuel classification – Pyrolysis – Direct combustion of heat – Different digesters and sizing.

Fuel cell: Classification of fuel for fuel cells – Fuel cell voltage– Efficiency – V-I characteristics

Text Books:

1. Solar Energy**:** Principles of Thermal Collection and Storage, S. P. Sukhatme and J. K. Nayak, TMH, New Delhi, 3rd Edition.
2. Renewable Energy Resources, John Twidell and Tony Weir, Taylor and Francis - second edition,2013.

Reference Books:

1. Energy Science**:** Principles, Technologies and Impacts, John Andrews and Nick Jelly, Oxford University Press.
2. Renewable Energy- Edited by Godfrey Boyle-oxford university.press,3rd edition,2013.
3. Handbook of renewable technology Ahmed and Zobaa, Ramesh C Bansal, World scientific, Singapore.
4. Renewable Energy Technologies /Ramesh & Kumar /Narosa.
5. Renewable energy technologies – A practical guide for beginners – Chetong Singh Solanki, PHI.
6. Non-conventional energy source –B.H.khan- TMH-2nd edition.

Weblinks:

1. https://nptel.ac.in/courses/103103206

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–OE0002	Energy Conservation and Management	3:0:0	3

Course objectives:

- To make the students aware of global energy scenario
- To apply good engineering practices in energy conservation activities
- To summarize the salient features of energy conservation Act 2001.
- To study about energy management and methods of improving energy efficiency in different electrical systems.
- To calculate life cycle costing analysis and return on investment on energy efficient technologies.

Course Outcomes: At the end of the Course the student shall be able to

- Understand the classification of Energy and global energy scenario(L3)
- Understand the importance of Energy Conservation. (L2)
- Understand the schemes of energy conservation act 2001 (L3)
- Analyze the performance of electrical utilities and their efficient improvement approaches (L3)
- Analyze the life cycle coasting and return on investment of energy efficient technologies(L2)

UNIT – I

ENERGY SCENARIO: Classification of Energy – Primary and Secondary Energy, Commercial Energy and Non-commercial Energy and Renewable & Non-renewable energy; commercial energy production, final energy consumption, energy needs of growing economy, energy intensity on purchasing power parity (PPP), energy consumption in various sectors, long term energy scenario, Indian energy scenario, energy pricing.

UNIT - II

ENERGY CONSERVATION: Energy conservation and its importance – need of energy conservation, energy strategy for the future, energy efficiency and its benefits. Energy security – definition, purpose of implementing national energy security policy. Energy conservation systems- short, medium, long term energy conservation. Energy conservation equipments - Automatic power factor controller (APFC) - Intelligent power factor controller(IPFC).

UNIT - III

ENERGY CONSERVATION ACT – 2001: Energy conservation act – 2001 and its features, power and function of bureau, responsibilities and duties of state designated agencies, schemes of BEE under energy conservation act 2001 – Energy conservation building codes – standards and labelling – demand side management – Bachat lamp yojana(BLY) – promoting energy efficiency in small and medium enterprises – designated consumers – certification of energy auditors and managers (introduction only).

UNIT - IV

ENERGY MANAGEMENT: Energy management – energy management program, function of energy manager, principles of energy management and quality of energy manger, Energy management techniques in transformers and motors - Transformer losses& Energy efficient transformers. - Distribution losses in industrial systems. Assessment of transmission and distribution losses in power systems. - Economics of energy efficient motors and systems. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

UNIT - V

ECONOMIC ASPECTS AND ANALYSIS: Electricity billing, electrical load management and maximum demand control, Benefits of demand side management- Harmonics-causes-effects-overcoming - Economics Analysis – Depreciation Methods – Time value of money – Rate of return – Present worth method – Replacement analysis – Life cycle costing analysis.

TEXTBOOKS:

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
3. Energy efficient electric motors by John.C.Andreas, Marcel Dekker Inc Ltd–2nd edition, 1995.
4. Amlan Chakrabarti, "Energy Engineering and management", PHI Publication.

REFERENCEBOOKS:

1. Energy management by W.R.Murphy & G.Mckay Butterworth, Elsevier publications. 2012
2. S.C.Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.
3. Doty, Steven; Turner, Wayne C, Energy Management Hand book (8th Edition), Fairmont Press, Inc., 978-0-88173-707-3

Web Links:

1 www.energy.gov/energy saver/blower-door-tests.
2 https://beeindia.gov.in/content/energy auditor.
3 www.pcra.org/pages/display180-energy-audit
4 https://www.myscheme.gov.in/schemes/peacedea

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–OE0003	Electrical Safety & Standards	3:0:0	3

Course Objectives:

- To Explain the importance of electrical safety and security measures.
- To Demonstrate the principles of safe electrical wiring and fitting practices.
- To Demonstrate the importance of issuing safety clearance notices before energizing equipment.
- To Classify hazardous zones and the associated risks in electrical environments.
- To Explain regulations regarding physical clearances in electrical installations.

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

1. Explain the principles and scope of electrical safety, including its relevance across residential, commercial, and industrial sector. (L2)
2. Understand the Indian power sector organization and Electricity rules, electrical safety in residential, commercial, agriculture, hazardous areas. (L2)
3. Outline the electrical safety during installation, testing and commissioning procedure. (L2)
4. Make use of specification of electrical plants and classification of safety equipment for various hazardous locations. (L2)
5. Understand Safety Management & Standards in Electrical Systems. (L2)

UNIT-I

Introduction to Electrical Safety, Shocks and its Prevention: Terms and definitions, objectives of safety and security measures, Hazards associated with electric current and voltage, who is exposed, principles of electrical safety, Approaches to prevent Accidents, scope of subject electrical safety. Primary and secondary electrical shocks, possibilities of getting electrical shock and its severity, medical analysis of electric shocks and its effects, shocks due to flash/ Spark over's, prevention of shocks, safety precautions against contact shocks, flash shocks, burns, residential buildings and shop.

UNIT-II

Electrical Safety in Residential, Commercial and Agricultural Installations: Wiring and fitting –Domestic appliances –water tap giving shock –shock from wet wall –fan firing shock –multi-storied building –Temporary installations – Agricultural pump installation –Do's and Don'ts for safety in the use of domestic appliances.

UNIT-III

Electrical Safety during Installation, Testing and Commissioning: Preliminary preparations –safe sequence –risk of plant and equipment –safety documentation –field quality and safety -personal protective equipment –safety clearance notice –safety precautions – safeguards for operators –safety.

UNIT–IV

Electrical Safety in Hazardous Areas: Hazardous zones –class 0,1 and 2 – spark, flashovers and corona discharge and functional requirements – Specifications of electrical plants, equipment's for hazardous locations – Classification of equipment enclosure for various hazardous gases and vapours – classification of equipment/enclosure for hazardous locations.

UNIT-V

Safety Management of Electrical Systems and Standards: Principles of Safety Management, Management Safety Policy, Safety organization, safety auditing, Motivation to managers, supervisors, employees. Review of IE Rules and Acts, their Significance: Objective and scope – ground clearances and section clearances – standards on electrical safety - safe limits of current, voltage –Rules regarding first aid and firefighting facility. The Electricity Act, 2003,

Textbooks:

1. Rao, S. and Saluja, H.L., "Electrical Safety, Fire Safety Engineering and Safety Management", Khanna Publishers, 1988.
2. Pradeep Chaturvedi, "Energy management policy, planning and utilization", Concept Publishing company, New Delhi, 1997

Reference Books:

1. Cooper.W.F, "Electrical safety Engineering", Newnes-Butterworth Company, 1978.
2. John Codick, "Electrical safety hand book", McGraw Hill Inc., New Delhi, 2000.
3. Nagrath, I.J. and Kothari, D.P., "Power System Engineering", Tata McGraw Hill, 1998.
4. Wadhwa, C.L., "Electric Power Systems", New Age International, 2004.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc20_mg43
2. https://onlinecourses.swayam2.ac.in/nou20_cs08/preview
3. https://www.udemy.com/course/electrical-safety

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–OE0004	Utilization of Electrical Energy	3:0:0	3

Course Objectives:

- To study the laws of illumination and their applications for various lighting schemes.
- To explain the various methods of Electric heating.
- To explain the various electric traction systems and its equipment
- To identify the speed-time curves of different services and energy consumption levels at various modes of operation.
- To analyze the economic aspects of utilization of electrical energy.

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

1. Apply the concepts of illumination to Calculate the illumination levels required for various lighting schemes (L3).
2. Explain the appropriate heating techniques for different applications (L2).
3. Apply the concepts of D.C and A.C traction systems (L3).
4. Apply speed-time curves and the energy consumption of different services under various operating conditions (L3).
5. Analyze the economic aspects of utilization of electrical energy (L4).

UNIT-I

Illumination: Basic definitions of Illumination, Laws of Illumination, Polar Curves, Calculation of MHCP and MSCP, Lamps: Incandescent Lamp, Sodium Vapour Lamp, Fluorescent Lamp, CFL and LED. Requirement of Good Lighting Scheme, Types, Design and Calculation of Illumination, Numerical Problems.

UNIT-II

Electric Heating: Electrical Heating: Advantages, Modes of heat transfer, Design of heating Element, Methods of Electric Heating – Resistance, Arc heating, Induction and Dielectric Heating, Applications of electric heating, Numerical Problems.

UNIT-III

Electric Traction – I: Introduction, Systems of Electric Traction, Comparison Between A. C. and D. C Traction, Special Features of Traction Motors, The Locomotive, Wheel arrangement and Riding Qualities, Transmission of Drive, and Motor Coaches for Track Electrification, DC Equipment, AC Equipment, Overhead Equipment, Numerical Problems.

UNIT–IV

Electric Traction – II: Introduction to Speed-Time Curves of Different Services, Calculations of Tractive Effort Mechanics of Train Movement, Adhesive Weight and Dead Weight, and Coefficient of Adhesion, Numerical Problems.

UNIT-V

Economic Aspects of Utilizing Electrical Energy: Power Factor Improvement, Load Factor improvement, Off Peak Loads, Use of Exhaust Steam, Waste Heat recovery, Pit Head Generation, Diesel Plant, General Comparison of Private Generating Plant and Public Supply-Initial Cost and Efficiency, Capitalization of Losses.

Textbooks:

1. E. Openshaw Taylor, Utilisation of Electric Energy, Universities Press, Penram International Publishers, 2010
2. N.V. Suryanarayana, Utilisation of Electrical power including Electric drives and Electric Traction, New Age Publishers, 2017.

Reference Books:

1. H. Partab, Art & Science of Utilization of Electric Energy, Dhanpat Rai & Sons, 1998.
2. J. B Gupta, Utilization of Electric Power & Electric Traction S.K. Kataria & Sons, Reprint 2020, 10th Edition.
3. Generation, distribution and utilization of electrical energy, C.L Wadhwa, Wiley Eastern Limited.
4. Electrical Power Systems, S. L. Uppal, Khanna publishers.

Web Links:

1 https://onlinecourses.nptel.ac.in/noc22_ee94/preview
2 https://archive.nptel.ac.in/courses/108/105/108105060/
3 https://archive.nptel.ac.in/courses/112/103/112103263/
4 https://archive.nptel.ac.in/courses/112/107/112107090/
5 https://onlinecourses.nptel.ac.in/noc23_ag06/preview

Honors Track offered by EEE

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–HN4101	Distributed Generation and Micro Grid	3:0:0	3

Course Objectives:

- To understand conventional and distributed generation systems.
- To analyze microgrid structure and operation modes.
- To design integration of renewable and conventional energy sources.
- To develop AC and DC microgrid models with control systems.
- To evaluate and manage power quality issues in microgrids.

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

1. Explain the principles of distributed and conventional power generation systems.
2. Analyze the configuration and operation of microgrids under different modes.
3. Design integration systems for hybrid energy sources in the power grid.
4. Develop basic AC and DC microgrid architectures with appropriate control strategies.
5. Analyze power quality issues and control operation of micro grid

UNIT-I

INTRODUCTION: Conventional power generation: advantages and disadvantages, Energy crises, Non - conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

UNIT-II

DISTRIBUTED GENERATIONS (DG): Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra-capacitors, flywheels. Captive power plants.

UNIT-III

IMPACT OF GRID INTEGRATION: Requirements for grid interconnection, limits on operational parameters,: voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

UNIT–IV

BASICS OF A MICROGRID: Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids.

UNIT-V

CONTROL AND OPERATION OF MICROGRID: Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

Text Books:

1. H. Lee Willis, Walter G. Scott, Distributed Power Generation – Planning and Evaluation, Marcel Decker Press.

2. Robert Lasseter, Paolo Piagi, Micro-grid: A Conceptual Solution, PESC 2004, June 2004.

Reference Books:

1. F. Katiraei, M.R. Iravani, "Transients of a Micro-Grid System with Multiple Distributed Energy Resources" International Conference on Power Systems Transients (IPST-05) in Montreal, Canada on June 19-23, 2005.

2. Z.Ye R. Walling, N.Miller, P.Du.K.Nelson,"Facility Microgrids, General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005.

Web Links:

https://archive.nptel.ac.in/courses/108/107/108107143/

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–HN4102	Grid Interface of Electric Vehicles	3:0:0	3

Course Objectives:

- To acquire knowledge on energy exchange between storage element and power grid.
- To provide knowledge on the benefits of V2G for enhancing energy sustainability
- To learn the challenges in implementing V2G integrated power system
- To learn the impacts of EV and V2G on the power grid
- To familiarize the intelligent management systems for Electric Vehicles

Course Outcomes: After the completion of the course, the students should be able to

1. Analyse the methods of energy exchange between storage element to power system grid.
2. Analyze technical, economic, and environmental benefits of Vehicle-to-Grid (V2G) for sustainable energy and transport
3. Analyse the technical, economic, and regulatory challenges affecting effective implementation of V2G technology
4. Comprehend the impact of EV and V2G on power grid
5. Realize the concept of EVs intelligent systems for efficient Electric Vehicle management and charging

UNIT-I

INTRODUCTION TO G2V AND V2G: Introduction to power grid and smart grid. Definition of G2V and V2G - History and Development of V2G. Incorporating V2G for EVs, Types of storage: Short-term and Long-Term.

UNIT-II

BENEFITS OF V2G: Benefits of V2G. Technical Benefits: Storage Superiority and Grid Efficiency - Economic Benefits: EV Owners and Societal Savings - Environment and Health Benefits: Sustainability in Electricity and Transport.

UNIT-III

CHALLENGES IN V2G: Technical Challenges- Effect of Battery Degradation, Conversion Efficiency of EV Charger. The Economic and Business Challenges of V2G - Evolving Nature of V2G Costs and Benefits. Introduction to Regulatory Challenges and Frameworks.

UNIT-IV

IMPACT OF EV AND V2G ON POWER GRID: Impact of Electric Vehicles on power quality issues - Load management using Renewable Energy Sources and EVs. Impacts of EVs on environment.

UNIT-V

MANAGEMENT OF EVs: Introduction to Machine to Machine (M2M) communication- M2M in distributed energy management systems - M2M communication for EVs - Overview of cloud-based energy management service for Electric vehicles - Data loggers for EVs. - Charging Station Discovery Selection and Status Server (CDSSS).

Text Books:

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017
2. Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, Springer,2015
3. ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor; Jesus Fraile-Ardanuy, IET 2020

References:

1. Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015
2. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle-to-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–HN4103	Advanced Microcontroller based Systems	3:0:0	3

Course Objectives

- To familiarize students with the architecture and advanced features of modern microcontrollers like ARM Cortex-M series.
- To develop proficiency in embedded C programming, peripheral interfacing, and interrupt management.
- To introduce real-time operating system (RTOS) concepts and their application in embedded systems.
- To explore advanced interfaces such as SPI, I2C, CAN, and wireless communication protocols.
- To enable students to design and develop real-world embedded control applications using microcontrollers.

Course Outcomes (COs)

1. Understand and apply the architecture and instruction set of advanced microcontrollers like ARM Cortex-M.
2. Develop embedded C programs and interface microcontroller peripherals for real-world applications.
3. Configure and use timers, interrupts, and analog/digital peripherals effectively.
4. Implement and troubleshoot communication protocols including UART, SPI, I2C, and wireless interfaces.
5. Design and deploy microcontroller-based real-time embedded systems using RTOS concepts.

UNIT-I: Advanced Microcontroller Architecture

Overview of Advanced Microcontrollers (ARM Cortex-M, MSP430, etc.), ARM Cortex-M Architecture: Processor Modes, Registers, Instruction Set, Exception Handling and Vector Tables, Memory Map and Addressing Modes, Power Management Features

UNIT-II: Programming and Development Environment

Embedded C Programming Techniques, ARM-based Development Tools and IDEs (Keil, STM32CubeIDE), Use of Linker Scripts, Startup Files, GPIO Programming and Bit Manipulation Techniques, Assembly and Mixed-Language Programming

UNIT-III: Timers, Interrupts and Peripheral Interfacing

Timer, Counter, Watchdog Timer Configurations, Nested Vectored Interrupt Controller (NVIC), ADC, DAC Interfacing and Applications, PWM Generation and Capture, Interfacing with LEDs, LCDs, Keypads, Relays, Motors, and Sensors

UNIT-IV: Communication Protocols and Interfaces

UART, SPI, I2C: Configuration and Data Handling, USB and CAN Protocol Basics, Wireless Communication Interfaces: Bluetooth, Zigbee, Wi-Fi, Serial Communication with External Devices, Data Logging and Storage (EEPROM, SD Cards)

UNIT-V: Real-Time Embedded Systems and Applications

Basics of RTOS: Tasks, Scheduling, Semaphores, Mutex, Task Communication and Synchronization, RTOS in ARM Cortex-M (Free RTOS), Case Studies: Embedded Applications in Industrial Control, IoT, and Robotics, System Design Methodology and Power Optimization

Textbooks:

1. "Advanced Microprocessors and Peripherals", K M Bhurchandi, A K Ray, TMH Publications.
2. "Advanced Microprocessors and Microcontrollers", B.P.Singh, Renu Singh, New Age International Publishers

Reference Textbooks:

1. "Embedded Systems: Introduction to the MSP432 Microcontroller", Jonathan W. Valvano, Create Space Publishers.
2. "Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C", Yifeng Zhu, E-Man Press Publishers.

Minors Track offered by EEE

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–MT2201	Fundamentals of Special Electrical Machines	3:0:0	3

Course objectives:

- To describe the operation and characteristics of permanent magnet dc motor.
- To analyze the performance and control of stepper motors, and their applications.
- To explain theory of operation and control of switched reluctance motor.
- To explain operation and Torque Speed characteristics of different BLDC and PMSM Motors.
- To understand the significance of LIM and applications of linear motors.

Course Outcomes: After completion of the course, the student will be able to:

1. Explain the principle and operation of PMDC Motors (L2).
2. Analyze the performance and control of stepper motors, and their applications. (L4).
3. Explain the working and power converters of switched reluctance motor (L2).
4. Analyze Torque Speed characteristics of different BLDC and PMSM Motors. (L4).
5. Understand the significance of LIM for traction drives and applications of Hysteresis motor (L2).

UNIT –I

Permanent magnet materials and PMDC motors:
Introduction-classification of permanent magnet materials used in electrical machines-minor Hysteresis loop and recoil line -B-H loop -PMDC motor construction-Principle of operation-torque equation-Equivalent circuit- Application of permanent magnets in motors-Torque Speed Characteristics of PMDC Motor

UNIT – II

Stepper Motors: Principle of operation of Stepper Motor – Constructional details - Classification of stepper motors-single stack and multi stack configurations - Control circuits for stepper motors – Open loop and closed loop control of two-phase hybrid stepping motor, Numerical Problems

UNIT – III

Switched Reluctance Motors: Construction and Principle of operation of Switched Reluctance Motor – Comparison of conventional and switched reluctance motors – Torque producing principle and torque expression – Drive and power circuits for SRM – Position sensing of rotor – Applications of SRM.

UNIT – IV

Permanent Magnet Brushless DC Motor: Principle of operation of BLDC motor - Types of constructions - Surface mounted and interior type permanent magnet DC Motors – Torque and EMF equations for square wave-construction-working of Sine wave PMBLDC Motor – Torque

– Speed characteristics of square wave for PMBLDC Motor - Merits & demerits of square wave & Sine wave PMBLDC Motor – Applications.

UNIT –V

Other Special Electrical machines:

Construction– principle of operation–Double sided LIM from rotating type Induction Motor – Schematic of LIM drive for traction - principle of operation and characteristics of Hysteresis motor-Applications of Hysteresis motor

Textbooks:

1. Brushless Permanent magnet and reluctance motor drives, Clarenden press, T.J.E. Miller, 1989, Oxford.
2. Special Electrical Machines, K.Venkata Ratnam, University press, 2009, New Delhi.

Reference Books:

1. Special electrical machines, E.G. Janardhanan, PHI learning private limited, 2014,

Weblinks:

1. https://nptel.ac.in/courses/108102156

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–MT3101	Fundamentals of Power Systems	3:0:0	3

Course Objectives:

- To study the principle and operation of conventional power generating stations
- To study the principle and operation of non-conventional power generating stations
- To introduce Mechanical design calculations of transmission lines and discuss the concepts of neutral grounding
- To classify distribution systems
- To study different types of load curves and tariffs applicable to consumers

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

1. Describe the operation of conventional power stations. (L2)
2. Describe the operation of non-conventional power stations. (L2)
3. Calculate sag of transmission line on equal and unequal heights of towers. (L3)
4. Analyze the various factors associated with power distribution. (L4)
5. Analyse different economic factors of power generation and tariffs. (L4)

UNIT-I

Generating Power Stations: Conventional Power Generating Stations: Block diagram of thermal power station (TPS), brief description of TPS components. Block diagram of hydro power station, Selection of site, description of main components, Nuclear fission and chain reaction, principle of operation of nuclear reactor, description of components.

UNIT-II

Non- Conventional Power Generating Stations: Principles of solar radiation, solar energy collectors. Role and potential of wind energy options, horizontal and vertical axis turbines-applications.

UNIT-III

Mechanical Design of Transmission lines: Sag and Tension Calculations with equal and unequal heights of towers, Effect of Wind and Ice on weight of Conductor - Stringing chart and sag template and its applications-Numerical Problems.

Neutral Grounding: Effectively grounded system, ungrounded system, Resonant Grounding, methods of neutral grounding, Generator neutral breaker, grounding Practice

UNIT-IV

General Aspects of Distribution Systems: Classification of distribution systems, design features of distribution systems, radial distribution, ring main distribution -AC distributors fed at one end and at both ends, comparison of DC and AC distribution -Kelvin's law- Limitations of Kelvin's law- Choice of scheme-Size of feeders, load modeling and characteristics-Numerical Problems-Applications.

UNIT-V

Economic Aspects & Tariff:

Economic Aspects – load curve, load duration and integrated load duration curves, discussion on economic aspects: connected load, maximum demand, demand factor, load factor, diversity factor, plant capacity factor and plant use factor, base and peak load plants.

Tariff Methods– Costs of generation and their division into fixed, semi-fixed and running costs, desirable characteristics of a tariff method, tariff methods: simple rate, flat rate, blockrate, two-part, three–part, and power factor tariff methods.

Textbooks:

1. Raja, A. K., Amit Prakash Srivastava, and Manish Dwivedi. Power plant engineering. New Age International, 2006.
2. Rajput, R. K. "Non-conventional Energy Sources and Utilization." S. K. Kataria & Sons, 2012.
3. Wadhwa, C. L. Electrical power systems. New Age International, 2006.
4. Mehta, V. K., and Rohit Mehta. Principles of Power System. S. Chand Publishing, 2005.

Reference Books:

1. Kothari, Dwarkadas Pralhaddas, and I. J. Nagrath. Power system engineering. New Delhi, India: Tata McGraw-Hill, 2008.
2. Grigsby, Leonard L. Electric power generation, transmission, and distribution. CRC press, 2007.
3. Singh, Sri N. Electric power generation: transmission and distribution. PHI Learning Pvt. Ltd., 2008.
4. Bansal, N. K. Non-conventional energy resources. Vikas Publishing House, 2014.

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–MT3201	Fundamentals of Electrical Measurements and Instrumentation	3:0:0	3

Course Objectives:

- To study the principle of operation and working of different types of instruments, Measurement of voltage and current.
- To study the working principle of different types of instruments for measurement of power, energy.
- To understand the principle of operation and working of DC and AC Potentiometers
- To understand the principle of operation and working of various types of bridges for measurement of parameters –Resistance, Inductance and Capacitance.
- To learn various Transducers and Display devices.

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

1. Choose the right type of instrument for measurement of voltage and current for AC and DC (L1)
2. Explain the principle of operation and working of different types of instruments (L2)
3. Utilize the potentiometer for Calibrating ammeter, voltmeter, and wattmeter (L3)
4. Select suitable bridge for measurement of electrical parameters (L3)
5. Demonstrate the concepts of various transducers and measurement of electrical quantities using Digital meters (L2)

UNIT-I

Measuring Instruments: Functional elements of an instrument – Static and dynamic characteristics – Errors in measurement – Statistical evaluation of measurement data – classification of torques –deflection, controlling, damping torques , Electrodynamometer and Electrostatic – ammeter, voltmeter.

UNIT-II

Measurement of Electrical and Magnetic Quantities: Principle and operation – Single and three phase watt meters and energy meters – Ballistic galvanometer – Equation of motion — Determination of B-H curve and measurements of iron loss by using bridge method.

UNIT-III

Potentiometers

DC Potentiometers: Principle and operation of D.C. Crompton's potentiometer – Standardization– Measurement of unknown resistance, current and voltage- applications.

AC Potentiometers: Types of AC potentiometers –standardization – applications.

UNIT–IV

AC and DC Bridges

DC bridges: Sensitivity of Wheat stone's bridge – Carey Foster's bridge– Kelvin's double bridge for measuring low resistance- measurement of high resistance – Megger.

AC bridges: Measurement of inductance – Quality Factor – Maxwell's bridge–Hay's bridge – Anderson's bridge- Measurement of capacitance and loss angle – Desauty bridge –Schering bridge, numerical problems

UNIT-V

Transducers and Digital Meters Transducers: Concept and Classification of transducers – Selection of transducers – Resistive, capacitive & inductive transducers, LVDT – Piezoelectric Transuders

Digital Meters: Digital Voltmeter–Successive approximation, ramp and integrating type - Digital frequency meter–Digital multimeter–Digital Tachometer..

Textbooks:

1. A.K. Sawhney, 'A Course in Electrical & Electronic Measurements & Instrumentation' DhanpatRai and Co 2004.
2. J. B. Gupta, 'A Course in Electronic and Electrical Measurements', S. K. Kataria& Sons, Delhi, 2003.
3. Doebelin E.O. and Manik D.N., Measurement Systems – Applications and Design, Special Indian Edition, Tata McGraw Hill Education Pvt. Ltd., 2007
4. H.S. Kalsi, 'Electronic Instrumentation', Tata McGraw Hill, II Edition 200

Reference Books:

1. D.V.S. Moorthy, 'Transducers and Instrumentation', Prentice Hall of India Pvt Ltd, 2007.
2. A.J. Bouwens, 'Digital Instrumentation', Tata McGraw Hill, 1997.A.Nagoor kani, "Control Systems", RBA Publications, 2nd Edition, 2006.
3. Martin Reissland, 'Electrical Measurements', New Age International (P) Ltd., Delhi, 2001.Control systems – K.Alice mary, P.Ramana.
4. Alan. S. Morris, Principles of Measurements and Instrumentation, 2nd Edition, Prentice Hall of India, 2003.

Web Links:

1. https://nptel.ac.in/courses/108101037
2. https://www.electrical4u.com/electrical-engineering-articles/measurement

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–ML3201	Fundamentals of Electrical Measurements and Instrumentation Lab	0:0:3	1.5

Course Objectives:

- To determine the unknown inductance, resistance, capacitance using DC and AC Bridges
- To analyze the calibration of various instruments.
- To understand the measurement of frequency and phase difference by using CRO
- To understand the measurement of various non-electrical parameters using appropriate measuring instruments
- To understand the measurement of pressure and Weight using Transducers

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

1. Apply suitable method for measuring R, L and C parameters in an electric network(L3)
2. Analyze the calibration of various instruments (L4)
3. Demonstrate the measurement of frequency and phase difference by using CRO (L2)
4. Analyze the measurement of various electrical and non-electrical parameters using appropriate measuring instruments (L4)
5. Analyze the measurement of pressure and Weight using Transdusers (L4)

List of Experiments

1. Measurement of L using a bridge technique.
2. Measurement of C using a bridge technique.
3. Measurement of Low Resistance using Kelvin's double bridge.
4. Measurement of High resistance and Insulation resistance using Megger.
5. Calibration and testing of single-phase Energy meter.
6. Calibration of dynamometer wattmeter using phantom loading.
7. Calibration of Voltmeter and Ammeter by using DC Potentiometer.
8. Measurement of frequency and phase difference by using CRO.
9. Measurement of displacement with the help of LVDT.
10. Measurement of pressure and weight using piezoelectric transducer

Additional experiments:

1. Resistance strain gauge – strain measurement and Calibration

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–MT4101	Fundamentals of Power Electronics	3:0:0	3

Course Objectives:

- To understand the principles of power semiconductor devices and their switching characteristics.
- To analyze and design various power converters including rectifiers, choppers, and inverters.
- To study control techniques and modulation strategies in power electronics.
- To explore applications of power electronics in renewable energy systems and motor drives.

Course Outcomes:

By the end of this course, students will be able to:

CO1: Explain the operation, characteristics, and protection methods of various power semiconductor devices.

CO2: Analyze and design controlled and uncontrolled rectifiers for different load types.

CO3: Design and evaluate the performance of DC-DC converters for practical applications.

CO4: Analyze inverter circuits and apply suitable modulation techniques for harmonic control.

CO5: Describe the role of power electronics in renewable energy integration and advanced applications like EVs and smart grids.

UNIT I: Power Semiconductor Devices

Overview of Power Electronics and Applications, Characteristics and Ratings of Power Devices: Diode, SCR, MOSFET, IGBT, Static and Dynamic characteristics of power devices

UNIT II: AC-DC Converters

Single-phase and Three-phase Uncontrolled Rectifiers with R load, Single-phase and Three-phase Controlled Rectifiers (half and full converters) with R load.

UNIT III: DC-DC Converters

Classification: Buck, Boost, Buck-Boost converters, Operation in Continuous conduction Modes, Control strategies

UNIT IV: DC-AC Converters

Single-phase half bridge and Full bridge Voltage Source Inverter (VSI) and Three-phase Voltage Source Inverter (VSI), Pulse width Modulation Techniques

UNIT V: AC-AC Converters

Single-phase half wave and full wave-controlled AC voltage controllers, Single phase step-up and step-down cyclo converters

Text Books:

1. Power Electronics – by P.S.Bhimbra, Khanna Publishers.
2. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
3. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.

Reference Books:

1. R. W. Erickson and D. Maksimovic, “Fundamentals of Power Electronics”, Springer Science & Business Media, 2007.
2. Power Electronics: Essentials & Applications by L.Umanand, Wiley, Pvt. Limited,India, 2009

Web Resources:

1 https://nptel.ac.in/courses/108/105/108105066/

Course Code	Course Title	Hrs./Week L:T:P	Credits
R23EEE–ML4101	Fundamentals of Power Electronics Lab	0:0:3	1.5

Course objectives:

- To study the characteristics of various power electronic devices.
- To analyze the performance of single–phase bridge converters with both resistive and inductive loads.
- To understand the operation of AC voltage regulator with resistive loads.
- To understand the working of Buck and Boost converters.
- To understand the operation of Single phase voltage source inverters.

Course outcomes: After completion of the course, the student will be able to

1. Discuss the characteristics of various power electronic devices (L2).
2. Analyse the performance of single–phase bridge converters (L3).
3. Analyse the output characteristics of Buck and Boost converters (L2).
4. Design the single-phase AC voltage regulator with Resistive loads (L3).
5. Understand single–phase square wave inverter with PWM technique (L2)

Any 10 of the Following Experiments are to be conducted

1. Study of Characteristics of Thyristor.
3. Study of Characteristics of Power MOSFET.
4. Study of Characteristics of Power IGBT.
5. Study of Single -Phase Half wave-controlled rectifier with R load.
6. Study of Single -Phase fully controlled bridge converter with R load.
7. Analysis of DC-DC Buck converters in CCM operation.
8. Analysis of DC-DC Boost converters in CCM operation.
9. Single-Phase Half Bridge VSI with R-load.
10. Single-Phase Full Bridge VSI with R load.
11. Single-Phase AC-AC voltage regulator with R-load.
12. Single -phase PWM inverter with sine triangle PWM technique.