DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

ANNA UNIVERSITY, CHENNAI – 25

VISION:

The vision of the department is to produce analytically proficient and technologically competent Electrical and Electronics Engineers who can serve and take forward the academic, industry and research organizations to newer heights and be effective for building the nation.

MISSION:

- To impart high quality technical education with the state of the art laboratory practice.
- To provide conducive academic ambience to enable best teaching and learning processes.
- To generate resources through research and consultancy projects for pursuing research and developmental activities in emerging areas.
- To associate with academic and industrial organizations for research activities to develop and provide vital and viable solutions for social needs indigenously.
- To develop leadership skills in students with high degree of ethics, morals and values and instill confidence to lead the organization.
ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. POWER ENGINEERING AND MANAGEMENT
REGULATION – 2023
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABUS I TO IV SEMESTERS

1. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

I. To produce graduates with domain knowledge in Power Engineering and Power Business Management who are employable in Core Power engineering, Energy Marketing and Auditing related public and private organisations.

II. To motivate the graduates to take up entrepreneurship as career / pursue research to identify and actively participate in energy management, power trading and be part of renewable energy-based power plants and its service industries.

III. To make students evolve themselves as a consultant and provide solutions to the practical problems faced by power industries.

2. PROGRAM OUTCOMES (POs)

On Successful Completion of the programme, the graduate would have:

PO1 The ability to independently carry out research/investigation and development work to solve practical problems.

PO2 The ability to write and present a substantial technical report/document.

PO3 The ability to demonstrate a degree of mastery in power management towards monitoring and analysis of renewable energy based power plants and energy related equipment.

PO4 The ability to Model and analyse the renewable energy systems with energy storage technology using electrical computation software.

PO5 The ability to perform experiments, understand the power management principles and apply these to lead a team, manage the power projects and work in multidisciplinary environments.

PO6 The ability to recognize the need for energy conservation and sustainability development and have the preparation to engage in independent and life-long learning towards product development.

. MAPPING OF PEOs with POs

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**Note:**
- The Summer Internship has to be carried out in core industries during the 2nd semester vacation.
- Minimum period of training = 4 weeks.

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**Note:**
- The Summer Internship has to be carried out in core industries during the 2nd semester vacation.
- Minimum period of training = 4 weeks.
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### EMPLOYABILITY ENHANCEMENT COURSES (EEC)

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TOTAL CREDITS: 20
## SUMMARY

Name of the Programme: M.E POWER ENGINEERING AND MANAGEMENT

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UNIT I  ENERGY CONSERVATION AND ENERGY EFFICIENCY IN ELECTRICAL SYSTEMS  

UNIT II  TRANSFORMERS AND MOTORS  

UNIT III  HVAC AND REFRIGERATION SYSTEM  

UNIT IV  LIGHTING SYSTEM  

UNIT V  SUSTAINABLE DEVELOPMENT - CASE STUDIES  
Introduction to Sustainable Development – Need for Sustainable Development – Importance of Sustainable Development – Pillars of Sustainable Development – Goals of Sustainable Development – Global, Regional and Community initiatives for Sustainable Development – Need for CO₂ Mitigation – Introduction to PAT Scheme - Case Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Know the importance of Energy Conservation and Energy Efficiency in Electrical Systems.
CO2: Learn the various measures for energy conservation in transformers and motors.
CO3: Understand the energy efficiency in Refrigeration systems.
CO4: Design effective lighting systems.
CO5: Acquire the concept of goals towards Sustainable Development and PAT scheme.

REFERENCES:

**MAPPING OF COs WITH POs**

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**RM3151 RESEARCH METHODOLOGY AND IPR**

**UNIT I RESEARCH PROBLEM FORMULATION** 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

**UNIT II RESEARCH DESIGN AND DATA COLLECTION** 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

**UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING** 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

**UNIT IV INTELLECTUAL PROPERTY RIGHTS** 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.
UNIT V  PATENTS  

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:

2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,

PW3101  MODERN POWER SYSTEM ENGINEERING  LT P C

UNIT I  POWER FLOW ANALYSIS  9

UNIT II  STATE ESTIMATION  9

UNIT III  POWER SYSTEM SECURITY  9

UNIT IV  POWER SYSTEM PROTECTION  9
Introduction to Power System Protection– Operating principles and Relay Construction – Overcurrent Protection– Microprocessor based Overcurrent Relays

12
UNIT V  VOLTAGE STABILITY


TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Carry out power flow analysis for transmission and distribution network.
CO2: Compute the state of the power system.
CO3: Carry out contingency analysis to analyze the power system security.
CO4: Understand over current protection for system security.
CO5: Analyze the concept of voltage stability.

REFERENCES:


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UNIT I  
POWER MANAGEMENT IN INDIA
Growth of Power Industry in India, Organizational Structure of central and state companies and its 
major roles and regulations, Power scenario in India, Load management in power sector, Grid 
Management, Development of power projects in India vs. demand study, Management of Electricity 
Demand Scenario in TamilNadu (TN) state and India, Load and Energy Management System - Case 
Study: Power demand study in state, Load management study in state.

UNIT II  
ACT AND REGULATORY COMMISSIONS
Introduction to the Power Scenario, Overview of the Indian Electricity Act 1910, Electricity Supply Act 
Regulatory Commission (SERC), Central Electricity Regulatory commission (CERC), Tribunal, 
Electricity Regulatory and Industry Structure in India.

UNIT III  
STATE UTILITY SERVICES
Distribution System, Commercial Operations of a Distribution Utility, Metering and Billing, Revenue 
Collection, Emerging Trends in Metering Technology, Available Transfer Capability losses and 
remedial measures.

UNIT IV  
TARIFF POLICY AND DETERMINATION OF TARIFF
Tariff policy, Tariff regulations, Tariff structure, fixed tariff, Availability Based Tariff (ABT), time of the 
day tariff, Multi Year Tariff, Assessment of tariff levels, Determination of tariff for Generation, 
transmission and distribution levels, Comparison of year wise tariff/ state wise. Case Study: Present 
tariff Scenario in Tamil Nādu and compare with other states.

UNIT V  
POWER PURCHASE MANAGEMENT
Scope of the Power Purchase Management, Definition and interpretation of terms of a model Power 
Purchase Agreement (PPA), Desirable Principles of Power Purchase Agreements, Requirements of 
PPA, Risks and responsibilities in a PPA, Negotiating Power Purchase Agreements, PPA - Financial 
and legal issues, Drafting of a model PPA.

Case Study: Study and Analysis of a sample PPA between a Generation and Distribution Utility, 
Financial Statement Analysis of a State Power Sector Organization, Power Project Appraisal, Returns 
of a large Power Project, etc.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Acquire knowledge about power scenario in India.
CO2: Understand the electricity acts and regulatory commission policies.
CO3: Identify elements in distribution utility and the concept of billing.
CO4: Evaluate the tariff policy and its regulations.
CO5: Understand and create awareness about power purchase and its management.

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
REFERENCES:

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UNIT I INTRODUCTION
Introduction to EV Systems: Benefits of EV – Battery Charging Modes - Electric Vehicle Supply Equipment (EVSE) and its components – Classification of chargers based on charging levels: AC Slow Charger, DC Fast Charger - AC-DC Converter and DC-DC Converter for EV Charger: Types and Working Principles - Modes of charging based on IEC 61851 - Plugs and connectors - Cables: without thermal management, with thermal management - Standards related to Connectors and Communication – Challenges in Charging Infrastructure - Battery Swapping

UNIT II BUSINESS MODEL AND ELECTRICITY TARIFF STRUCTURE
Introduction - integrated business model - independent business model - tariff structure

UNIT III ELECTRIC DISTRIBUTION SYSTEM FOR FAST CHARGING INFRASTRUCTURE
Single line diagram of fast charging infrastructure - Major components of fast charging infrastructure - Single point of failure - Configuration of electric distribution considering redundancy - Other configurations
UNIT IV POWER QUALITY AND EMI/EMC CONSIDERATIONS


UNIT V ENERGY STORAGE SYSTEMS

Need for Energy Storage Systems for charging infrastructure - Renewable Energy Resources and ESS for Fast Charging Infrastructure - Modes of operation - Microgrids for Charging Infrastructure

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Design and select AC and DC chargers.
CO2: Understand and create awareness about power purchase and its tariff policy and its regulations.
CO3: Design a fast-charging infrastructure in a distribution network.
CO4: Understand the consequences of power quality issues and EMI/EMC in power grid.
CO5: Analyze the need for ESS in EVSE and ESS integrated to the microgrid.

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DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
LIST OF EXPERIMENTS:
1. Power flow analysis by Newton Raphson method
2. Power flow analysis by Fast decoupled method
3. Distribution Load Flow Analysis: Ladder Iterative Technique
4. Contingency analysis: Generator shift factors and line outage distribution factors
5. State Estimation by Weighted Least Square Method
6. Digital Overcurrent Relay Setting and Relay Coordination
7. Voltage stability: PV and VQ curves
8. Characteristics of Solar PV System
9. Power Quality Analysis of Sinusoidal PWM Inverter
10. Maximum Power Point Tracking for Solar PV System

TOTAL: 60 PERIODS

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Analyze the power flow using Newton-Raphson method, Fast decoupled method and Ladder Iterative Technique.
CO2: Perform contingency analysis and state estimation
CO3: Select and coordinate over current relay
CO4: Acquire knowledge in steady state voltage stability.
CO5: Analyze the characteristics of PV system, Wind Energy Conversion System and hybrid power system.

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PW3112  ELECTRIC VEHICLE LABORATORY  L  T  P  C
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LIST OF EXPERIMENTS:
1. Study of Grid to Vehicle (G2V) charging and Vehicle to Grid (V2G) charging.
2. Study of various charging levels practiced in EV charging infrastructure.
3. Performance Analysis of Uni-directional and Bi-directional converters used in EV charging.
4. Performance Analysis of slow and fast EV chargers.
6. Performance Analysis of various Battery Technologies.
7. Implementation of Smart Battery Management System (SBMS).

TOTAL: 60 PERIODS

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: acquire knowledge about various charging levels, G2V and V2G charging.
CO2: analyze about the performance of wired and wireless charging for EV.
CO3: model and analyze different rectifier circuits using computational software and to understand their various operating modes.
CO4: analyze the various power quality issues in the distribution network due to increasing penetration of EV charging infrastructure.
CO5: design and analyze the solar powered EVSE and determination of efficiency for e-bicycle.
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PW3201 ENERGY MANAGEMENT AND AUDIT LT P C 3 0 0 3

UNIT I GENERAL ASPECTS OF ENERGY MANAGEMENT AND ENERGY AUDIT 9


UNIT II MATERIAL AND ENERGY BALANCE 9

Components of materials and energy balance – Basic principles - material and energy balance diagram - Energy policy and planning - roles and responsibilities of energy manager – employees training and planning- Financial Management: financial analysis technique - Simple Payback Period, Return on Investment, Net Present Value, Internal Rate of Return
UNIT III  ENERGY EFFICIENCY IN THERMAL UTILITIES


UNIT IV  ENERGY EFFICIENCY IN ELECTRICAL UTILITIES


UNIT V  BUILDING MANAGEMENT SYSTEM AND ECBC ON ELECTRICAL POWER


COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Acquire basic knowledge in the field of energy management and auditing process.
CO2: Learn the basic concepts of economic analysis and load management.
CO3: Design effective thermal utility system.
CO4: Improve the efficiency in Electrical Utilities such as Lighting System, Motor, Fans and Pumps.
CO5: Acquire the fundamental concepts in the Building Energy Management System (BEMS), ECBC Code and Guidelines for Electrical power

REFERENCES:

OBJECTIVE:

- To provide an introduction to the field of operations management and explain the concepts, strategies, tools, and techniques for managing the transformation process that can lead to competitive advantage.

UNIT I  INTRODUCTION 12

UNIT II  FACILITY DESIGN 12

UNIT III  DESIGN OF WORK SYSTEMS 12
UNIT IV  PLANNING AND INVENTORY CONTROL

UNIT V  QUALITY MANAGEMENT
Definitions of quality-The Quality revolution-Quality gurus; TQM philosophies - Quality Management tools, certification and awards- Quality Control: Acceptance Sampling- The Operating Characteristic Curve- Control Charts for Variables and Attributes; Quality Circles Lean Management – philosophy-continuous improvement -Six sigma.

TOTAL: 60 PERIODS

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

CO1: Understand the concepts of production and its design, capacity planning and make or buy decisions and apply and adapt the concepts in managing operations.

CO2: Understand and apply location models to complex plant location decisions and choose among the different types of layout by applying layout planning tools.

CO3: Understand the different approaches, analyze, design and develop the work system.

CO4: Understand, apply and evaluate the various inventory models and choose the best inventory control policy.

CO5: Understand the quality management principles, apply the quality tools and develop a quality management system.

READING LIST:
2. Journal of Operations Management – Wiley Online Library

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PW3252 OPTIMIZATION TECHNIQUES FOR ENERGY MANAGEMENT LT P C 3 0 0 3

UNIT I PROBABILITY THEORY 9
The nature of random variables: populations and samples, parameters and statistics - Probability concepts: properties of random variables, probability distribution functions.

UNIT II DEMAND ANALYSIS AND FORECASTING 9

UNIT III INTRODUCTION TO OPTIMIZATION 9
Problem formulation: decision variables, objective function, maxima and minima constraints - Analysis techniques: simulation, optimization and stochastic optimization - Multi-objective optimization - non-inferior solutions, trade off analysis, weighted and constraints method.

UNIT IV LINEAR PROGRAMMING AND APPLICATION 9
Assumptions, problems formulation and solutions, graphical methods, simplex algorithm, duality concept, sensitivity analysis -Power system planning using optimization techniques - case study.

UNIT V DYNAMIC PROGRAMMING AND APPLICATION 9
Introduction, multi stage decision problems, recursive equations, principle of optimality, discrete dynamic programming - Optimal energy resource, technology mix in micro and macro level energy planning exercises - Power generation expansion planning - case study.

TOTAL: 45 PERIODS
COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Define and use optimization techniques and concepts.
CO2: Understand the concept of optimization methods for energy system planning.
CO3: Define an optimization problem and exploring the solution by applying optimization methods and interpreting results.
CO4: Excel the selection of optimization techniques for real time problems and to analyze the solutions.
CO5: Analyze the various operating modes of different configurations in different applications.

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UNIT I   INTRODUCTION

UNIT II   MECHANICAL ENERGY STORAGE SYSTEM
Overview - Pumped Hydroelectric Storage (PHS) – Compressed-Air Energy Storage (CAES) – Various CAES – Flywheel Energy Storage (FES) – Comparison of PHS, CAES and FES

UNIT III   ELECTROCHEMICAL ENERGY STORAGE

UNIT IV   FUEL CELL

UNIT V   ALTERNATE ENERGY STORAGE TECHNOLOGIES

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Gained knowledge of various storage technologies
CO2: Understand the mechanical storage system
CO3: Do performance analysis of Various Battery Energy Storage System
CO4: Analyze the operation of fuel cell
CO5: Gain Knowledge on various types of alternate storage technologies and perform the selection based on techno-economic viewpoint.

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LIST OF EXPERIMENTS:

6. Lighting design using DIALUX to determine the lux level and efficacy for different lighting fixtures.
10. Design of grid connected Solar PV using PVsyst.
11. Performance analysis of Compressors and Blowers.

P = 60, TOTAL = 60 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Acquire knowledge in the field of the energy audit and performance analysis of EEM.
CO2: Analyze the various PQ issues and the mitigation measures in the Distribution System using PSCAD/ETAP software.
CO3: Perform cost benefit analysis for the Pumps and Fans.
CO4: Learn various waste minimization and resource conservation techniques for electrical system.
CO5: Design and Develop a grid connected SPV system using PVsyst.
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UNIT I    INTRODUCTION
Overview of Distribution System - Importance of Distribution Systems - Differences of Power Supply between Urban and Rural Areas - Distribution system Consumer Classification

UNIT II    OVERVIEW OF DISTRIBUTION SYSTEM
Factors affecting planning - Planning Techniques - Planning Models (Short Term Planning, Long Term Planning and Dynamic Planning) - Planning for the future - Load forecasting - Load characteristics and Load models

UNIT III   DISTRIBUTION SYSTEM DESIGN
Types of Sub-Transmission - Distribution Substation - Bus Schemes - Substation Location - Rating of Substation - Calculation of voltage drops with primary feeders and secondary feeders, uniformly distributed load and non-uniformly distributed load

UNIT IV    POWER QUALITY AND DISTRIBUTION SYSTEM PERFORMANCE ANALYSIS
Power Quality Problems in Distribution Systems - Power Quality Study as per IEEE and IEC Standards - Distribution Feeder Analysis – Ladder Iterative Technique, Power loss calculations and control measures - Distribution system voltage regulation: voltage control - Application of capacitors in Distribution system - Case study on TNEB distribution system

UNIT V    DISTRIBUTION AUTOMATION

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Gain knowledge about distribution system management
CO2: Understand about distribution system operation and planning
CO3: Understand the design concept of a distribution system
CO4: Acquire knowledge about Power quality issues in distribution system
CO5: Gain ability to understand the distribution system automation

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PW3002 HYBRID POWER AND ENERGY SYSTEMS LT P C
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UNIT I INTRODUCTION TO HYBRID POWER AND ENERGY SYSTEMS 9

UNIT II POWER ELECTRONIC CONVERTERS AND CONFIGURATIONS FOR HYBRID SYSTEMS 9
Introduction – Types: AC bus connected, DC bus connected – Converters: DC – DC converters, AC – DC converters, DC – AC converters, Multilevel converters, Three port converters

UNIT III STANDARDS FOR HYBRID SYSTEMS 9
IEEE 2800-2022: Inverter Based Resources (IBR), POC, POM, POI, RPA, IBR continuous rating, reactive power capability, voltage and reactive power control modes, Active power – frequency response, Low and high voltage ride through capability, Current injection during ride through, Power quality

UNIT IV HYBRID ENERGY STORAGE SYSTEMS 9

UNIT V CASE STUDIES FOR HYBRID RENEWABLE ENERGY SYSTEMS 9

TOTAL = 45 PERIODS
COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

CO1: Analyze the impacts of hybrid energy technologies on the environment and demonstrate them to harness electrical power.

CO2: Design the power converters such as AC-DC, DC-DC, and AC-AC converters for Hybrid systems.

CO3: Understand the IEEE Standard 2800-2022 and its technical requirements for IBR plant connected to associated transmission systems.

CO4: Understand the various energy storage technologies, and its types, modes of operation, energy storage system for fast charging stations.

CO5: Perform Case studies of hybrid systems, cost analysis, energy resources optimization using HOMER software.

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UNIT  I  SOLAR PV SYSTEMS OVERVIEW

UNIT  II  GRID-CONNECTED PHOTOVOLTAIC SYSTEMS

UNIT  III  STANDALONE SOLAR PV SYSTEMS
Introduction—Design Methodology for Standalone SPV systems — Need for Balance Of System (BOS) – Batteries for SPV system– Installation, Trouble Shooting and Safety

UNIT IV  ENERGY ESTIMATION

UNIT V  GRID CODE REQUIREMENTS AND STANDARDS

COURSE OUTCOMES:
Upon completion of the course, students will be able to:
CO1:  Review the perspectives of solar PV systems and its types
CO2:  Understand various types of Grid Connected Solar PV system and SPV plant grounding
CO3:  Study the various aspects of standalone solar PV systems
CO4:  Perform Energy estimation of grid connected and standalone solar PV system
CO5:  Understand Technical requirements of grid codes and standards for interconnection

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PW3003 SCADA SYSTEM AND APPLICATIONS MANAGEMENT LT P C 3 0 0 3

UNIT I INTRODUCTION TO SCADA
Overview- general features - SCADA architecture - SCADA Applications – Benefits - Remote Terminal Unit (RTU) - Human- Machine Interface Units (HMI) - Display Monitors/Data Logger Systems - Intelligent Electronic Devices (IED) - Communication Network - SCADA Server, SCADA Control systems and Control panels

UNIT II SCADA COMMUNICATION
SCADA Communication requirements - Communication protocols: Past, Present and Future - Structure of Communications Protocol - Comparison of various communication protocols - IEC 61850 based communication architecture - Communication media like Fiber optic, PLCC- Interface provisions and communication extensions -synchronization with NCC, DCC, IOT, Cyber cell -Redundancy of Network

UNIT III SCADA IN POWER SYSTEM AUTOMATION

CASE STUDIES: SCADA Design for 66/11kV and 132/66/11kV or 132/66 kV or any utility Substation and IEC 61850 based SCADA Implementation issues in utility Substations
UNIT IV  ENERGY MANAGEMENT CENTRE

Functions-Control and Load Management - Economic Dispatch - Distributed Centre’s and Power Pool Management-Energy Management System and its role

UNIT V  SCADA MONITORING AND CONTROL

Online monitoring the event and alarm system: Trends and Reports, Blocking List - Event Disturbance Recording - Control Function: Station control, Bay Control, Breaker Control and Disconnector Control

TOTAL = 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:

CO1: Learn the SCADA system components and its significance.
CO2: Understand the need and advantages of communication protocols for SCADA
CO3: Get implementation knowledge about the application of SCADA to Power System.
CO4: Get exposure to the best operating mechanism for Energy Centre based on SCADA concepts
CO5: Understand the need and importance of monitoring and control logic for SCADA based power systems.

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</table>
UNIT I  INTRODUCTION

UNIT II  NETWORK INFLUENCE OF GENERATION TYPE

UNIT III  GRID INTEGRATION OF WIND POWER

UNIT IV  GRID-CONNECTED SPV SYSTEM
Introduction- Configurations-Components of Grid-connected SPV system– Grid-connected PV System Design: Small Power Applications and Power Plants–Safety in installation of SPV system– Installation and troubleshooting of SPV power plants - International PV programs

UNIT V  GRID CODE COMPLIANCE AND GRID INTEGRATION STANDARDS

TOTAL = 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, students will be able to:
CO1: Know about the integration of various renewable energy sources into the grid.
CO2: Analyze various grid issues due to renewable energy sources.
CO3: Analyze and understand the grid-connected WPP.
CO4: Design the grid connected SPV system.
CO5: Understand about the various grid interconnection standards and grid code compliance.
REFERENCES:

7. IEC TS 63102:2021 Grid code assessment methods for grid connection of wind and PV power plants
8. CEA technical standards for connectivity to the grid
9. CEA technical standards for connectivity of the distributed generation resources
10. IEEE Std 2800-2022 IEEE standard for interconnection and interoperability of inverter-based resources (IBRS) interconnecting with associated transmission electric power systems
11. IEEE Std 1547-2018 IEEE standard for interconnection and interoperability of distributed energy resources with associated electric power systems interface.

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MAPPING OF COs WITH POs
UNIT I WASTE SOURCES AND CHARACTERIZATION


UNIT II TECHNOLOGIES FOR WASTE TO ENERGY CONVERSION


UNIT III BIOMASS GASIFIERS, PYROLYSIS AND BIOMASS HANDLING


UNIT IV WASTE TO ENERGY OPTIONS AND ENVIRONMENTAL IMPLICATIONS


UNIT V CENTRALIZED AND DECENTRALIZED WASTE TO ENERGY PLANTS


TOTAL = 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be able to:

CO1: Understand the various types of wastes from which energy can be generated and characterization of waste for energy utilization

CO2: Gain knowledge on the various technologies for waste to energy conversion

CO3: Develop knowledge on various types of biomass gasifiers and their operations, types of pyrolysis process and Biomass handling

CO4: Gain knowledge on waste to energy conversion options, environmental standards for waste to
energy plant operations and Carbon Credit Mechanism
CO5: Understand the principles of Centralized and Decentralized Waste to Energy Production plants through case studies.

REFERENCES:

### MAPPING OF COs WITH POs

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PW3055 IOT FOR SMART POWER SYSTEMS LT P C 3 0 0 3

UNIT I INTRODUCTION

UNIT II IOT ARCHITECTURE AND PROTOCOLS
IoT Architecture – Layers – Protocol: SCADA, RFID – Internet of Energy (IoE) architecture and its requirements for Power Systems - IoT communication topologies for power system application

UNIT III IOT FOR SMART GRID
Integration of Internet of Things (IoT) into Smart Grid (SG) – Smart Grid Architectures: Four layered

UNIT IV IOT BASED SMART MONITORING SYSTEMS

UNIT V IOT FOR ENERGY MANAGEMENT
Smart Energy Management – Cyber Physical Systems – Smart Electricity Management – Demand Side Management-Case Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Gain knowledge about various IoT technologies and its importance in power system
CO2: Able to analyze different IoT architectures and communication topologies for power system applications
CO3: Understand IoT for Smart Grid
CO4: Attain knowledge about various IoT based smart monitoring systems
CO5: Apply IoT for Energy Management

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PW3057 RENEWABLE ENERGY TECHNOLOGY LT P C 3 0 0 3

**UNIT I INTRODUCTION**

**UNIT II SOLAR ENERGY**

**UNIT III WIND ENERGY**

**UNIT IV BIOENERGY**
Biomass Resources - Biomass Conversion Technologies and their classification, Biogas Generation:

UNIT V OTHER TYPES OF ENERGY


TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Gain knowledge about the Renewable Energy (RE) Resource potential available in India as well as global RE scenario and need for RE Technology.
CO2: Understand the basics of Solar radiation, Solar Thermal Energy Conversion and SPV systems.
CO3: Understand the concepts of various Wind Energy Conversion System.
CO4: Gain knowledge about Bioenergy and Biomass Conversion Technologies.
CO5: Gain knowledge about energy conversion technologies for harnessing the energy from other RE resources such as Hydrogen, Fuel Cell, Geothermal, OTEC, Wave Energy and Tidal Energy.

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TOTAL: 45 PERIODS

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
UNIT I  CLIMATE AND SHELTER

UNIT II  PRINCIPLES OF ENERGY CONSCIOUS BUILDING DESIGN

UNIT III  PASSIVE SOLAR HEATING

UNIT IV  ENERGY CONSERVATION IN BUILDING

UNIT V  EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS

COURSE OUTCOMES:
Upon the successful completion of the course, students will be able to:
CO1: Understand the different climate zones and modelling methods.
CO2: Design energy conscious building.
CO3: Understand the concepts of Passive Solar Heating (PSH) and design guidelines for PSH.
CO4: Gain knowledge about the energy conservation techniques in buildings.
CO5: Know about different energy efficient technologies for electrical system.

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**PW3056 MICRO GRID OPERATION AND CONTROL**

UNIT I MICRO SOURCES AND STORAGE 9

UNIT II DC MICROGRID 9
Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Inertia Control – Secondary Control: Centralized and Decentralized Control – Simulation Studies

UNIT III AC MICROGRID 9
Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Synchronous Generator Control for VSC – Secondary Control – Simulation Studies
UNIT IV HYBRID MICROGRID

Hybrid AC/DC Microgrid Structure: AC Coupled, DC Coupled, AC-DC Coupled – Control Strategies: Different modes of operation during transition – Simulation Studies

UNIT V MICROGRID PROTECTION


TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1: Analyze micro-sources and storage systems.
CO2: Analyze the configurations and control aspects of AC microgrid.
CO3: Understand and analyze the configurations and control aspects of DC microgrid.
CO4: Acquire knowledge about configurations and control aspects of Hybrid microgrid.
CO5: Learn the protection aspects of microgrid.

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UNIT I  HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS  9
History of Evolution of Electric Vehicles (EV) - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power Train Components and Sizing, Gears, Clutches, Transmission and Brakes

UNIT II  MECHANICS OF HYBRID ELECTRIC VEHICLES  9

UNIT III  CONTROL OF DC AND AC MOTOR DRIVES  9
Speed control for Constant Torque, Constant HP operation of all Electric Motors - DC/DC chopper based Four Quadrant Operation of DC Motor Drives, Inverter-based V/f Operation (motoring and braking) of Induction Motor Drives, Vector Control Operation of Induction Motor and PMSM, Brushless DC Motor Drives, Switched Reluctance Motor (SRM) Drives

UNIT IV  ENERGY STORAGE SYSTEMS  9
Battery: Principle of operation, Types, Estimation Of Parameters, Battery Modeling, SOC of Battery, Traction Batteries and their capacity for Standard Drive Cycles, Vehicle to Grid operation of EV's - Alternate sources: Fuel cells, Ultra capacitors, Fly wheels

UNIT V  HYBRID VEHICLE CONTROL STRATEGY AND ENERGY MANAGEMENT  9
HEV Supervisory Control - Selection of modes - Power Split Mode - Parallel Mode - Engine Brake Mode - Regeneration Mode - Series Parallel Mode - Energy Management of HEV's

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, students will be able to:
CO1: Learn the electric vehicle architecture and power train components.
CO2: Acquire the concepts of dynamics of Electrical Vehicles.
CO3: Understand the vehicle control for Standard Drive Cycles of Hybrid Electrical Vehicles (HEVs).
CO4: Ability to model and understand the Energy Storage Systems for EV.
CO5: Acquire the knowledge of different modes and Energy Management in HEVs.

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ET3055 EMBEDDED NETWORKING AND AUTOMATION OF ELECTRICAL SYSTEM 3 0 0 3

UNIT I BUILDING SYSTEM AUTOMATION 9

UNIT II EMBEDDED NETWORKING OF INSTRUMENT CLUSTER 9

UNIT III AUTOMATION OF SUBSTATION 9

UNIT IV METERING OF SMART GRID 9
Characteristics of Smart Grid - Generation by Renewable Energy Sources based on solar grid - Challenges in Smart Grid and Microgrids - electrical measurements with AMI - Smart meters for EV plug in electric vehicles power management - Home Area Net metering and Demand side Energy Management applications.

UNIT V SMART METERS FOR PQ MONITORING 9
Power Quality issues of Grid connected Renewable Energy Sources - Smart meters for Power Quality monitoring and Control - Power Quality issues - Surges - Flicker - Interharmonics - Transients - Power Quality Benchmarking - Power Quality Meters- Meter data management In Smart Grid-, communication enabled Power Quality metering.

45
COURSE OUTCOMES:
At the end of this course, the students will have the ability to
CO1: Demonstrate criteria of choice of sensors, components to build meters.
CO2: Illustrate the demand for BUS communication protocols are introduced
CO3: Analyse the need and standards in Substation automation
CO4: Deployment of PAN for metering networked commercial applications
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded networked communications.

REFERENCES:
1. Control and automation of electrical power distribution systems, James Northcote-Green, Robert Wilson, CRC, Taylor and Francis, 2006

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UNIT I   INTRODUCTION TO UAV
Overview and background - History of UAV - classification - societal impact and future outlook
Unmanned Aerial System (UAS) components - models and prototypes - System Composition - Applications

UNIT II   THE DESIGN OF UAV SYSTEMS

UNIT III   HARDWARES FOR UAVs
Real time Embedded processors for UAVs - sensors - servos - accelerometer - gyros - actuators - power supply - integration, installation, configuration, and testing - MEMS/NEMS sensors and actuators for UAVs - Autopilot - AGL.

UNIT IV   COMMUNICATION PAYLOADS AND CONTROLS
Payloads - Telemetry - tracking - Aerial photography - controls - PID feedback - radio control frequency range - modems - memory system - simulation - ground test - analysis - trouble shooting.

UNIT V   THE DEVELOPMENT OF UAV SYSTEMS

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, the students will have the ability to
CO1: Identify different hardware for UAV.
CO2: Determine preliminary design requirements for an unmanned aerial vehicle.
CO3: Design UAV system.
CO4: Identify and integrate various systems of unmanned aerial vehicle.
CO5: Design micro aerial vehicle systems by considering practical limitations.

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UNIT I EMBEDDED SYSTEM AND ELECTRIC VEHICLES ARCHITECTURE

UNIT II POWERTRAIN CONTROL AND ENERGY MANAGEMENT SYSTEM IN EV
Powertrain Components - Powertrain control and Optimization - Embedded Controllers for motor control- ECU for Energy Management system - Battery Management System (BMS) - Battery State of Charge (SoC) Estimation - Energy Consumption Monitoring - Charging Optimization- ECU for Charging.

UNIT III COMMUNICATION AND CONNECTIVITY IN EV
Vehicle-to-Vehicle Technology(V2V) - Vehicle-to-Infrastructure(V2I) Technology Communication - Communication Protocol (CAN, LIN, Ethernet, etc.) - Wireless Charging and Communication for EV - Over the air (OTA) Updates and Remote diagnostics in EV.

UNIT IV FAULT MONITORING AND DIAGNOSTICS IN EV
Overview of Fault Monitoring and Diagnostics in EV - Fault detection techniques - Fault Monitoring in Electric Powertrain - Fault Monitoring in Charging Infrastructure - On-board Diagnostics (OBD) with self-check mechanisms - Diagnostics and Reporting - Case studies on fault detection, Diagnosis and Resolution

UNIT V SAFETY, SECURITY AND AUTONOMOUS SYSTEMS IN EV
Safety Standards and Regulations for EVs - Functional Safety and ISO26262 in EV -Cybersecurity in EVs - Threats and Countermeasures - Antilock Braking system(ABS) -Electronic Stability Control (ESC) - Advanced driver Assistance systems (ADAS) -Autonomous Driving in EVs.
COURSE OUTCOMES:
At the end of this course, the students will have the ability to

CO1: Able to understand the principles and components of electric vehicles, including powertrain systems, energy storage systems, motor controllers, and vehicle dynamics.
CO2: Able to learn about the unique requirements and challenges associated with embedded controllers in EV applications.
CO3: Able to learn about hardware platforms, such as microcontrollers and microprocessors, as well as communication protocols and interfaces used for control and monitoring of EV.
CO4: Able to gain hands-on experience in developing embedded control algorithms for various EV systems, including motor control, battery management, regenerative braking, and charging systems.
CO5: able to understand the integration of embedded controllers in autonomous electric vehicles

REFERENCES:
1. "Embedded Control Systems for Electric Machines" by Jiming Wang, Shan Chai, and Shuxin Zhou (Published in 2011)
2. "Electric and Hybrid Vehicles: Design Fundamentals" by Iqbal Husain (Published in 2013)
3. "Electric and Hybrid Vehicles: Power Sources, Models, Sustainability, Infrastructure, and the Market" by Gérard-André Capolino (Published in 2010)
4. "Embedded Systems for Electric Vehicles" by Jürgen Valldorf and Wolfgang Gessner (Published in 2011)
5. "Power Electronics and Electric Drives for Traction Applications" by Gonzalo Abad, J. Miguel Guerrero, and Juan de la Casa (Published in 2016)

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UNIT I       INTELLIGENT SYSTEMS AND PYTHON PROGRAMMING  9
Introduction to Machine Learning and Deep Learning - Performance Improvement with Machine Learning - Building Intelligent Systems - Introduction to Python - Python Programming

UNIT II       PYTHON FOR ML  9
Python Application of Linear Regression and Polynomial Regression using SciPy - Interpolation, Overfitting and Underfitting concepts & examples using SciPy - Clustering and Classification using Python.

UNIT III      EMERGING TRENDS IN HARDWARE ARCHITECTURES FOR DEEP LEARNING  9
Quantization and Precision Reduction Techniques - Hardware aware neural Architecture. Hardware-software co-design for deep learning systems Memory hierarchy and cache optimization for deep learning Parallelization and distributed training of deep learning models Energy-efficient deep learning hardware architectures Hardware acceleration for specific deep learning applications (e.g., natural language processing, computer vision)

UNIT IV       PYTHON FOR DL  9
Python Applications for DL - Python for CNN and YOLO

UNIT V       CASE STUDIES  9
Development of Intelligent System for Power system protection - Smart Energy - IOE- Motor control - BMS - Intelligent systems for Industry 4.0 and Industry 5.0

COURSE OUTCOMES:
At the end of this course, the students will have the ability in
CO1: Able to gain proficiency in the Python programming language and learn how to apply it in the context of intelligent systems
CO2: Able to learn Python libraries such as NumPy, Pandas, and scikit-learn to preprocess data, build and train Machine Learning models, and evaluate their performance
CO3: Able to learn Deep Learning libraries such as TensorFlow or PyTorch to build, train, and evaluate Deep Learning models for tasks such as image classification, natural language processing, and computer vision.
CO4: Able to learn hardware components, such as processors, memory, and accelerators, and how they are integrated.
CO5: Able to learn intelligent systems implementations, examine their design choices, evaluate their performance, and understand the challenges.

TOTAL: 45 PERIODS
REFERENCES:
1. "Intelligent Systems: Principles, Paradigms, and Pragmatics" by Rajendra P. Srivastava (Published in 2013)
2. "Intelligent Systems: A Modern Approach" by Thomas Bäck, David B. Fogel, and Zbigniew Michalewicz (Published in 2000)
3. "Intelligent Systems: Modeling, Optimization, and Control" by Grzegorz Bocewicz and Konrad Jackowski (Published in 2016)
4. "Intelligent Systems: Architecture, Design, and Control" by Janos Sztipanovits and Gabor Karsai (Published in 2018)
5. "Intelligent Systems: Concepts and Applications" by Veera M. Boddu (Published in 2017)

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ET3052 BLOCKCHAIN TECHNOLOGIES

UNIT I INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN
Introduction to Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain-Hardware architecture for Blockchain.

UNIT II BITCOIN AND CRYPTOCURRENCY

UNIT III INTRODUCTION TO ETHEREUM
Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts, , Transactions, Receiving Ethers, Smart Contracts.
UNIT IV  INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING


UNIT V  BLOCKCHAIN APPLICATIONS

Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After the completion of this course, student will be able to
CO1: Understand and explore the working of Blockchain technology
CO2: Analyze the working of Smart Contracts
CO3: Understand and analyze the working of Hyperledger
CO4: Apply the learning of solidity to build de-centralized apps on Ethereum
CO5: Develop applications on Blockchain

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UNIT I  INTRODUCTION TO BIG DATA  9

UNIT II  SEARCH METHODS AND VISUALIZATION  9
Search by simulated Annealing - Stochastic, Adaptive search by Evaluation - Evaluation Strategies - Genetic Algorithm - Genetic Programming - Visualization - Classification of Visual Data Analysis Techniques - Data Types - Visualization Techniques - Interaction techniques - Specific Visual data analysis Techniques

UNIT III  MINING DATA STREAMS  9

UNIT IV  FRAMEWORKS  9
MapReduce - Hadoop, Hive, MapR - Sharding - NoSQL Databases - S3 - Hadoop Distributed File Systems - Case Study - Preventing Private Information Inference Attacks on Social Networks - Grand Challenge: Applying Regulatory Science and Big Data to Improve Medical Device Innovation

UNIT V  R LANGUAGE  9

COURSE OUTCOMES:

After the completion of this course, student will be able to:
CO1: Understand the basics of big data analytics
CO2: Ability to use Hadoop, Map Reduce Framework.
CO3: Ability to identify the areas for applying big data analytics for increasing the business outcome.
CO4: Gain knowledge on R language
CO5: Contextually integrate and correlate large amounts of information to gain faster insights.

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ET3251 AUTOMOTIVE EMBEDDED SYSTEMS LT P C 3 0 0 3

UNIT I ELECTRONIC ENGINE CONTROL SYSTEMS 9

Overview of Automotive systems, fuel economy, air-fuel ratio, emission limits and vehicle performance; Automotive microcontrollers - Electronic control Unit - Hardware & software selection and requirements for Automotive applications – open source ECU - RTOS - Concept for Engine management-Standards; Introduction to AUTOSAR and Introduction to Society SAE - Functional safety ISO 26262 - Simulation and modeling of automotive system components.

UNIT II SENSORS AND ACTUATORS FOR AUTOMOTIVES 9

Review of sensors- sensors interface to the ECU, conventional sensors and actuators, Modern sensor and actuators - LIDAR sensor- smart sensors- MEMS/NEMS sensors and actuators for automotive applications.

UNIT III VEHICLE MANAGEMENT SYSTEMS 9


UNIT IV ONBOARD DIAGNOSTICS AND TELEMATICS 9


UNIT V ELECTRIC VEHICLES 9

COURSE OUTCOMES:

At the end of this course, the students will have the ability to
CO1: Insight into the significance of the role of embedded system for automotive applications.
CO2: Illustrate the need, selection of sensors and actuators and interfacing with ECU
CO3: Develop the Embedded concepts for vehicle management and control systems.
CO4: Demonstrate the need of Electrical vehicle and able to apply the embedded system technology for various aspects of EVs
CO5: Improved Employability and entrepreneurship capacity due to knowledge up gradation on recent trends in embedded systems design and its application in automotive systems.

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TOTAL: 45 PERIODS
UNIT I  INTRODUCTION TO INTELLIGENT TRANSPORTATION SYSTEMS  9

UNIT II  TELECOMMUNICATIONS IN ITS  9
Importance of telecommunications in the ITS system, Information Management, Traffic Management Centres (TMC). Vehicle – Road side communication – Vehicle Positioning System

UNIT III  ITS FUNCTIONAL AREAS  9

UNIT IV  ITS USER NEEDS AND SERVICES  9

UNIT V  AUTOMATED HIGHWAY SYSTEMS  9
Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programs in the World – Overview of ITS implementations in developed countries, ITS in developing countries, Case studies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students should be able to:
CO1: understand the sensor technologies
CO2: understand the communication techniques
CO3: apply the various ITS methodologies
CO4: understand the user needs
CO5: define the significance of ITS under Indian conditions

REFERENCES:
1. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by KanPaul Chen, John Miles.
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CO3059                                 WIRELESS SENSOR NETWORKS     L T P C
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UNIT I        ARCHITECTURE OF WIRELESS SENSOR NETWORKS 9
Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture — Hardware components, energy consumption of sensor nodes, Network architecture — Sensor network scenarios, types of sources and sinks, single hop versus multi-hop networks, multiple sinks and sources, design principles, Development of wireless sensor networks.

UNIT II        FUNDAMENTALS OF WIRELESS COMMUNICATION AND CHANNEL CHARACTERISTICS 9
Wireless channel and communication fundamentals — frequency allocation, modulation and demodulation, wave propagation effects and noise, channels models, spread spectrum communication, packet transmission and synchronization, quality of wireless channels and measures for improvement, physical layer and transceiver design consideration in wireless sensor networks, energy usage profile, choice of modulation, power management.

UNIT III       MAC AND LINK LAYER PROTOCOLS 9
MAC protocols – fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols, Link Layer protocols — fundamentals task and requirements, error control, framing, link management

UNIT IV       METHODS OF NETWORKING COMMUNICATION, ROUTING, DESIGN 9
Gossiping and agent-based uni-cast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, mobile nodes, Data –centric and content-based networking – Data –centric routing, Data aggregation, Data-centric storage, Higher layer design issue

UNIT V        SENSOR NETWORK APPLICATIONS 9
Target detection and tracking, Habitat monitoring, Environmental disaster monitoring, Practical implementation issues, IEEE 802.15.4 low rate WPAN, Sensor Network Platforms and tools-Sensor node hardware, Node-level software platforms, node –level simulators.

TOTAL: 45 PERIODS
COURSE OUTCOMES
On completion of this course, the students will be able to
CO1: Understand challenges, architectural components, energy considerations, network scenarios, and design principles of wireless sensor networks,
CO2: Equip students with a comprehensive understanding of wireless communication fundamentals and their specific application in wireless sensor networks.
CO3: Design, analyse, and implement efficient MAC protocols for reliable communication in wireless environments.
CO4: Gain advanced knowledge in gossiping, energy-efficient communication, geographic routing, and data-centric networking.
CO5: Design and implement wireless sensor network solutions for real-world applications.

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UNIT I  INTRODUCTION TO DISTRIBUTED GENERATION
DG definition - Reasons for distributed generation-Benefits of integration - Distributed generation and the distribution system - Technical, Environmental and Economic impacts of distributed generation on the distribution system - Impact of distributed generation on the transmission system-Impact of distributed generation on central generation

UNIT II  DISTRIBUTED ENERGY RESOURCES
Combined heat and power (CHP) systems-Wind energy conversion systems (WECS)- Solar photovoltaic (PV) systems-Small-scale hydroelectric power generation-Other renewable energy sources-Storage devices-Inverter interfaces

UNIT III  DG PLANNING AND PROTECTION
Generation capacity adequacy in conventional thermal generation systems-Impact of distributed generation-Impact of distributed generation on network design-Protection of distributed generation- Protection of the generation equipment from internal Faults-Protection of the faulted distribution network from fault currents supplied by the distributed generator-Impact of distributed generation on existing distribution system protection.

UNIT IV  AC MICROGRID
Hierarchical Control: Primary, Secondary and Tertiary Control– Primary Control: Droop Control, Virtual Synchronous Generator Control for VSC – Secondary Control – Simulation Studies

UNIT V  DC MICROGRID
Hierarchical Control: Primary, Secondary and Tertiary Control – Primary Control: Droop Control, Virtual Inertia Control – Secondary Control: Centralized and Decentralized Control – Simulation Studies

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Students able to:
CO1: Understand the concepts of Distributed Generation and Microgrids.
CO2: Gain Knowledge about the various DG resources.
CO3: Familiarize with the planning and protection schemes of Distributed Generation.
CO4: Learn the concept of Microgrid and its mode of operation.
CO5: Acquire knowledge on the impacts of Microgrid.

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PS3252SMART GRID

UNIT I INTRODUCTION TO SMART GRID
Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, Functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

UNIT II SMART GRID TECHNOLOGIES (TRANSMISSION)
Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control

UNIT III SMART GRID TECHNOLOGIES (DISTRIBUTION)
DMS, Volt/VAr control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, and Plug in Hybrid Electric Vehicles (PHEV).
UNIT IV  SMART METERS AND ADVANCED METERING INFRASTRUCTURE

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

UNIT V  COMMUNICATION PROTOCOLS FOR POWER SYSTEM AUTOMATION

Introduction to Communication Protocol, Comparison of Communication media and different communication network topologies Description of Different Communication Protocol - Physical based Protocol(RS-232,RS-485) - Layered Based Protocol(IEC-61850 - Substation Automation) (C37.118 - Wide Area Monitoring and Protection),(DNP3 - Distribution Automation),MODBUS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students will be able to:
CO1: Understand on the concepts of Smart Grid and its present developments.
CO2: Analyze about different Smart Grid transmission technologies.
CO3: Analyze about different Smart Grid distribution technologies.
CO4: Acquire knowledge about different smart meters and advanced metering infrastructure.
CO5: Develop more understanding on LAN, WAN and Cloud Computing for Smart Grid applications.

REFERENCES:
4. Xi Fang, SatyajayantMisra, GuoliangXue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey”, IEEE Transaction on Smart Grid

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UNIT I INTRODUCTION
Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory- Power coefficient-Sabinin’s theory-Aerodynamics of Wind turbine

UNIT II WIND TURBINES
HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. Of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control-Schemes for maximum power extraction.

UNIT III FIXED SPEED SYSTEMS
Generating Systems- Constant speed constant frequency systems -Choice of Generators- Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

UNIT IV VARIABLE SPEED SYSTEMS
Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modelling - Variable speed variable frequency schemes.

UNIT V GRID CONNECTED SYSTEMS
Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Students will be able to:
CO1: Attain knowledge on the basic concepts of Wind energy conversion system.
CO2: Attain the knowledge of the mathematical modelling and control of the Wind turbine
CO3: Develop more understanding on the design of Fixed speed system
CO4: Study about the need of Variable speed system and its modelling.
CO5: Learn about Grid integration issues and current practices of wind interconnections with power system.

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UNIT I SINGLE PHASE AC-DC CONVERTER  
Static Characteristics of power diode and SCR, half controlled and fully controlled converters with R-L, R-L-E loads and freewheeling diodes – continuous and discontinuous modes of operation - inverter operation – Sequence control of converters – performance parameters: harmonics, ripple, distortion, power factor – effect of source impedance and overlap-reactive power and power balance in converter circuits

UNIT II THREE PHASE AC-DC CONVERTER  

UNIT III SINGLE PHASE INVERTERS  
Introduction to self-commutated switches: MOSFET and IGBT - Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – Design of UPS-VSR operation

UNIT IV THREE PHASE INVERTERS  
180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – VSR operation-Application to drive system – Current source inverters.

UNIT V MODERN INVERTERS  

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to:

CO1: Ability to acquire and apply knowledge of mathematics in power converter analysis.

CO2: Ability to model, analyze and understand power electronic systems and equipment.

CO3: Ability to formulate, design and simulate phase-controlled rectifiers for generic load and for machine loads.

CO4: Ability to formulate, design, simulate switched mode inverters for generic load and for machine loads.

CO5: Ability for device selection and calculation of performance parameters of power converters under various operating modes.
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UNIT I
INTRODUCTION

UNIT II ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM 9


UNIT III CONVENTIONAL LOAD COMPENSATION METHODS 9


UNIT IV LOAD COMPENSATION USING DSTATCOM 9


UNIT V SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM 9


TOTAL: 45 PERIODS

COURSE OUTCOMES:

Students able to:
CO1: Ability to understand consequences of Power quality issues.
CO2: Ability to conduct harmonic analysis of single phase and three phase systems supplying non-linear loads.
CO3: Ability to design passive filter for load compensation.
CO4: Ability to design active filters for load compensation.
CO5: Ability to understand the mitigation techniques using custom power devices such as distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR) & UPQC.

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**HV3052**

**ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY**

**UNIT I**

**INTRODUCTION**

Definitions of EMI/EMC - Sources of EMI - Inter systems and Intra system - Conducted and radiated interference - Characteristics - Designing for electromagnetic compatibility (EMC) - EMC regulation - typical noise path - EMI predictions and modelling, Methods of eliminating interferences and noise mitigation

**UNIT II**

**GROUNDING AND CABLING**

Cabling - types of cables, mechanism of EMI emission / coupling in cables - capacitive coupling, inductive coupling - shielding to prevent magnetic radiation - shield transfer impedance, Grounding - safety grounds - signal grounds - single point and multipoint ground systems - hybrid grounds - functional ground layout - grounding of cable shields - guard shields - isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding - Earth measurement Methods

**UNIT III**

**BALANCING, FILTERING AND SHIELDING**

Power supply decoupling - decoupling filters-amplifier filtering - high frequency filtering - EMI filters characteristics of LPF, HPF, BPF, BEF and power line filter design - Choice of capacitors, inductors, transformers and resistors, EMC design components - shielding - near and far fields shielding effectiveness - absorption and reflection loss - magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets-windows and coatings - grounding of shields

**UNIT IV**

**EMI IN ELEMENTS AND CIRCUITS**

Electromagnetic emissions, noise from relays and switches, non-linearity in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction
UNIT V  ELECTROSTATIC DISCHARGE, STANDARDS AND TESTING TECHNIQUES

Static Generation- human body model- static discharges- ESD versus EMC, ESD protection in equipment- standards - FCC requirements – EMI measurements – Open area test site measurements and precautions- Radiated and conducted interference measurements, Control requirements and testing methods

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students able to:
CO1: Ability to understand the types and sources of EMI.
CO2: Ability to understand the needs of grounding and cabling.
CO3: Ability to understand the design concept of filtering and shielding.
CO4: Ability to study the effect of EMI in elements and circuits.
CO5: Ability to know about the effects of electrostatic discharge and testing techniques.

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UNIT I  INTRODUCTION TO AIS AND GIS  9
Introduction – characteristics – comparison of Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – main features of substations, Environmental considerations, Planning and installation- GIB / GIL

UNIT II  MAJOR EQUIPMENT AND LAYOUT OF AIS AND GIS  9
Major equipment – design features – equipment specification, types of electrical stresses, mechanical aspects of substation design- substation switching schemes - single feeder circuits; single or main bus and sectionalized single bus- double main bus-main and transfer bus- main, reserve and transfer bus- breaker-and-a- half scheme-ring bus.

UNIT III  INSULATION COORDINATION OF AIS AND GIS  9

UNIT IV  GROUNDING AND SHIELDING  9
Definitions – soil resistivity measurement – ground fault currents – ground conductor – design of substation grounding system – shielding of substations – Shielding by ground wires and lightning masts.

UNIT V  FAST TRANSIENTS PHENOMENON IN AIS AND GIS  9
Introduction – origin of VFTO - Disconnector switching — propagation and mechanism of VFTO – VFTO characteristics – Effects of VFTO - Controlling methods

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Students able to:
CO1: Ability to understand the fundamental components of AIS AND GIS.
CO2: Ability to understand the layout of AIS and GIS.
CO3: Ability to understand the insulation coordination of AIS and GIS.
CO4: Ability to understand the significance of grounding and shielding.
CO5: Ability to know about the effects of very fast transients in Substation

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HV3152 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING LT P C 3 0 0 3

UNIT I INTRODUCTION
Review of basic field theory – Maxwell’s equations – Constitutive relationships and Continuity equations – Laplace’s, Poisson’s and Helmholtz’s equation – principle of energy conversion – force/torque calculation.

UNIT II BASIC SOLUTION METHODS FOR FIELD EQUATIONS
Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method

UNIT III FORMULATION OF FINITE ELEMENT METHOD (FEM)
Concept of FEM - Integral Formulation – Energy minimization – Discretization – Shape functions – Stiffness matrix –1D and 2D planar and axial symmetry problems

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UNIT IV  COMPUTATION USING FEM PACKAGES


UNIT V  ELECTROMAGNETIC FIELD MODELLING AND ANALYSIS

Three phase transmission lines, Magnetic actuators, Transformers, Insulators, Rotating machines.

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:
CO1 explain the concepts of electromagnetic field theory and energy conversion
CO2 formulate and compute Electromagnetic Field problems from Maxwell’s equations
CO3 formulate FEM problems from the fundamental concepts
CO4 compute the respective fields and circuit parameters using FEM (post processing)
CO5 check and optimize the design of electrical power equipment

TOTAL = 45 PERIODS

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UNIT I  
MATRICES  
The Cholesky decomposition - Generalized Eigen vectors, Canonical basis - QR factorization - Least squares method - Singular value decomposition

UNIT II  
CALCULUS OF VARIATIONS  
Concept of variation and its properties – Euler’s equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries - Direct methods: Ritz and Kantorovich methods

UNIT III  
ONE DIMENSIONAL RANDOM VARIABLES  
Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions – Function of a Random Variable

UNIT IV  
LINEAR PROGRAMMING  
Formulation – Graphical solution – Simplex method – Two phase method - Transportation and Assignment Models

UNIT V  
FOURIER SERIES  
Fourier Trigonometric series: Periodic function as power signals – Convergence of series – Even and odd function: cosine and sine series – Non-periodic function: Extension to other intervals - Power signals: Exponential Fourier series – Parseval’s theorem and power spectrum

TOTAL: 60 PERIODS

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

CO1: Apply the concepts of Matrix theory in Electrical Engineering problems.

CO2: Use calculus of variation techniques to solve various engineering problems.

CO3: Solve electrical engineering problems involving one-dimensional random variables.

CO4: Formulate and solve linear programming problems in electrical engineering.

CO5: To solve engineering problems using Fourier series techniques.

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### MA3159 NUMERICAL METHODS AND OPTIMIZATION TECHNIQUES

**UNIT I** ORDINARY DIFFERENTIAL EQUATIONS
Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method

**UNIT II** FINITE DIFFERENCE METHOD FOR PARTIAL DIFFERENTIAL EQUATIONS

**UNIT III** FINITE ELEMENT METHOD

**UNIT IV** LINEAR PROGRAMMING
Two variable LP model - Graphical solution - Simplex method - Special cases in the simplex method - Transportation and Assignment problem

**UNIT V** DETERMINISTIC DYNAMIC PROGRAMMING
Recursive Nature of Dynamic Programming Computations - Forward and Backward Recursion - Selected Dynamic Programming Applications

**TOTAL: 60 PERIODS**
OUTCOMES:

At the end of the course, students will be able to
CO1: Solve the simultaneous ordinary differential equations (Initial Value Problem) numerically.
CO2: Solve numerically set of Partial differential equations.
CO3: Solve the set of PDEs by finite element method.
CO4: Obtain the most optimal solution for a constrained problem.
CO5: Handle the Dynamic Programming problems using forward and backward recursion.

REFERENCES:


MAPPING OF COs WITH POs

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