Jharkhand University of Technology

Ranchi, 834010

SCHEME OF INSTRUCTION AND SYLLABUS

For B.Tech. Program in Electrical Engineering

(Effective from 2024-25)

DEPARTMENT OF ELECTRICAL ENGINEERING

Semester-Vth

1) PCC-I (Power Electronics)

L: T:P

Course Code:
Rationale:
Course Outcomes:

CO1	To equip the students with a basic understanding of modern power semiconductor devices, and various important topologies of power converter circuits for specific types of applications
CO2	To equip students with an ability to understand and analyze non-linear circuits involving power electronic converters.

Course Content:

Unit-I
Power Semiconductor Devices –power diodes, power transistors, SCRs, TRIAC, GTO, power MOSFETs, IGBTs-Principles of operation, characteristics, ratings, protection and gate drive circuits
.

Unit-2
Controlled rectifiers- single- phase and three-phase- power factor improvement - dual converters.

Unit-3
DC-DC converters- Buck, Boost, Buck-Boost- with circuit configuration and analysis.

Unit -4
DC-AC converters- single-phase/three-phase, VSI, CSI, frequency and voltage control.

Unit-5
AC-AC converters- single/three-phase controllers, phase control, PWM AC voltage controller, Principle of ON-OFF control and cyclo-converters.

References

1. Rashid, M.H, ‘Power Electronics - Circuits, Devices and Applications’, Prentice Hall Publications, 3rd Edition, 2003.
2. M.D.Singh and K.B.Kanchandhani, ‘Power Electronics’, Tata McGraw-Hill Publishing Company Limited, 2nd Edition, 2006.
3. Ned Mohan, Tore M. Undeland, William P. Robbins, ‘Power Electronics’, John Wiley & Sons Publications, 3rd Edition, 2006.
4. Vedam Subramaniam, ‘Power Electronics’, New Age International (P) Ltd Publishers, 2001.

5. Philip T. Krein, ‘Elements of Power Electronics’, Oxford University Press, 1st Edition, 2012.
6. V.R.Moorthi, ‘Power Electronics- Devices, Circuits and Industrial Applications’, Oxford University Press, 1st Edition, 2005. 7. P.S. Bimbhra, ‘Power Electronics’, Khanna Publishers, 3rd Edition, 13th Reprint, 2004

PCC-II (Electrical Machines – II)

L: T:P-

Code:
Rationale:
Course Outcomes

CO1	Construction and performance of salient and non – salient type synchronous generators
CO2	Principle of operation and performance of synchronous motor.
CO3	Construction, principle of operation and performance of induction machines.
CO4	Starting and speed control of three-phase induction motors.
CO5	Construction, principle of operation and performance of single-phase induction motors and special machines.

Course Content:

UNIT I

SYNCHRONOUS GENERATOR

Constructional details – Types of rotors –winding factors- EMF equation – Synchronous reactance – Armature reaction – Phasor diagrams of non-salient pole synchronous generator connected to infinite bus--Synchronizing and parallel operation – Synchronizing torque - Change of excitation and mechanical input- Voltage regulation – EMF, MMF, ZPF and A.S.A method – steady state power- angle characteristics– Two reaction theory –slip test -short circuit transients - Capability Curves.

UNIT II

SYNCHRONOUS MOTOR

Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power Developed-Hunting – natural frequency of oscillations – damper windings- synchronous condenser.

UNIT III

THREE PHASE INDUCTION MOTOR

Constructional details – Types of rotors –- Principle of operation – Slip –cogging and crawling- Equivalent circuit – Torque-Slip characteristics - Condition for maximum torque – Losses and efficiency – Load test - No load and blocked rotor tests - Circle diagram – Separation of losses – Double cage induction motors –Induction generators – Synchronous induction motor.

UNIT IV

STARTING AND SPEED CONTROL OF THREE PHASE INDUCTION MOTOR

Need for starting – Types of starters – DOL, Rotor resistance, Autotransformer and Star delta starters – Speed control – Voltage control, Frequency control and pole changing – Cascaded Connection-V/f control – Slip power recovery Scheme-Braking of three phase induction motor: Plugging, dynamic braking and regenerative braking.

UNIT V

SINGLE PHASE INDUCTION MOTORS AND SPECIAL MACHINES

Constructional details of single phase induction motor – Double field revolving theory and operation – Equivalent circuit – No load and blocked rotor test – Performance analysis – Starting methods of single-phase induction motors – Capacitor-start capacitor run Induction motor- Shaded pole induction motor - Linear induction motor – Repulsion motor - Hysteresis motor - AC series motor- Servo motors- Stepper motors - introduction to magnetic levitation systems.

TEXT BOOKS:

1. A.E. Fitzgerald, Charles Kingsley, Stephen. D. Umans, 'Electric Machinery', Mc Graw Hill publishing Company Ltd, 6th Education 2017.
2. Stephen J. Chapman, 'Electric Machinery Fundamentals'4th edition, McGraw Hill Education Pvt. Ltd, 4th Edition 2017.
3. D.P. Kothari and I.J. Nagrath, 'Electric Machines', McGraw Hill Publishing Company Ltd, 5th Edition 2017
4. P.S. Bhimbhra, 'Electrical Machinery', Khanna Publishers, edition 2, 2021.

REFERENCES

1. Vincent Del Toro, 'Basic Electric Machines' Pearson India Education, 2016.
2. M.N. Bandyo padhyay, Electrical Machines Theory and Practice, PHI Learning PVT LTD., New Delhi, 2011.
3. B.R.Gupta, 'Fundamental of Electric Machines' New age International Publishers,3rd Edition, Reprint 2015.
4. Murugesh Kumar, 'Electric Machines', Vikas Publishing House Pvt. Ltd, First edition 2010.
5. Alexander S. Langsdorf, 'Theory of Alternating-Current Machinery', McGraw Hill Publications, 2001.

Power Electronics Laboratory

List of Experiments

- Characteristics of SCR, IGBT, MOSFET
- Single-phase Fully Controlled SCR Converter
- Buck Converter using MOSFET
- Boost Converter using MOSFET
- Buck-Boost Converter using IGBT
- Single-phase Inverter using IGBT
- Single-phase step-down Cyclo-converter
- Speed Control of single-phase A.C Motor
- Single-phase Half Controlled SCR Converter
- Illumination Control of Lamp
- Speed Control of single-phase Capacitor Run Induction Motor

Electrical Machines – II Laboratory

List of Experiments

A demonstration of the static and rotational electrical machines (constructional details) is ought to be done in an introductory class.

- Load test on three-phase induction motor
- No-load and blocked rotor test on three-phase induction motor
- Load test on grid connected induction generator
- Load test on self-excited induction generator
- Load test on single-phase induction motor
- Regulation of three-phase alternator by E.M.F and M.M.F methods
- Load test on three-phase alternator
- Synchronization of three-phase alternator with infinite bus bar
- V and inverted V-curves of synchronous motor
- Speed Control on three-phase induction motor

Electromagnetic Field

Code:

L: T:P:

Rationale:

Course Outcomes

COI	Visualize and explain Gradient, Divergence, and Curl operations on electromagnetic vector fields and identify the electromagnetic sources and their effects.
CO2	Compute and analyse electrostatic fields, electric potential, energy density along with their applications.
CO3	Compute and analyse magneto static fields, magnetic flux density, vector potential along with their applications.
CO4	Explain different methods of emf generation and Maxwell's equations
CO5	Explain the concept of electromagnetic waves and characterizing parameters

Course content

UNIT I

ELECTROSTATICS – I 12

Sources and effects of electromagnetic fields – Coordinate Systems – Vector fields –Gradient, Divergence, Curl – theorems and applications - Coulomb's Law – Electric field intensity – Field due to discrete and continuous charges – Gauss's law and applications.

UNIT II

ELECTROSTATICS – II 12

Electric potential – Electric field and equipotential plots, Uniform and Non-Uniform field, Utilization factor – Electric field in free space, conductors, dielectrics - Dielectric polarization –Dielectric strength - Electric field in multiple dielectrics – Boundary conditions, Poisson's and Laplace's equations, Capacitance, Energy density, Applications.

UNIT III

MAGNETOSTATICS 12

Lorentz force, magnetic field intensity (H) – Biot–Savart's Law - Ampere's Circuit Law – H due to straight conductors, circular loop, infinite sheet of current, Magnetic flux density (B) – B in free space, conductor, magnetic materials – Magnetization, Magnetic field in multiple media –Boundary conditions, scalar and vector potential, Poisson's Equation, Magnetic force, Torque, Inductance, Energy density, Applications.

UNIT IV

ELECTRODYNAMIC FIELDS 12

Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Relation between field theory and circuit theory – Applications.

UNIT V

ELECTROMAGNETIC WAVES 12

Electromagnetic wave generation and equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossy and lossless dielectrics, conductors- skin depth - Poynting vector – Plane wave reflection and refraction.

TEXT BOOKS:

1. Mathew N. O. Sadiku, S.V. Kulkarni 'Principles of Electromagnetics', 6th Edition, Oxford University Press Inc. Asian edition, 2015.

2. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition, 2014.

3. Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010.

REFERENCES

1. V.V.Sarwate, 'Electromagnetic fields and waves', Second Edition, Newage Publishers, 2018.

2. J.P.Tewari, 'Engineering Electromagnetics - Theory, Problems and Applications', Second Edition, Khanna Publishers 2013.

3. Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Fifth Edition (Schaum's Outline Series), McGraw Hill, 2018.

4. S.P.Ghosh, Lipika Datta, 'Electromagnetic Field Theory', First Edition, McGraw Hill Education(India) Private Limited, 2017.

5. K A Gangadhar, 'Electromagnetic Field Theory', Khanna Publishers; Sixteenth Edition Eighth Reprint :2015

Industrial Applications of Electric Energy

Code:

L: T:P:

Rationale: This subject gives a comprehensive idea in utilization of electrical power such as drives, electric heating, electric welding and illumination, electric traction, electrolysis process

Course Outcomes

CO1	Describe in applications of different motors.
CO2	Demonstrate on electric tariff
CO3	Examine the characteristics and intensity of lightning systems for different types of lamps.
CO4	Analyse various electrolytic processes
CO5	Know the Process of different kinds of electric heating and electric welding.
CO6	Know the application of different lamps.

Course Content

Unit- I

Motor power rating and selection

General considerations in selecting motor power rating, Selection of motor capacity for continuous duty, Equivalent current, torque and power methods, Selection of capacity for short term and intermittent periodic duty. Electric Tariff Classification of costs, Formulation of Electric Tariff, Various kinds of Tariff, Economics of Generation, Load duration curve, Base load and peak load plants, Effect of Load Factor, diversity Factor and power factor on tariff.

Unit-II

Electric Heating and Welding

Advantages of electrical heating, Design of heating elements, Heating methods, Resistance Heating, Induction Heating, Dielectric Heating, Resistance furnace, Causes of failure of heating elements, Temperature control of resistance furnace, Arc furnace, Advantages of electric welding, Welding methods: Resistance welding, Electric arc welding, Atomic hydrogen welding, Modern welding techniques: Ultrasonic and Laser welding.

Unit-III

Illumination

Introduction, terminology in illumination: luminous flux, luminous intensity, lumen candela power, illumination lux, lamp efficiency, Brightness glare, Space height ratio, Polar curve, Laws of illumination, Co-efficient of utilization, Maintenance factor, Depreciation factor, Solid Angle, Types of Lamps: Arc Lamp, Incandescent lamp, Sodium vapor lamp, Mercury Vapor Lamp, Fluorescent Lamp, Neon Lamp, Types of Lighting Scheme, Flood Lightning, Street lightning, Compact Lighting Characteristics.

Unit-IV

Electrolytic Processes

Fundamental principles, Faradays law of electrolysis, Extraction and refining of metals, Electro deposition.

Textbooks

1. C.L. Wadhwa- Generation, Distribution and Utilization of Electrical Power- Wiley Eastern Ltd, New Delhi, 2006.

2. J B Gupta, S K Kataria and Sons- Utilization of Electrical Power and Electric Traction, Delhi, 2011.

Reference books

1. H. Pratab- Art & Science of Utilization of Electrical Energy - Dhanpat Rai & Co.(P) Ltd. 2013.

2. Er. R K Rajput- Utilization of Electric power - Lakshmi publications Pvt. Ltd, 1st Edition 2006.

3. L Thereja, A.K Thereja- Electrical Technology volume – III, S Chand Publisher – 2013.

IOT for Electrical Engineering

Code:

Rationale:

Course Outcomes

Introduction

Definition, Components in internet of things, Sensing and Actuation Anywhere, Anytime, Genesis of the Internet of Things, Power Sources, Internet Principles, Internet Communications: An Overview (IP, TCP, The IP Protocol Suite (TCP/IP), UDP), IP Addresses (DNS, Static IP Address Assignment, Dynamic IP Address Assignment, IPv6), MAC Addresses, TCP and UDP Ports.

IoT in the power sector

Asset Performance Management, Operational Optimization, Comprehensive Customer Services and Experiences

Advanced Embedded Development Platforms

System on Chip (SoC), ARM®, Raspberry Pi, Evolution of Pi and technical specification comparative study, GPIO Interfacing Cloud, Analytics & UI, Client Server Model, HTTP, Thingspeak, AWS, Cloud MQTT.

Home Automation

Sensor based automated technologies, PIR Sensor, GSM module, Node MCU Module, Bluetooth module, Humidity sensor.

Textooks

1. Adrian McEwen, Hakim Cassimally- "Designing the Internet of Things", Wiley publication, st Edition, November 2013.

2. Ramamurthy, A. and Jain, P- The Internet of Things in the Power Sector Opportunities in Asia and the Pacific, 2017.

Reference books:

1. Luigi Atzori, Antonio Lera, Giacomo Morabito- “The Internet of Things: A Survey”, Journal on Networks,Elsevier Publications, October, 2010.

2. Honbo Zhou- "The Internet of Things in the Cloud: A Middleware Perspective”, , CRC Press-2012.

3. Dieter Uckelmann, Mark Harrison- “Architecting the Internet of Things- Springer, 2011.

Neural Network and Fuzzy Logic

Course Code L:P:P

Rationale:

Course Outcomes

Introduction to Fuzzy sets: Fuzzy relation, Approximate reasoning, Rules; Fuzzy control design parameters: Rule base, data base; Choice of fuzzification procedure; Choice of defuzzification procedure; Nonlinear fuzzy control; Adaptive fuzzy control; Introduction to Neural Networks: Biological Neurons, Artificial Neurons – various models, Artificial Neural Networks – various structures, Learning Strategies, Applications.

Texts / References:

8. S. Haykin, Neural Networks: A Comprehensive Foundation, Prentice- Hall India, 2nd Edition, 1999.
9. J. S. R. Jang, C. T. Sun, and E. Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, 2nd Edition, Pearson Education, 2005.
10. J. A. Freeman and D. M. Skapura, Neural Networks: Algorithms, Applications, and Programming Techniques, 1st Edition, Pearson Education, 2007.

Modern Control System

Course Code:

Rationale:

Course Outcomes:

CO1	Apply modern control techniques to electrical systems
CO2	Compare and analyse the classical control system with modern control system
CO3	Develop advanced controllers to the existing system using modern control design techniques

Course content

Unit-I

Modelling of physical system in state space format- Definition of state- Basic properties of state- transition matrix - solution to vector differential equation.

Unit-II

Concept of controllability and observability - Concept of stabilizability and detectability - Kalman decomposition.

Unit -III

Pole placement design of controller - Observer design - Stability of controller design based on the observer using separation principle.

Unit-IV

Introduction to non-linear systems - Phase plane analysis - Multiple equilibrium points. Stability analysis of non-linear system using Lyapunov direct method - Instability theorem - Lasalle's invariance principle.

References

1. Chi-Tsong Chen, 'Linear System Theory and Design', Oxford University Press, 4th Edition, 2012.

2. Khalil H.K., 'Nonlinear Systems', Prentice Hall Publications, 3rd Edition, 2002

3. Stanley M. Shiners, 'Modern Control System theory and Design', John Wiley and Sons Publications, 2nd Edition, 1998.

4. Ogata K. 'Modern Control Engineering', Prentice Hall Publications, 5th Edition, 2010.

Design of Electrical Apparatus

Course Code

RATIONALE: - This course offers the preliminary instructions and techniques to design the main dimensions and other major part of the transformer and DC and AC rotating machines. The course also provides the students with an ability to understand the step-by-step procedure for the complete design of electrical machines.

COURSE OUTCOME:

CO1	Able to understand the design of main dimensions and other major part of the transformer and DC and AC rotating machines.
CO2	Capable of evaluating the procedure for the design of main dimensions and other major part of the transformer and DC and AC rotating machines.
CO3	Equipped to apply in-depth knowledge related to the design of electrical machines.

Unit-1

General concepts in the design of rotating machines-output equation-Magnetic and electric loadings-Common design features of all rotating machines-Conducting, insulating and magnetic materials used in electrical apparatus - mmf calculation for the magnetic circuit of rotating machines-Leakage reactance calculation.

Unit-II

Armature winding –output equation-Choice of specific loadings-Choice of poles-design of conductors, winding, slot, air gap, field poles and field coils, commutator and brush Predetermination of efficiency, temperature rise and open circuit characteristics from design data (qualitative treatment only).

Unit-III

Output equation-Design of core and coils for single phase and three phase transformers Design of tank and cooling tubes-Predetermination of circuit parameters, magnetising current, losses, efficiency, temperature rise and regulation from design data (qualitative treatment only).

Unit-IV

Output equation-Choice of specific loadings-Design of stator-Design of squirrel cage and slip ring rotors-Stator and rotor winding designs-Predetermination of circuit parameters, magnetising current, efficiency and temperature rise from design data (qualitative treatment only).

Unit-V

Constructional features of synchronous machines-SCR-Output equation-specific loadings Main Dimensions-Stator Design-Design of salient pole field coil.

References

1.Sawhney, A.K., ’A Course in Electrical Machines Design’, Dhanpat Rai and Sons Publications, 4th Edition, 2010.

2. Sen, S.K., ’Principles of Electrical Machine Design with Computer Programmes’, Oxford and I.B.H Publishing Co. Pvt. Ltd, 2nd Edition, 2006.

3. Rai, H.M., ’Principles of Electrical Machines Design’, Sathya Prakash Publications, 3rd Edition, 1994.

Utilization of Electrical Energy

Course Code:

Rationale: To design illumination systems, choose appropriate motors for any drive application, to debug a domestic refrigerator circuit and to design battery charging circuitry for specific applications

Course outcome:

CO1	Develop a clear idea on various illumination techniques and hence design lighting scheme for specific applications.
CO2	Identify an appropriate method of heating for any particular industrial application
CO3	Evaluate domestic wiring connection and debug any faults occurred.
CO4	Construct an electric connection for any domestic appliance like refrigerator as well as to design a battery charging circuit for a specific household application.
CO5	Realize appropriate type of electric supply system and to evaluate the performance of traction unit.

Course Content

Unit-I

Illumination – Terminology, Laws of illumination, Photometry, lighting calculations. Electric lamps – Different types of lamps, LED lighting and Energy efficient lamps. Design of lighting schemes - factory lighting - flood lighting – street lighting.

Unit-II

Refrigeration-Domestic refrigerator and water coolers - Air-Conditioning-Various types of air conditioning system and their applications, smart air conditioning units - Energy Efficient motors: Standard motor efficiency, need for more efficient motors, Motor life cycle, Direct Savings and payback analysis, efficiency evaluation factor.

Unit-III

Domestic utilization of electrical energy – House wiring. Induction based appliances, Online and OFFLINE UPS, Batteries. Power quality aspects – nonlinear and domestic loads. Earthing – domestic, industrial and sub-station

Unit-IV.

Electric Heating- Types of heating and applications, Electric furnaces - Resistance, inductance and Arc Furnaces, Electric welding and sources of welding, Electrolytic processes – electrometallurgy and electro-plating.

Unit-V

Traction system – power supply, traction drives, electric braking, tractive effort calculations and speed-time characteristics. Locomotives and train - recent trend in electric traction.

References

1. Dr. Uppal S.L. and Prof. S. Rao, 'Electrical Power Systems', Khanna Publishers, New Delhi, 15th Edition, 2014.

2. Gupta, J.B., 'Utilisation of Electrical Energy and Electric Traction', S. K. Kataria and Sons, 10th Edition, 2012.

3. Rajput R.K., ’Utilisation of Electrical Power’, Laxmi Publications, 1st Edition, 2006.

4. N. V. Suryanarayana, ‘Utilisation of Electrical Power’, New Age International Publishers, Reprinted 2005.

5. C. L. Wadhwa, ‘Generation Distribution and Utilization of Electrical Energy’, New Age International Publishers, 4th Edition, 2011.

6. H. Partab, ‘Modern Electric Traction’, Dhanpat Rai & Co., 3rd Edition, 2012.

7. Energy Efficiency in Electrical Utilities, BEE Guidebook, 2010.

Fundamentals of FACTS

Course code:

Rationale: Familiarize the students with the basic concepts, different types, scope and applications of FACTS controllers in power transmission

Course Outcome:

CO1	Understand various Power flow control issues in transmission lines, for the purpose of identifying the scope and for selection of specific FACTS controllers.
CO2	Apply the concepts in solving problems of simple power systems with FACTS controllers
CO3	Design simple FACTS controllers

Course Content

Unit-I

Fundamentals of ac power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers.

Unit-II

Principles of shunt compensation – Variable Impedance type & switching converter type-Static Synchronous Compensator (STATCOM) configuration, characteristics and control.

Unit-III

Principles of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC).

Unit-IV

Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters-power circuit configurations.

Unit-V

UPFC-Principles of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the controlled series compensators and phase shifters.

References

1. Hingorani, L. Gyugyi, ‘Concepts and Technology of Flexible AC Transmission System’, Standard Publishers Distributors, 1st Edition, 2011.

2.R.M. Mathur and R.K. Varma, ‘Thyristor-Based FACTS Controllers for ElectricalTransmission Systems’, Wiley India Pvt. Limited Publications, 1st Edition, 2011.

3. K. R. Padiyar, ‘FACTS Controllers in Power Transmission and Distribution’, New Age International Publications, 1st Edition, 2009.

4. Enrique Acha, Claudio R. Fuerte-Esquivel, Hugo Ambriz-Pérez, César AngelesCamacho, ‘FACTS: Modelling and Simulation in Power Networks’, John Wiley & Sons, 2004.

5. Enrique Acha, Vassilios Agelidis, Olimpo Anaya, T.J.E.Miller, ‘Power Electronic Control in Electrical Systems’, Newness Power Engineering Series, 2002.

6. T.J.E.Miller, ‘Reactive Power Control in Electric Systems’, Wiley Publications, 1982.

Industrial Automation

Course Code:

Rationale: Understand automation technologies and identify advantages, limitations and applications of the same. Selection of proper sensor and its working. Design of controller using different controlling methods. Develop ability to recognize, articulate and solve industrial problems using automation technologies

Course Outcome:

CO1	Understand the need of automation in real world and Industry 4.0 challenges
CO2	Analyse the need of transducer and working of different transducers and actuators
CO3	Determine the effects of different controllers and design of controllers using analogy and digital platform
CO4	Analyse the different advanced control schemes applied to different industrial processes.
CO5	Analyse the Architecture of PLC, and design different process control applications through ladder logic.
CO6	Understand DCS, SCADA hardware and software and its merits/demerits in industrial automation

Course Content:

Unit-I

Introduction to Industry 4.0 History

of industrial revolutions, Concept of IR4.0, Typical architecture of IR4.0, Design principles and major role players in IR4.0, Advantages and Challenges.

Unit-II

Sensors, Actuators and Signal conditioning

Displacement sensors, Force sensors, Ultrasonic sensors, Temperature sensors, Pressure sensors, Dc motors, Servo motors, Stepper motors, Piezo electric actuators, Pneumatic actuators etc. Estimation of errors and calibration, Filtering, Amplification, Isolation, ADC, DAC, Sensor protection circuits, Signal transmission and noise suppression,

Unit-III

Controller tuning Need

of controller, Effects P, I, D, PI, PD and PID controller, Design of controller parameters using Ziegler Nichols tuning method, Cohen coon tuning method, Implementation of Analog and Digital PID controller.

Unit-IV

Advanced control techniques Feed

forward control, Ratio control, Cascade control, Adaptive control, Duplex or split range control, Override control, Model predictive Control.

Unit-V

Programmable Logic Controller (PLC)

An overview of PLC, Introduction, definitions and history of PLC, Architecture of PLC system, input and output modules, Ladder logic, PLC Programming, Application Examples.

Unit-VI

Introduction to Distributed Control System, SCADA

DCS architecture, Functional requirements of Distributed control systems, Communication Protocol, Introduction to SCADA, SCADA system components, architecture and communication, Application examples

Textbooks

1. Krishna Kant, Computer-Based Industrial Control, 2nd edition Prentice Hall of India Ltd.

2. John R. Hackworth, Fredrick D. Hackworth Jr., Programmable Logic Controllers: Programming Methods and Applications, Pearson.

Reference books

1. Surekha Bhanot, Process Control Principles & Applications, OXFORD, 1st Edition

2. Ogata, Modern Control Engineering, 4th edition, Prentice Hall of India

3. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, McGrawHill, 2009

Special Electrical Machines

Course Code:

Rationale: To expose the students to the construction, principle of operation and performance of special electrical machines as an extension to the study of basic electrical machines

Course Outcome:

CO1	to understand the construction, principle of operation and performance of Synchronous Reluctance motors
CO2	to understand the construction, principle of operation and performance of Stepping motors
CO3	to understand the construction, principle of operation and performance of Switched Reluctance motors
CO4	to understand the construction, principle of operation and performance of permanent magnet brushless DC motors
CO5	to understand the construction, principle of operation and performance of permanent magnet brushless Synchronous motors

Course Content

Unit-I

Constructional features – Types – Axial and Radial flux motors – Operating principles Variable Reluctance and Hybrid Motors – SYNREL Motors – Voltage and Torque Equations – Phasor diagram - Characteristics.

Unit-II

Constructional features–Principle of operation–Variable reluctance motor –Hybrid motorSingle and multi-stack configurations –Torque equations – Modes of excitationsCharacteristics–Drive circuits–Microprocessor control of stepping motors – Closed loop control.

Unit-III

Constructional features–Rotary and Linear SRMs-Principle of operation–Torque production–Steady state performance prediction – Analytical method – Power Converters and their controllers– Methods of Rotor position sensing–Sensor less operation–Closed loop control of SRM- Characteristics.

Unit-IV

Permanent Magnet materials–Magnetic Characteristics –Permeance coefficient-Principle of operation–Types–Magnetic circuit analysis–EMF and torque equations –Commutation- Power controllers–Motor characteristics and control.

Unit-V

Principle of operation–Ideal PMSM – EMF and Torque equations – Armature reaction MMF–Synchronous Reactance – Sinewave motor with practical windings - Phasor diagram – Torque/speed characteristics- Power controllers- Converter Volt-ampere requirements.

References

1. T.J.E.Miller, 'Brushless Permanent Magnet and Reluctance Motor Drives', Clarendon Press, Oxford, 1993.

2. T.Kenjo, 'Stepping Motor and Their Microprocessor Controls', Clarendon Press London, 1995.

3. R.Krishnan, 'Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application', CRC Press, New York, 2001.

4. P.P.Aearnley, 'Stepping Motors – A Guide to Motor Theory and Practice', Peter Perengrinus London, 2002.

5. T.Kenjo and S.Nagamori, 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London, 1988.

Professional Elective-II

Sensor and Actuators

Course Code L.T.P

Rationale:

Course Outcome

Unit -I

Introduction Definition of sensor and transducer, classification,_characteristics. Selection criteria of transducers. Smart sensor: Block diagram, features.

Unit-II

Displacement and velocity Measurement

Linearandrotarydisplacementsensors:Potentiometer,capacitive,inductive ,Position measurement :Optica encoder, proximity sensors.

Unit-III

Velocity measurement: Tachometer types, Stroboscope, Encoder. Measurement of Force, Weight and Pressure Force and weight measuremen :Strain gauge, load cell .Pressure measurement: Manometer types, Strain gauge, diaphragm gauge, capsule, bellows, bourdon tube, piezoelectric sensor.

Unit-IV

Temperature measurement

Temperature scales, Mechanical thermometers: Filled insystems, Metallic expansion, Electrical thermometers: RTD, Thermo-couple, Semiconductor temperature sensors.

Unit-V

Level& Flow measurement

Mechanicalmethods:floatanddisplacer.Electricalmethods:Resistance,inductive, capacitance type.Ultrasonic level gauging. Basic principles of flow measurement. Differential pressure devices: orifice, venturi, flow nozzle, pitot tube, annubar.

Unit-V

Actuators

Definition, types and selection of Actuators; linear; rotary; Logical and Continuous Actuators, Pneumatic actuator- Electro-Pneumatic actuator; cylinder, rotary actuators, Mechanical actuating system: Hydraulic actuator - Control valves; Construction, Characteristics and Types, Selection criteria.

Unit-VI

Electrical actuating systems

Solid-state switches, Solenoids, Electric Motors- Principle of operation and its application: D.C motors - AC motors - Single phase & 3 Phase Induction Motor; Synchronous Motor; Stepper motors - Piezoelectric Actuator.

Unit-VII

Micro Sensors

Principles and examples, Force and pressure micro sensors, position and speed micro sensors, acceleration micro sensors, chemical sensors, biosensors, temperature micro sensors and flow micro sensors. Simulation and characterization of various sensors using COMSOL Multiphysics.

Unit-VIII

Micro actuators

Actuation principle, shape memory effects-one way, two way and pseudo elasticity. Types of microactuators: Electrostatic, magnetic, fluidic, inversepiezoeffect.

Textbook

1. S.K.Singh- Industrial instrumentation and control, 3rdEdition,TMH

Reference books

1. Murthy.D.V.S- Transducers and Instrumentation, ,2001,Prentice Hall of India.

2. Patranabis. D- Sensors and transducers, , 2003, PHI.

3.Sergej Fatikow and Ulrich Rembold- Microsystem Technology and Microrobotics, ,1st edition, SpringerVerlag Berlin Heidelberg.

4. Manfred Kohl- Shape memory actuators, first edition, Springer.

Power Generation and Control

Course Code: **L.T.P**

Rationale: This subject provides the basic knowledge of various types of power generating stations. Students will be able to know the know the philosophy of components of generating power stations, generation control, substations, tariff, and power factor improvement

Course Outcome:

CO1	Understand various energy sources and their applications to power stations.
CO2	Discuss the requirement and description of various components used in different power generation station
CO3	Compare various sources of power generation and evaluate their power output
CO4	Analyze the performance of the speed governing system
CO5	Elaborate on the process of testing and commissioning for different substation components
CO6	Measure power factor and tariffin electrical power system.

Course Content

Unit-I

Introduction Introduction to different sources of Energy. Discussion on application of energy sources to power station.

Unit-II

Thermal Power Plant Layout of thermal power plant, Main Equipment, Coal Handling plant, Boiler, Super heater, Reheater, Economizer, Air Preheater steam turbine, condenser, Ash handling plant, Cooling tower and ponds, Feed water heater, E.S.P, Power supply to auxiliaries. Governor, specific speed, Plant auxiliaries. Load frequency control, Turbine speed governing system, Modelling of speed governing system, Turbine model, generator model, load model, Integrated representation of various model, Excitation System: DC exciter, AC exciter, static exciter, AVR.

Unit-III

Hydro Power Plant Classification according to (i) Water Flow (ii) Load (iii) Head, surge tank, Penstock, spillway, Tail Race, Types of turbines (i) Pelton turbine, (ii) Franci's turbine, (iii) Kaplan turbine, Governor, specific speed, Plant auxiliaries.

Unit-IV

Nuclear Power Plant

Location, Layout of nuclear power plant, Fission, Fusion, controlled chain reaction, Classification of Nuclear reactors –Advanced Gas cooled Reactor, Pressurized Water Reactor, Boiling Water Reactor, Fast Breeder Reactor, Reactor Control & Cooling.

Unit-V

Diesel Electric Power plant and Gas Turbine Power plant Introduction, Selection of site, Layout and Main components, Application

Unit-VI

.

Electrical System Testing and commissioning of generators and power transformers.HT, EHT, and LV Substation arrangements. Station batteries and battery chargers. Tariffs-Types, power factor improvement.

Unit-VII

Textbook

1. B.R. Gupta- Generation of Electrical Energy- S.Chand Publication, 2009.

2. J.B.Gupta, S.K.Kataria- A course in power system- Sons Publication,2013.

Reference books

1.B.G.A. Skrotzki and W.A. Vopat, Power Station Engineering and Economy, McGraw Hill, Digitized on Dec 2007.

2. Sudipta De- Nag's Power Plant Engineering, 5th Edition- McGraWHill, 2021

Renewable Energy Resource

Course Code: **L.T.P**

Rational: To facilitate the students to achieve a clear conceptual understanding of technical aspects of Renewable Sources of Energy

Course Outcome:

CO1	Understand the need of renewable energy sources for future requirements globally.
CO2	Demonstrate on various solar thermal system applications
CO3	Apply the concept of solar PV for maximizing the energy efficiency
CO4	Describe the process of extraction of power from wind energy and biomass energy.
CO5	Analyze the scope of Geothermal and Ocean energy.
CO6	Reflect the concept of principle of operation of fuel cell and its applications

Course Content

Unit-I

Fundamentals of Energy Energy Consumption and standard of living, Classification of Energy Resources, Importance of NonConventional Energy Sources, Common Forms of Energy, Advantages and Disadvantages of Conventional energy Sources, Environmental aspects of energy, Environment–economy-energy and sustainable development, Energy densities of fuels, Energy scenario in world and India.

Unit-II

Basics of Solar Energy Extraterrestrial and Terrestrial Radiations, Depletion of Solar Radiation, Solar Time, Solar Radiations Measurement.

Unit-III

Solar Thermal Systems Solar Collectors: Classification, Performance indices, Working of Flat plate collector and Evacuated Tube collector, various other types of Collectors, Solar Passive Space – Heating and Cooling Systems, Solar thermal energy applications in Water Heater, Cookers, Furnaces, Green House, Dryer and Distillation.

Unit-IV

Solar Photovoltaic Systems Solar Cell Fundamentals, P-N Junction, Generation of electron hole pair, Photoconduction, Solar Cell Characteristics, Effect of variation of isolation and temperature, Energy payback period, Solar Cell Classification, Solar Cell, Module, Panel and Array Construction, Cell mismatch and Effect of shadowing. Maximizing the Solar PV Output and Load Matching, Maximum Power Point Tracker (Perturb and Observance method and Incremental conductance method).

Unit-V

Wind and Biomass energy Wind Energy: Origin of Winds, Nature of Winds, Wind Turbine Siting, Major Application of Wind Power, Power extraction from wind, Wind Turbine Types and Their Construction, Speed control strategies for wind turbine, Power versus wind speed Characteristics, Wind Energy Conversion Systems (WECS), Environmental aspects of wind energy, Wind energy programme in India.

Unit-VI

Biomass Energy: Usable Forms of Biomass, their Composition and Fuel Properties, Biomass Resources, Energy Farming, Biomass Conversion Technologies, Urban Waste to Energy Conversion, Biomass Gasification, Biomass Liquefaction, Biomass to Ethanol Production.

Unit-VII

Geothermal Energy Applications, Origin, and Distribution of Geothermal Energy, Types of Geothermal Resources, Environmental aspects of Geothermal energy, Geothermal Energy in India

Unit-VIII

Ocean Energy

Ocean Thermal Electric Conversion (OTEC) systems like open cycle, closed cycle, Environmental impact, Tidal Energy: Energy from tides, Tidal energy conversion scheme: single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy.

Unit-IX

Wave energy

Power from wave, wave energy conversion devices, advantages and disadvantages of wave energy, Environmental impact

Unit-X

Fuel cells Principle of working of various types of fuel cells and their working, performance and limitations, MHD (Magneto hydro dynamics) generation principles, advantages and disadvantages.

Textbook

1. B. H. Khan, "Non – Conventional Energy Resources" Tata Mc Graw Hill, 2nd edition 2009.

2. N. K. Bansal, Manfred Kleemann, Michael Meliss, "Renewable energy sources and conversion technology", Tata Mc Graw Hill, 1990.

Reference books

1. Kothari D.P., "Renewable energy resources and emerging technologies", Prentice Hall of India Pvt. Ltd, 2006.

2. Rai G.D, "Non-Conventional Energy Sources", Khanna Publishers, 4th Edition 2000.

3. Ashok V. Desai, "Nonconventional Energy", New Age International Publishers Ltd, Reprint 2003.

Restructuring of Power System

Course Code:

Rationale:

Course Outcome

Content

Introduction to restructuring of power industry: Deregulation of power industry, unbundling of electric utilities, Issues involved in deregulation, Deregulation of various power systems –Fundamentals of Economics: Consumer behavior, Supplier behavior, Market equilibrium, Short and long run costs, Various costs of production –Market models: Market models based on Contractual arrangements, Comparison of various market models, Market Mechanism.

Power System Operation In Competitive Environment Role of the independent system operator, Operational planning activities of ISO: ISO in Pool markets, ISO in Bilateral markets, Operational planning activities of a GENCO: GENCOs in Pool and Bilateral markets, market participation issues, competitive bidding

Transmission congestion management: Definition of Congestion, reasons for transfer capability limitation, Importance of congestion management, Features of congestion management –Classification of congestion management methods –Calculation of ATC -Non – market methods –Market methods –Nodal pricing –Inter zonal and Intra zonal congestion management –Price area congestion management –Capacity alleviation method

Ancillary service management and pricing of transmission network: Introduction of ancillary services –Types of Ancillary services –Classification of Ancillary services –Load generation balancing related services –Voltage control and reactive power support devices –Black start capability service -ancillary service –Co-optimization of energy and reserve services -International comparison - Transmission pricing –Principles –Classification –Role in transmission pricing methods –Marginal transmission pricing paradigm –Composite pricing paradigm –Merits and demerits of different paradigm

Power market development in India: Institutional structure in Indian Power sector, generation, transmission and distribution utilities. SO & LDCs.PFC, REC, ERCs, traders, Power Exchanges and their roles. Availability based tariff, Open access, Industry structure and regulatory framework, market development, RE policies, RPO, Tariff policies. Policy changes, regulatory changes, Critical issues / challenges before the Indian power sector.

Essential Readings

1. Lorrin Philipson, H. Lee Willis, “Understanding Electric Utilities and De-Regulation”, CRC Press, 2nd edition, 2005.

2. Kankar Bhattacharya,Jaap E. Daadler and Math H.J. Boolen, "Operation of restructured power systems", Springer, 1st edition, 2001.

3. Loi Lei Lai : Power system Restructuring and Deregulation: Trading, Performance and Information Technology, John Wiley & Sons, Pvt. Ltd., 1 st edition, 2001.

Supplementary Readings

1. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 1st edition, 2002.

2. Mohammad Shahidehpour and Muwaffaq Alomoush, "Restructured electrical power systems: operation, trading and volatility", CRC Press; 1 st edition, 2017

Energy Audit and Accounting

Course Code: **L.T.P**

Rationale: The objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs and accounting the cost of energy.

Course Outcome:

CO1	Learn the need of energy audit.
CO2	Understand the concept of energy conservation and audit.
CO3	Apply the concept of accounting in energy audit.
CO4	Design the capacitor rating for power factor improvement.
CO5	Evaluate the energy efficiency of furnace & CHP System.
CO6	Create a report for an Economic Evaluation

Course content

Unit-I

General Aspects Indian Energy scenario, definition of energy conservation, management and audit, Energy audit-need, Types of energy audit, Energy Audit Reporting Format, Energy audit instruments, Energy Conservation schemes, Energy index, Cost Index, Representation of energy consumption. Economic and ecological implications on management & auditing systems, auditing on emission, pollution, safety and reliability.

Unit-II

Energy Utilization and Conversion System Furnace: Classification of furnace, controlled atmosphere in furnace, furnace fuels, efficiency of energy in furnace, thermal efficiency, heat losses, reducing heat losses. Combined heat and power systems: Characteristic of prime movers, heat and power requirement, economics of C.H.P. system

Unit-III

Industrial Heating: Resistance heating, Induction heating, arc Heating, dielectric and microwave atmosphere generators, radiant heating

Unit-IV

Lighting: Lamp lifetime, efficient lighting

Unit-V

Motive power and power factor improvement Cost of electrical Energy, Power factor improvement, Capacitor rating, sitting the capacitor, effect of power factor improvement. Hydraulic power system, Electrical Measurement, Temperature measurement and optimal start control.

Unit-VI

Economic Analysis Introduction, Basic Concepts, Interest Rate, Inflation Rate, Tax Rate, Cash Flows, break even charts, Compounding Factors, Single Payment, Uniform-Series Payment, Economic Evaluation Methods Net, Present Worth, Rate of Return Benefit–Cost Ratio, Payback Period, Summary of Economic Analysis Methods, LifeCycle Cost Analysis Method, General Procedure for an Economic Evaluation.Financing Options, Direct Purchasing, Leasing, Performance Contracting

Textbooks

1. W.R. Murphy and G. McKay, "Energy management", Butterworth & Co Publishers, Oxford, UK, 2001.

2. Moncefkrarti- Energy Audit of Building systems: An Engineering approach, CRC PRESS, Second Edition, 2009.

Reference books

1. Tarik Al, Shemmeri- A Workbook for Energy Management in building- Wiley-Blackwell.

2. Y. Pabbi- Energy audit: Thermal power, combined cycle, and co-generation plants, TERI, 2011.

3. WC Turner- Energy Management Handbook, Seventh Edition, (Fairmont Press Inc., 2007).

4. Bureau of Energy Efficiency (BEE) (2016); Study material for Energy managers and Auditors Examination: Paper I.

Wind and Solar Electrical Systems

Course Code: **L.T.P.**

Rationale: To familiarize the students with basics of solar and wind energy systems and various techniques for the conversion of solar and wind energy into electrical energy

Course Outcome:

CO1	Describe the solar radiation, measurements and characteristics of solar PV cell.
CO2	Develop the model of a PV system and its applications.
CO3	Describe the basic types and mechanical characteristics and model of wind turbine.
CO4	Analyze the electrical characteristics and operation of various wind-driven electrical generators.
CO5	Understand various power electronic converters used for hybrid system

Course Content

Unit-I

Basic characteristics of sunlight – solar spectrum – insolation specifics– irradiance and irradiation- pyranometer – solar energy statics- Solar PV cell – I-V characteristics –P-V characteristics– fill factor- Modeling of solar cell– maximum power point tracking.

Unit-II

PV module – blocking diode and bypass diodes– composite characteristics of PV module – PV array– PV system –PV-powered fan–PV fan with battery backup–PV-powered pumping system –PV powered lighting systems–grid- connected PV systems.

Unit-III

Wind source–wind statistics-energy in the wind –turbine power characteristics - aerodynamics – rotor types – parts of wind turbines– braking systems–tower- control and monitoring system.

Unit-IV

General characteristics of induction generators– grid-connected and self-excited–steady- state equivalent circuit-performance predetermination–PMSG–steady-state performance.

Unit-V

Power electronic converters for interfacing wind electric generators – power quality issues hybrid systems-wind-diesel systems – wind-solar systems.

References

1. S N Bhadra, S Banerjee and D Kastha, ‘Wind Electrical Systems’, Oxford University

Press, 1st Edition, 2005.

2. Chetan Singh Solanki, ‘Solar Photovoltaics: Fundamentals, Technologies and Applications’ PHI Learning Publications, 2nd Edition, 2011.

3. Roger A. Messenger and Jerry Ventre, ‘Photovoltaic Systems Engineering’, Taylor and Francis Group Publications, 2nd Edition, 2003.

4. M. Godoy Simoes and Felix A. Farret, ‘Alternative Energy Systems: Design and Analysis with Induction Generators’, CRC Press, 2nd Edition, 2008.

5. Ion Boldea, ‘The Electric Generators Handbook- Variable Speed Generators’, CRC Press, 2010.

6. Bin Wu, Yongqiang Lang, Navid Zargari, Samir Kouro, ‘Power Conversion and Control of Wind Energy Systems’, IEEE Press Series on Power Engineering, John Wiley & Sons, 2011.

7. S. Sumathi,L. Ashok Kumar,P. Surekha ,‘Solar PV and Wind Energy Conversion Systems’, Springer 2015.

Power System Economics and Control Techniques

Course Code: **L.T.P**

Rationale:

Course Outcome:

CO1	Calculate various factors such as load factor, demand factor, etc. and interpret different tariff and pricing structures.
CO2	Develop generation dispatching schemes for conventional and restructured power systems.
CO3	Apply frequency, voltage and reactive power control schemes on power system.

Course Content

Unit-I

Load curves and forecasting – load factor, demand factor, diversity factor, capacity factor, utilization factor - Types of Electrical Tariff – Economic decision making in power system planning

Unit-II

Restructuring of power system – spot and derivative markets – economics of microgrids and distributed generation

Unit-III

Economic Dispatch and Unit Commitment - General problem formulation and constraints - Offer and locational marginal pricing-based dispatch - Solution methods.

Unit-IV

Load frequency control of single area and two area systems - Tie line bias control - Automatic Voltage Regulator and its dynamics

Unit-V

Reactive power and Voltage control – General concepts of series and shunt compensation – Introduction to FACTS

References

1. Allen J. Wood, Bruce F. Wollenberg and Gerald B Sheble, 'Power Generation, Operation, and Control', John Wiley and Sons, 3rd Edition, 2014.

2. Steven Stoft, 'Power system economics', Wiley India, 2002

3. Abhijit Chakrabarti & Sunita Halder, 'Power System Analysis- Operation & Control', PHI New Delhi, 3rd Edition, 2010.

4. Daniel Kirschen and Goran Strbac, 'Fundamentals of Power System Economics', John Wiley, 2004

5. Robert H.Miller, James H.Malinowski, 'Power System Operation', Tata McGrawHill,2nd Edition, 2009.

6. Nikos Hatziargyrio, 'Microgrids – Architectures and Control', Wiley-IEEE Press, 2014

Electron Devices

Course Code: **L.T.P**

Rationale: To educate on the construction and working of common electronic devices and to prepare for application areas.

Course Outcome:

CO1	Understand the semiconductor physics of the intrinsic, p and n materials and various devices and characteristics.
CO2	Analyse simple diode circuits under DC and AC excitation
CO3	Analyse and design simple amplifier circuits using BJT in CE, CC and CB configurations.
CO4	Understand the analysis and salient features of CE, CC & CB amplifier circuits.
CO5	Understand the construction and characteristics of FET, MOSFET and UJT

Course Content

Unit-I

Semi-conductors – charge carriers, electrons and holes in intrinsic and extrinsic semi conductors –Hall effect.

Unit-II

Diodes – PN junction – current equation – Junction Capacitance – breakdown characteristics of Zener diode, Tunnel diode, Schottky diode.

Unit-III

Bipolar junction transistors – Characteristics – Analysis of CB, CE, CC amplifier configurations.

Unit-IV

Unipolar devices – FET, MOSFET, UJT and Opto-Electronic devices – theory and characteristics.

Unit-V

Rectifiers and switched mode power supplies – theory and design, filter circuits, applications.

References

1. David, A. Bell, ‘Electronic Devices and Circuits’, PHI, 5th Edition, 2008.

2. Millman and Halkias ‘Electronic Devices and Circuits’, McGraw - Hill International Student,2nd Edition, 2007.

3. Robert L. Boylestad and Louis Nashelsky, ‘Electronic Devices and Circuit Theory’, Pearson Prentice Hall, 10th Edition, 2009.

4. Thomas L. Floyd, ‘Electronic Devices’, Pearson Education Limited, 9th Edition, 2013.

5. Allen Mottershead, ‘Electronic Devices and Circuits - An Introduction’, PHI, 18th Reprint, 2010. 6. Albert Malvino and David J Bates, ‘Electronic Principles’, McGraw Hill, 7th Edition, 2007.

Economic Evaluation of Power Project

Course Code: **L.T.P**

Rationale: To assess the feasibility of power projects from business, financial, and sustainability perspectives

Course Outcome:

CO1	Do a basic cost-benefit analysis of power projects in generation, transmission, and distribution.
CO2	Study the different business models in power systems.
CO3	Study the different metering techniques
CO4	Analyze and evaluate the economics of power projects.

Course Content

Unit-I

Considerations in Project Evaluation – Project Selection and Evaluation –

Unit-II

Project Development – Pre-investment stage – Investment Stage – Operational Stage – Post Operational Phase

Unit-III

Evaluation of Power Generation Projects – Cost of Power Generation – Levelized Cost of Energy – Generation Planning – Investment Analysis– Time Value of Money – Net Present Value – Benefit/cost Ratio – Payback Period - Profit/investment Ratio – Business Economic

Unit-IV

Feasibility Study – Power Purchase Agreements

Unit-V

Investing in Transmission – The Nature of the Transmission Business – Cost-Based Transmission Expansion – Value-Based Transmission Expansion – TSO economics Distribution System Finance – Tariff and Energy Bills – Financing Distributed Generation

Unit-VI

Projects – Net Metering – Net Feed-in - Rooftop Solar PV Business models – Grid-Connected and Stand-alone PV systems - Customer Savings Analysis – Grid Parity – Utility and DSO economics

Unit-VII

Case Studies – Evaluation of Renewable and Non-Renewable Energy projects

References

1. Hisham Khatib, 'Economic Evaluation of Projects in the Electricity Supply Industry', 3rd edition, IET, 2014.

2. Marcelino Madrigal and Steven Stoft, 'Transmission Expansion for Renewable Energy Scale-Up', 2012, Washington DC, World Bank.

3. Santosh Raikar, Seabron Adamson, 'Renewable Energy Finance: Theory and Practice', Elsevier, 2019. 4. Daniel S. Kirschen, Goran Strbac, 'Fundamentals of Power System Economics, Wiley, 2018.

5. Steven Stoft, 'Power System Economics: Designing Markets for Electricity', Wiley-IEEE Press, 2002. 6. Contemporary Research Papers, Project Reports and Allied Materials

Electric Vehicle Technology

Course Code: **L.T.P**

Rationale: The main objective of this course is to understand the basics of vehicle dynamics, drivetrain control, energy storage technology and vehicle design

Course Outcome:

CO1	Analyse dynamics, performance and characteristics of electric vehicles.
CO2	Understand the concept of electric traction and drive train topologies.
CO3	Explain the energy storage and drive control techniques used for electric propulsion systems.
CO4	Design electric vehicle drives, controllers and energy storage units

Course Content

Unit-I

Introduction to vehicle dynamics – Fundamentals of vehicle propulsion and brake – Vehicle Resistance – Dynamic equation of vehicle motion – Tire-Ground Adhesion – Maximum tractive effort – Power train tractive effort – Vehicle power plant characteristics – Transmission characteristics – Vehicle Performance – Gradeability – Acceleration performance – Brake performance

Unit-II

Basic components of electric vehicles – Fundamentals of electric traction – Basic architecture of electric drive trains – Electric vehicle drive train topologies – Configuration and power flow control of series, parallel and hybrid drive trains – Power converters for electric vehicles

Unit-III

Electric vehicle storage technology – Different types of batteries for electric vehicles – Basic battery parameters – Battery modeling and equivalent circuit – Methods of electric vehicle battery charging – Alternative energy sources – Hydrogen storage systems – Reformers – Supercapacitors/Ultracapacitors - Fuel cell powered vehicles – Flywheel technology

Unit-IV

Electric propulsion drive systems – DC motor drives and control – Induction motor drives and control – Permanent magnet brushless DC motor drives and control – AC and Switch reluctance motor drives and control – Drive system efficiency

Unit-V

Design specifications – Selection of motor and sizing – Selection of power electronics components and sizing – Inverter technology – Design of battery pack and auxiliary energy storage system – Design of ancillary systems – EV recharging and refueling system design

References

1. K. T. Chau, ‘Electric vehicle machines and drives: Design, analysis and application’, first edition, John Willey and Sons Singapore pte. ltd., 2015.

2. M. Ehsani, Y. Gao and A. Emadi, ‘Modern electric, hybrid electric and fuel cell vehicles: Fundamentals, Theory and design’, second edition, CRC press, 2011.

3. J. Larminie and J. Lowry, ‘Electric vehicle technology explained’, second edition, John Willey and Son ltd., 2012.

4. I. Husain, ‘Electric and hybrid vehicles: Design fundamentals’, CRC press, 2003.

Semester VI

Microprocessors and Embedded System

Course Code: **L.T.P**

Rationale: To provide an overview of a 16-bit Microprocessor, and its interfacing to solve design-based problems. Also, toacquaint students with insight of embedded systems, design perspective and applications

Course Outcome:

CO1	Analyse the architecture of a 16-bit Microprocessor (like 8086), assess and demonstrate programming proficiency using the various addressing modes and instructions of 8086.
CO2	Design memory interfacing using memory chips with proper decoder circuits with a 16-bit processor and analyse the interrupt structure of 8086 Microprocessor
CO3	Design circuits with interfacing chips to establish communication between 8086 and I/O to solve Realtime applications.
CO4	Apply different design constraints and communication protocols for embedded systems.
CO5	Analyse 8-bit Microcontroller (like 8051), its instructions, timers & counters and serial operation, and also analyse ARM processor
CO6	Develop skill for writing assembly and/or embedded C programs for interfacing various external devices with 8051 Microcontroller

COURSE DETAILS

Unit- I

Introduction

Review of digital electronics, a basic Microprocessor based system, tristate concept, bus structure, evolution of Microprocessors, machine instructions & format, addressing modes

Unit-II

Intel 8086 Microprocessor

Unit-III

Architecture, pins, 8086 instructions, sample programs, interrupts

Unit-IV

Memory and I/O Interfacing

Memory interfacing, Programmable Peripheral Interface (PPI 8255), Programmable Interrupt Controller (8259),

USART (8251)

Unit- V

Fundamentals of Embedded Systems

Embedded processor in system, components of embedded system, brief introduction to embedded software in system, design process in embedded system, programming methods for embedded system case study, communication protocols - I2C, SPI/CAN

Unit-VI

Microcontrollers & Interfacing

Overview of MCS-51 family of Microcontrollers, memory organization, pins, addressing modes, interrupts, timers & counters, serial communication, 8051 instruction set & interfacing with ADC, LCD, DC motor

Unit-VII

Brief on RISC philosophy and ARM principles

Textbooks

1. A. K. Ray and K. M. Bhurchandi, Advanced Microprocessor and Peripherals, McGraw Hill Education, 3rd edition, 2017. ISBN-10: 978-1259006135

2. Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay, The 8051 Microcontroller and Embedded Systems, 2nd edition, Pearson. ISBN-10: 9780131194021

Reference books

1. Douglas V. Hall and S. S. S. P. Rao, Microprocessors and Interfacing, Programming & Hardware, McGraw Hill Education, 3rd Edition, 2017. ISBN-10: 9781259006159

2. Muhammad Ali Mazidi, Sarmad Naimi, Sepher Naimi and Shujen Chen, ARM Assembly Language Programming & Architecture, Microdigitaled.com, 2nd edition, 2017. ISBN10: 9780997925906

3. Deshmukh, Microcontroller Theory & Applications, McGraw Hill Education, 2017. ISBN-10: 9780070585959.

4. Raj Kamal, Embedded Systems: Architecture, Programming & Design, McGraw Hill Education, 3rd Edition, 2017. ISBN: 9789332901490

Microprocessors and Embedded System LAB

After successfully completing the course, students will be able to

CO 1: Develop assembly language programming skills on 8086 Microprocessor.

CO 2: Develop assembly language programming skills on 8051 Microcontroller.

CO 3: Utilize software development tools to interface circuits and execute programs on 8086 Microprocessor.

CO 4: Design practical circuits to interface I/O devices with 8051 Microcontroller.

CO 5: Analyze the architectural features, develop programs using instructions of ARM and C language for different applications.

CO 6: Design and solve real life engineering problems using embedded systems.

Industrial Drives & Control lab

IOT Laboratory

Topics:

- Familiarisation of ESP32/Raspberry Pi and perform necessary software installation.
- To interface analog voltage input to ESP32/Raspberry Pi.
- To interface DHT11/DHT22, pressure, voltage and current sensor date input to ESP32/Raspberry Pi.
- To interface motor using relay with ESP32/Raspberry Pi.
- To interface OLED with ESP32/Raspberry Pi and write a program to print temperature and humidity.
- Write a program on ESP32/Raspberry Pi to retrieve tempurature and humidity data from
- DHT11/DHT22 to Thingspeak Cloud.
- Write a program to generate Thingspeak SNS alert service.
- Write a program on ESP32/Raspberry Pi to publish DHT11 data through MQTT protocol.
- To install MySQL data on ESP32/Raspberry Pi and perform SQL queries.
- Write a program to create TCP server on ESP32/Raspberry Pi and transfer data from TCP client.

Text Books:

1.Designing the Internet of Things, Adrian McEwen, Hakim Cassimally, Wiley publication, 1st

Edition, November 2013.

2.The Internet of Things in the Power Sector Opportunities in Asia and the Pacific, Ramamurthy,

A. and Jain, P, 2017.

Reference Books:

1.The Internet of Things: A Survey, Journal on Networks, Luigi Atzori, Antonio Lera, Giacomo

Morabito, Elsevier Publications, October, 2010.

2.The Internet of Things in the Cloud:A Middleware Perspective, Honbo Zhou, CRC Press-2012.

3.Architecting the Internet of Things, Dieter Uckelmann, Mark Harrison, Springer, 2011

Basket of Professional Elective- III

Special Machines and its control

Course Code **L.T.P**

Rationale: To understand the working of special machines like stepper motor, switched reluctance motor, BLDC motor &PMSM and Linear induction motor with proper design of controller for smart inverter used to control the above special machine

Course Outcome:

CO1	Understand the operation of different special machines.
CO2	Select different special machines as part of control system components
CO3	Analysis of Linear induction motor and its control.
CO4	Design digital controllers for different machines
CO5	Apply the knowledge of axial and radial flux motor into a way of thinking to solve in real time applications
CO6	Design Smart Inverters and Sizing for Grid Connection and Off Grid

Course Content

Unit-I

Stepper Motors

Introduction, Hybrid stepping motor, Construction, Principles of operation, Energization with two phase at a time, essential conditions for the satisfactory operation of a 2-phase hybrid steper motor, very slow speed synchronous motor for servo control-different configurations for switching the phase windings-control circuits for stepping motors, an open-loop controller for a 2-phase stepping motor.

Unit-II

Linear Induction Motor

Development of a double-sided LIM from rotary type IM- A schematic of LIM drive for electric traction development of one-sided LIM with back iron-field analysis of a DSLIM fundamental assumptions

Unit. -III

Synchronous Motors

Construction- Principle of operation of Permanent Magnet Synchronous Motors – EMF and torque equations – Starting – Rotor configurations –Dynamic model, Synchronous Reluctance Motors: Constructional featuresaxial and radial flux motors – operating principle – characteristics.

Unit -IV

Control of PMSM, BLDC and Switched Reluctance Motor

Bipolar optical sensor based control of Trapezoidal BLDC Motor, Sensorless control of BLDC motor, Torque ripple control of BLDC motor, Unipolar control for SRM, Torque ripple control of SRM.

Unit -V

Smart Inverters

Selection of power conditioning unit (PCU), Sizing of solar inverter for roof top and grid connected projects, Passive and active protection, IEC/IEEE /Grid Compliance of inverters, Grid-Connected Inverters vs. Stand Alone Inverters.

Textbooks

1. Miller, T. J. E., Brushless Permanent Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989.
2. Kenjo, T., and Sugawara, A., Stepping Motors and their Microprocessor Controls, Oxford Science Publications, 1984.

Reference books

1. Krishnan, R., Electric Motor Drives: Modeling, Analysis, and Control. Prentice Hall, (2001). 2
2.Krishnan, R., “Permanent Magnet and BLDC Motor Drives”, CRC Press,
3. Chang-liang, X., "Permanent Magnet

Electric Drives and Control

Course Code:

L.T.P.

Rationale:

Course Outcome:

Introduction

Course Content:

Unit-I

Basic elements of an electric drive, Four quadrant operation of an electric drive, Dynamics of motor load combination, Types of loads, Stable operating condition of various motor load combinations, Fundamental load torque equation, Speed and current limit control, Load curve, load equalization, motor selection and rating calculations.

Unit-II

DC Motor Drives

Review of characteristics of DC motors, Modification of characteristics of DC shunt and series motors, Concept of Electric Braking, Regenerative, Dynamic and Counter current braking of DC motors.

Unit-III

Control of DC motor drives

Open loop speed control, Closed loop Speed control, Closed loop speed and current control, Closed loop Torque control, Hysteresis controller, PI controller.

Unit- IV

Solid State Control of DC drive

Chopper and rectifier-based DC Separately excited motor and series motor drive control, four quadrant drive using dual converter.

Unit- V

Induction Motor Drives

Review of characteristics of three phase Induction motors, Modification of speed torque characteristics due to variation of stator voltage, Stator frequency and rotor resistance, Electric Braking of Induction Motors: Regenerative Braking, DC Dynamic braking and Plugging, Slip Power recovery.

Unit-VI

Speed Control of Induction Motors

Control of IM by three phase AC-AC Voltage controller, PWM Voltage Source Inverter fed induction motor drives, Current source inverter fed induction motor drives, Comparison of VSI and CSI fed drives, slip compensation schemes, closed loop control (V/f control).

Unit- VII

Synchronous and Brushless DC Motor Drives

Synchronous motors, cylindrical rotor, salient pole synchronous motor, permanent magnet synchronous motor, synchronous reluctance motor, Transients due to load disturbances, Braking, Permanent magnet AC motor drives, Sinusoidal PMAC motor drives, Brushless DC motor Drives.

Textbooks

1. G.K. Dubey, Fundamentals of Electric Drives, Second Edition, Narosa Publishers, 2007.

2. S. K. Pillai, A First Course On Electrical Drives, New Age International Publishers, 2nd Edition, 2007.

Reference books

1. Bimal K. Bose, Power Electronics and Motor Drives: Advances and Trends, Academic Press, Har/Cdr edition (13 September 2006).

2. N. K. De, P. K. Sen: Electric Drives, PHI Learning Pvt. Ltd., 7th Edition, 2004.

3. Bimal. K. Bose, Modern Power Electronics and AC Drives, PHI Publisher, 1st Edition, 2013.

4. S.A. Nasar, Boldea , Electrical Drives, CRC Press, Second Edition, 2006

5. M. A. El-Sharkawi , Fundamentals of Electrical Drives , Thomson Learning, 1st Edition, 2000.

Distribution System Planning and Automation

Course Code: **L.T.P.**

Rationale: This course gives the complete knowledge of electrical distribution systems, the design of feeders, substations It also gives conceptual knowledge on how to determine the performance of a distribution system through its important parameters i.e. voltage drops and power losses and the very important thing that protection of the system by means of protective devices and their co-ordination during the several fault conditions. it also specifies how to improve the voltage profiles and

Course Outcome:

CO1	Know the concept of distribution planning.
CO2	Understand load forecasting techniques
CO3	Identify appropriate substation location
CO4	Evaluate a distribution system for a given geographical service area
CO5	Determine the location and optimum size of capacitor for distribution system.

Unit-

Planning and forecasting techniques

Methods of load forecasting: regression analysis, correlation analysis and time series analysis, Load management, tariffs and metering of energy.

Unit-

Distribution Transformers: Types – Three phase and single phase transformers – connections Dry type and self- protected type transformers – regulation and efficiency. Sub Transmission Lines,

Unit-I

Distribution Sub–Stations: Distribution substations Bus schemes –description and comparison of switching schemes, Substation location and rating

Unit-II

Primary Systems

Types of feeders – voltage levels – radial type feeders. **Unit-**

Unit-III

Voltage Drop and Power Loss Calculations

Three phase primary lines – Copper loss – Distribution feeder costs – Loss reduction and Voltage improvement in rural networks.

Unit-IV

Distribution Systems

Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location.

Unit-V

Distribution System Protection

Basic definitions – types of over current protection devices. Objective of distribution system protection.

Unit-VI

Distribution System Automation

Reforms in power sector, Methods of improvement, Reconfiguration, Reinforcement, Automation, Communication systems, Sensors, Automation systems, Basic architecture of Distribution automation system, software and open architecture, RTU and Data communication , SCADA requirement and application functions, GIS/GPS based mapping of Distribution networks, Communication protocols for Distribution systems , Integrated sub, station metering system , Revenue improvement , issues in multi–year tariff and availability based tariff.

Textbooks

1. Turan Gonen : Electric Power Distribution Engg., Mc-Graw Hill,1986.

2. A. S. Pabla : Electric Power Distribution, TMH, 2000.

Reference books

1. Shahnia, Farhad, Arefi, Ali, Ledwich, "Electric Distribution Network Planning", Singapore Pte Ltd. 8,Springer Nature

2. James Northcote-Green , Robert G. Wilson, ``Control and Automation of Electrical Power Distribution Systems", 1st Edition, September 22,2006 , Taylor and Francis Publisher.

HVDC and FACTS

Course Code: **L.T.P**

Rationale:

Course Outcome:

CO1	Know the basic of HVDC transmission systems.
CO2	Analyze converter configurations used in HVDC and list the performance metrics.
CO3	Apply the control techniques to HVDC transmission systems.
CO4	Analyze the reactive power requirement and harmonics with its elimination in HVDC system.
CO5	Realize the application of FACTS devices in power system
CO6	Analyze and design shunt and series compensation in a transmission system

Course content

Unit-I

HVDC Transmission

DC Power Transmission: Introduction, Need for power system interconnections, Types of DC links, Relative merits, Components of a HVDC system, Modern trends in DC Transmission systems

Unit-II

.

Analysis of HVDC Converters

Pulse number, Choice of converter configurations, Analysis of Graetz circuit with and without overlap, Voltage waveforms, Analysis of two and three valve conduction mode, Converter Bridge characteristics, Inverter mode of operation, voltage waveforms

Unit-III

.

Converter and HVDC Control

Principles of DC link control, Converter Control characteristics, Control hierarchy Constant current (CC) control, CIA control, CEA Control, firing angle control of valves, starting and stopping of a dc link, Power control.

Unit-IV

Reactive Power and Harmonics in HVDC

Reactive power requirements in steady state, Conventional control strategies, Alternate control strategies,

Sources of Reactive Power, Harmonics and filters, Generation of harmonics, Types of ac filters, DC filters for HVDC system

Unit-V

.

Flexible AC Transmission Systems (FACTS)

FACTS concepts and general system conditions: Power flow in AC systems, Basic types of FACTS controllers, Shunt and series controllers, Current source and Voltage source converters

Static Shunt Compensators

Objectives of shunt compensation, Methods of controllable VAR generation, Static Var Compensator, Its characteristics, TCR, TSC, FC-TCR configurations, STATCOM, basic operating principle

Static Series Compensators

Objectives of series compensator, Variable impedance type of series compensators, TCSC, TSSC and

Combined Compensators

Introduction to Unified Power Flow Controller, Basic operating principles

Textbooks

1. Prabha Kundur, Power System stability and Control, McGraw Hill, Inc

2. K.R.Padiyar, HVDC Power Transmission Systems –Technology and System Interactions, New Age International Publishers

3. Narain G.Hingorani, Laszlo Gyugyi Understanding FACTS –Concepts and Technology of Flexible AC Transmission Systems,

Reference book

1. Sang, Y.H. and John, A.T., Flexible AC Transmission Systems, IEEE Press (2006).

2. S. Rao., EHVAC and HVDC Transmission Engineering and Practice

3. J. Arrillaga, High Voltage Direct Current Transmission, Peter Pregrinu

4. R. Mohan Mathur, Rajiv K. Varma Wiley- Thyristor Based FACTS Controllers for Electrical Transmission Systems 1 st Edition, 2002

5) SOLAR ENERGY UTILIZATION

COURSE DETAILS

Solar Radiation

History of solar energy utilization - Solar radiation and modelling - Empirical equations for predicting the availability of solar radiation – Measurement of global, direct and diffuse radiation – Radiation computations on inclined surfaces – Angstrom's turbidity - Solar chart - Standard radiation scale.

Solar Radiation Measurement and Estimating

Measurement of solar radiation - Solar energy measuring instruments – Pyranometer – Pyrheliometer – Sunshine recorder - Estimation of average solar radiation - Ratio of beam and total radiation on tilted surface of that on horizontal surface.

Solar Collectors

Flat plate collector - Materials for flat plate collector and their properties - Thermal Analysis of Flat- plate Collector and Useful Heat Gained by the fluid - fin efficiency, Collector efficiency, Heat Removal Factor, Focusing collectors, Types and applications of focusing collectors

Solar Energy Applications

Introduction and principle of operation of solar cooker, Solar air heater, Solar water heater, Solar distillation, Solar pond, Solar thermal power generation, Greenhouse effect, Solar PV application

Storage of Solar Energy

Types of Energy Storage, Thermal Storage, Electrical Storage, Chemical Storage, hydro-storage

Textbooks

1. Rai, G.D., Solar Energy Utilization, Khanna Publishers, N. Delhi, 2010.

2. Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co.,3rd Edition, 2008

Reference books

1. Jean Smith Jensen, Applied solar energy research: a directory of world activities and bibliography of significant literature, Volume2, Association for Applied Solar Energy, Stanford Research Institute, 2009.

2. Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, NewYork, 2006. Jui Sheng Hsieh, Solar Energy Engineering, Prentice- Hall, 2007.

Sustainable Energy and Applications

Battery Management Systems

Course Code: **L.P.T**

Rationale:

- To understand the basic operation and parameters associated with a battery.
- To know the functions of Battery Management System.
- To differentiate different types of Battery Management System.
- To analyze the battery performance and fault.
- To understand the protection mechanisms of Battery Management Systems.

Course Outcome:

CO1	Interpret the role of battery management system.
CO2	Identify the requirements of the Battery Management System.
CO3	Interpret the concept associated with the battery charging / discharging process.
CO4	Calculate the various parameters of battery and battery pack.
CO5	Design the model of the battery pack.

Course Content

Unit-I

Basic battery parameters -Cells & Batteries -Nominal voltage and capacity - C rate - State of Charge - State of Health - Energy and power – series and parallel operation - Charging and Discharging Process - Overcharge and Undercharge - Modes of Charging - Equivalent-circuit models

Unit-.II

Introduction and BMS functionality - Battery pack topology - BMS Functionality - Voltage Sensing - Temperature Sensing - Current Sensing - High-voltage contactor control - Isolation sensing - Thermal control – Protection - Communication Interface - Range estimation – State of-charge estimation - Cell Balancing - Cell total energy - cell total power.

Battery state of charge estimation - voltage-based methods to estimate of charge – Model based state estimation - Battery State of Health Estimation - Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode.

Unit-III

Types of BMS - Centralized BMS - Modular BMS - Master-Slave BMS - Distributed BMS Comparison of the different topology

Unit- IV.

Protection of BMS - Thermal management - Types of thermal management system - Thermal management impact on battery performance - Cell Balancing - Types of Cell balancing - External Communication of BMS

References

1. Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010
2. Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015.
3. Plett, Gregory L. Battery management systems, Volume II: Equivalent-circuit methods. Artech House, 2015.
4. Bergveld, H.J., Kraits, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002.
5. Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008.
6. Halil S. Hamut, Nader Javani, Ibrahim Dinçer "Thermal Management of Electric Vehicle Battery Systems" John Wiley & Sons, 29-Dec-2016.

Electric Power Quality

Course Code

Rationale:

Course Outcome:

CO1	Understand different types of power quality problems with their source of generation
CO2	nterpret results of power quality monitoring equipment and classify the power quality disturbances
CO3	Recommend viable solutions for mitigation of the power quality problems
CO4	Design active & passive filters for harmonic elimination

Course Content

Unit-I

Electric power quality phenomena: Introduction to power quality, IEEE and IEC - EMC standards, overview of power quality disturbances - voltage variations, interruptions, transients, waveform distortion and power frequency variations.

Unit- II

Power quality indices and monitoring: Power definitions and power quality indices for single phase, three-phase balanced and unbalanced systems under sinusoidal and nonsinusoidal conditions – importance and introduction to power quality monitoring.

Unit-III

Voltage variations: Definitions, sources, measurement, impact on equipment and mitigation of voltage sag, swell, interruption and voltage fluctuation.

Unit -IV

Harmonics: Harmonic sources, measurement of harmonic distortion, current and voltage limits of distortion, harmonic analysis using Fourier transform, effects of harmonic distortion and harmonic filters – passive, active and hybrid.

Unit-V

Custom Power Devices: Introduction to shunt and series compensators, DSTATCOM, Dynamic Voltage Restorer (DVR) and Unified Power Quality Conditioner (UPQC).

References

1. Dugan R. C., Mc Granaghan M. F. Surya Santoso, and Beaty H. W., ‘Electrical Power System Quality’, McGraw-Hill 2003.

2. Math H. Bollen, ‘Understanding Power Quality Problems: Voltage sags and interruptions’, IEEE Press, New York, 2000.

3. Ghosh, Arindam, and Gerard Ledwich, ‘Power quality enhancement using custom power devices’ Springer Science & Business Media, 2012.

4. Math H. Bollen, Irene Gu, ‘Signal Processing of Power Quality Disturbances’ Wiley IEEE Press, 2006.

5. J. Arrillaga, N.R. Watson, S. Chen, ‘Power System Quality Assessment’, Wiley, 2011.

Power System Reliability

Course Code: **L.T.P**

Rationale: To understand theoretical foundations of reliability analysis and to apply them on power system reliability evaluation.

Course Outcome:

CO1	Model and assess reliability of systems undergoing stochastic events
CO2	Apply probabilistic models to evaluation of power system reliability
CO3	Model variations in load demand and output of renewable energy sources

Course Content

Unit-I

Introduction to Probability and Statistics:

introduction to probability, probability density function, probability distribution function, Expectation, Variance, Covariance and Correlation and stochastic processes, Bernoulli Random Variable, Binomial Random Variable, Poisson Random Variable, Uniform Random Variable, Exponential Random Variable, Normal Random Variable, Weibull Random Variable

Unit-II

General reliability modeling and evaluation: system modeling for reliability; methods of reliability assessment: state space, cut-set and tie-set analysis, decomposition; Markov Approach

Unit-III

Reliability modeling and analysis of electric power systems: bulk power systems, distribution systems, and industrial systems. Component modeling: generator modeling, transmission line modeling, load modeling; capacity outage table; probability and frequency distributions; unit addition algorithm; load modelling algorithm. Generation adequacy assessment using discrete convolution: discrete convolution of generation and load models; generation reserve model; determination of LOLP, LOLF, EUE.

Unit-IV

Reliability of multi-node systems: methods for multi-area and composite system analysis; contingency enumeration/ranking; equivalent assistance; stochastic/ probabilistic load flow; decomposition; Monte Carlo simulation, Analysis of risk in power systems; understanding of causes and remedial measures; Modelling of variable energy resources

References

1. Chanan Singh, Panida Jirutitijaroen, Joydeep Mitra, 'Electric Power Grid Reliability Evaluation: Models and Methods', 1st edition, Wiley-IEEE Press, 2018.

2. Marko Čepin, 'Assessment of Power System Reliability: methods and Applications', 1st edition, Springer, 2011. 3.

3. G.F. Kovalev, L.M. Lebedeva, 'Reliability of Power Systems', 1st edition, Springer, 2019.

4.Wenyuan Li, 'Risk Assessment of Power Systems: Models, Methods, and Applications', 2nd edition, Wiley-IEEE Press, 2014.

5. Roy Billington, Ronald N Allan, 'Reliability Evaluation of Power Systems', 2nd edition, Springer, 1996

Electrical Machine Winding Calculations-I

Course Code: **L.T.P.**

Rationale:

Course Outcome:

An exposition of the magnetic and electric circuits of commutator-wound machines. Exercises involving: the geometrical layout of the armature windings, brush placement, interpoles, equalizing rings. Detailing of the process of commutation and of armature reaction. Calculations in respect of winding design and of estimation of machine parameters from design data.

References

1.Clayton A. E. , Hancock N. N. , "The Performance and Design of Direct Current Machines", 3rd Edition, Oxford & IBH, 1986 (Indian Reprint).

2.Taylor O. E. , "The Performance and Design of AC Commutator Motors", A. H. Wheeler & Co. , 1988 (Indian Reprint).

Basket of Professional Elective- IV

1)Inverter and SMPS

Industrial Automation

Course Code: L.T.P.

Rationale:

Course Outcome:

CO1	To educate on design of signal conditioning circuits for various applications.
CO2	To Introduce signal transmission techniques and their design
CO3	Study of components used in data acquisition systems interface techniques
CO4	To educate on the components used in distributed control systems
CO5	To introduce the communication buses used in automation industries

Course Content –

Unit-I

Process Control: Introduction, Process Control block diagram, Control System Evaluation, and Digital Control: Supervisory Control, Direct Digital Control, Networked Control Systems, and Distributed Digital Control. Smart Sensor. Definitions of the terms used to describe process control. Data Acquisition Systems: DAS Hardware, DAS Software. Data Logger.

Unit-II

Controller Principles: Process Characteristics: Process Equation, Process Load, Process Lag, Self- Regulation. Control System parameters: Error, Variable Range, Control parameter Range, Control Lag, Dead Time, Cycling, Controller Modes. Discontinuous Controller Mode: Two Position Mode, Multiposition Mode, Floating Control Mode. Continuous Control Mode: Proportional Control Mode, Integral Control Mode, Derivative Control Mode. Composite Control Modes: PI Control, PD Control, PID Control.

Unit-III

Analog Controllers: Introduction, Electronic Controllers: Error Detector, Single Controller Modes, Composite Controller Modes. Pneumatic Controllers: General features, Mode Implementation.

Unit-IV

Programmable Logic Controller: Evaluation of PLC, PLC Architecture, Basic Structure. PLC Programming: Ladder Diagram – Ladder diagram symbols, Ladder diagram circuits. PLC Communications and Networking, PLC Selection: I/O quantity and Type, Memory size and type, Programmer Units. PLC Installation, Advantages of using PLCs.

Unit-V

Distributed Control System: Introduction, Overview of Distributed Control System, DCS Software configuration, DCS Communication, DCS Supervisory Computer Tasks, DCS Integration with PLCs and Computers, Features of DCS, Advantages of DCS.

References

1. C.D. Johnson, 'Process Control Instrumentation Technology', PHI, 8th Edition, 2013.

2. S.K. Singh, 'Computer Aided Process Control', PHI, 2004.

3. Thomas E. Kissell, 'Industrial Electronics', PHI, 3rd Edition, 2003.

4. Noel M. Morris, 'Control Engg', McGraw-Hill, 4th Edition, 1992. 4.

5. Lukcas M.P., 'Distributed Control Systems', Van Nostrand Reinhold Co, Illustrated, 1986. 6.

6. Huges T, 'Programmable Controllers', ISA press, 4th Edition IIlustrated, 2005.

7.A.K. Ghosh, 'Introduction to Instrumentation & Control', PHI Learning Pvt. Ltd, 2004.

8. George C. Barney, 'Intelligent Instrumentation', Prentice Hall India.

Computer Aided Power System

Course Code: **L.T.P.**

Rationale: This course is designed to give students the required knowledge to calculate the Yabus including transformer and model the network using graph theory. It also gives the information how to compute Zubs and short circuit analysis using Zubs and the transient stability analysis of a power system

Course Outcome:

CO1	**Formulate Bus admittance matrix during load flow study**
CO2	Model power system components using graph theory.
CO3	Formulate incidence and network matrix of 3-phase networks
CO4	Calculate the Bus impedance (Zubs) using algorithm
CO5	Analyse the different fault study of 3-phase network using Zubs
CO6	Know the transient stability analysis.

Course Content

Unit-I

Load Flow Study using Computer Techniques Formation of Ybus when regulating transformer present, Network matrices, Reference frame, Network graph, Tree, branch, Basic loop and Cut sets, Basic Incidence matrices, Augmented matrices, Primitive networks, Network matrices by Singular and Non-singular transformation with Bus frame of reference, Branch frame of reference, Loop frame of reference.

Unit-II

Three Phase Networks Elements in impedance and admittance form, Balance excitation, Un-balance excitation, Transformation matrices for symmetrical components, Incidence and network matrix for 3-phase elements, Formation of Z bus, Addition of branch, Addition of link problems.

Unit-III

Representation of Three Phase Elements in Short Circuit Study Short circuit study of balanced network by Z bus, LG fault, L-L fault, 3-ph fault with and without fault impedance, Problems.

Unit-IV

Transient stability Analysis Load representation, Network performance equation, Swing equation, Machine equation, Solution techniques in transient stability study, RK 4th order method, Problems.

Textbooks

1. Glenn W. Stagg, Ahmed H. El-Abiad, Computer Methods in Power System Analysis, McGraw-Hill Book Company, International Editions, 2009.

2. L. P. Singh, Advanced Power System Analysis and Dynamics, New Age International (P) Limited, Publishers, Revised 4th Edition, 2011.

Reference books

1. N.V.Ramana, Power System Analysis, Pearson Publication,2011

2. M.A.Pai, Computer application techniques in Power System, TMH, 2006.

Wind and Biomass Energy

Course Code: **L.T.P**

Rationale: To provide a deep introduction about wind energy basics, wind energy conversion Technologies, Various types of Biomass energy sources and Biomass to energy conversion technologies.

Course Outcome:

CO1	Understand the basics of wind energy conversion and their operating characteristics
CO2	Understand the aerodynamics of wind rotor and design the wind turbine system
CO3	Understand the use of different power electronics converters and electrical machines used in standalone wind energy conversion systems.
CO4	Analyse the nature and principles of bioenergy systems.
CO5	Prioritize the concept of waste management to produce energy
CO6	Analyse the mechanism of different Biomass energy conversion technologies

Course Content:

Unit-I

Wind Energy: Basics &Types of Turbines Sources of Energy: Renewable energy sources and features. Introduction to wind energy. Wind Turbine Sitting, General theories of wind machines: Basic laws and concept of aerodynamics, efficiency limit for wind energy conversion. Description and performances of horizontal axis wind turbine: Design of the blades and determination of forces acting on the wind power plant, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems. Description and performances of vertical axis wind turbine

Unit-II

Wind Energy: Power Conversion Technologies and applications Conversion to electrical power: Induction and synchronous generators, Grid connected and Self-excited induction generator operation, Generation schemes with variable speed turbines, Constant voltage and

Constant frequency generation with power electronic control, Optimized control of induction generators and Synchronous generators. Reactive power compensation, Types of converters, Type of wind energy conversion system, MPPT techniques for wind electrical systems.

Unit-III

Biomass energy source Biomass energy sources, Energy content of various Bio – fuels, Energy plantation, Origin of Biomass photo synthesis process, Biomass Characteristics, Briquetting, Pelletization, Agrochemical, sustainability of Biomass.

Unit-IV

Biomass energy conversion technologies Biomass Conversion Technologies, Urban Waste to Energy Conversion, Biomass Gasification: Types of gasifiers. Fixed bed gasifiers, Fluidized bed gasifiers. Biomass Liquefaction: Biomass to Ethanol Production, Bio Diesel from edible

Unit-V

& non-edible oils, Production of Bio diesel from Honge & Jatropha seeds, Blending of Bio diesel, Performance analysis of diesel engines using bio diesel, Biogas production from waste Biomass, classification of Biogas digester, floating gasholder & fixed dome type.(Working Principle with diagram), Calculations for sizing the Biogas plant.

Textbooks

1. S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems, Oxford Univ. Press , 2005

2. B. H. Khan, “Non – Conventional Energy Resources” Tata Mc Graw Hill, nd edition

Reference books .

1. Kothari D.P., “Renewable energy resources and emerging technologies”, Prentice Hall of India Pvt. Ltd, 2006.

2. Rai G.D, "Non-Conventional Energy Sources", Khanna Publishers, 4th Edition 2000. 3. T. Ackermann, “Wind Power in Power Systems”, John Wiley and Sons Ltd.,

Tidal and Small Hydro Power

Course Code: **L.T.P.**

Rational: The objective of this course is to provide an understanding of the principles and technology involved in the design, operation, and maintenance of small hydro and tidal power plants

Course Outcome:

CO1	Understand the functioning of Hydro, Tidal, and Geothermal Energy systems.
CO2	Apply the knowledge in selecting the turbine according to site conditions.
CO3	Classify various Hydro power plant.
CO4	Estimate energy for various Tidal power plants.
CO5	Analyse the performance of different Tidal power plants.
CO6	Discuss the possible locations of SHP and Tidal energy around the globe

Unit-I

Basic working principle of Hydro and Tidal power plant Classification of Hydroelectric power plants: Large, small, Mini, Micro - Energy equation, Numerical problems. Tidal power, Mean extractable power, Numerical problems, Introduction to geothermal energy, Selection of Sites.

Unit-II

Hydro power Energy System Turbine Size, Types of Hydraulic turbines, Pelton Wheel, Francis Turbine, Propeller and Kaplan Turbines, Bulb Turbine, Specific Speed, Selection of turbines, Spillways, Surge Tanks, Water Hammer, Draft Tube, Schemes of Hydro Plants, Run-of-River Plants, Valley Dam Plants, High Head Diversion Plants, Pumped Storage Plants.

Unit-III

Tidal Power System Introduction to tidal energy, Tidal characteristics, Tidal range, Components of tidal Power plant, Types of tidal power plants- single basin single effect plant, Single basin double effect plant, Double basin double effect plants, and tidal energy estimation.

Unit-IV

Scope of Hydro and Tidal Power Energy System Possible locations of SHP and Tidal energy around the globe, Limitations, Some case Studies.

Textbooks

1. Nag P.K., “Power Plant Engineering” Tata McGraw Hill, nd Edition, 4th Fourth Reprint,2003.

2. R.H. Charlier, Ocean Energy: Tidal and Tidal power-, Springer, 2009.

Reference books

1. Bryan Leyland, Small hydroelectric engineering practice- CRC Press,2014.
2. 2. Harvey, A., Brown, A. and Hettiarachi, P., “Micro Hydro Design Manual”, Intermediate Technologym,1993.
3. 3. GD Rai, “Non-Conventional Energy” Khanna publication,

Electrical Machine Winding Calculations-II

Course Code: L.P.T

Rationale:

Course Outcome

An exposition of the magnetic and electric circuits of open-wound (AC) machines. Salient- and non-salient-pole windings. Exercises involving: the geometrical layout of armature windings, armature reaction, harmonics and their quantification, cage rotor, and damper windings. Estimation of machine parameters from design data.

Reference

1.Say M. G. , "The Performance and Design of Alternating Current Machines", 3rd Edition, CBS, 1983 (Indian Reprint).

2. Langsdorf A. S. , "Theory of Alternating Current Machinery", 2nd Edition, Tata McGraw-Hill, 1974.

Distribution Systems Control and Automation

Course Code: **L.P.T**

Rationale:

Course Outcome

Distribution systems, their importance in energy transfer, distribution loss minimization techniques, radial and ring system, voltage regulation, reconfiguration, capacitor placement, power flow analysis, sizing of conductors and transformers, fault analysis, data acquisition and control, remote reading of energy meter, role of computers in distribution system operation, state of the art.

1) T. M. Gonen, Electrical Energy Distribution.

2) C. L. Wadhwa. , Electrical Energy Distribution.

3) Recent publication in reputed journals and conference proceedings of relevance.

Power System Harmonics

Course Code: **L.P.T**

Rationale:

Course Outcome

Harmonic Sources: Power electronic converters, transformers, rotating machines, arc furnaces, fluorescent lighting. Harmonic effects within power system- resonances, harmonic torques, static power plant, control systems, power system protection, consumer equipment, measurements, and on power factor. Harmonic effects related to communication interference: telephone circuit susceptiveness, harmonic weights, I-T and kV-T products, shielding. Harmonic effects related to biological effects. Power theory, single and three-phase, non - sinusoidal conditions, Fryez and Budeno's methods. Power quality parameters. Transducers and data transmission, Hall effect voltage and current sensors. Harmonic mitigation techniques: passive filters, active filters. Algorithms for extraction of harmonic current in the line.

1) J. Arrillaga, Power System Harmonics, IEE Press.

2) G. T. Heydt, Power Quality, Stars in a Circle, 1991.

3) M. G. Say, Alternating Current Machines, ELBS.

Basket of Open Elective

Fuzzy Systems and Genetic Algorithms

Course Code: **L.T.P**

Rationale:

Course Outcome:

CO1	Understand the fundamentals of Fuzzy logic theory.
CO2	Employ fuzzy logic principles to existing engineering applications and compare the results with existing methods.
CO3	Design Fuzzy logic Systems for engineering applications.

Course Content:

Unit-I

Different faces of imprecision – inexactness, ambiguity, undecidability, Fuzziness and certainty, Fuzzy sets and crisp sets.

Unit-II

Intersection of Fuzzy sets, Union of Fuzzy sets - the complement of Fuzzy sets-Fuzzy reasoning.

Unit-III

Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference- Methods of decompositions and defuzzification.

Unit-IV

Methodology of fuzzy design- Direct & Indirect methods with single and multiple experts, Applications– Fuzzy controllers – Control and Estimation.

Unit-V

Genetic Algorithms- basic structure-coding steps of GA, convergence characteristics, applications.

References

1. Zimmermann H.J., ‘Fuzzy Set Theory - and its Applications’, Springer Netherlands, 2nd Edition, Illustrated, 2014.

2. Timothy J. Ross, ’Fuzzy Logic with Engineering Applications’, John Wiley & Sons Ltd Publications, 3rd Edition, 2011.

3. M. Mitchell, ‘Introduction to Genetic Algorithms”, Indian Reprint, MIT press Cambridge, 2nd Edition, 2014.

4. John Yen, Reza Langari, ‘Fuzzy Logic, Intelligence, Control & Information’, Pearson Education Inc., India, 2007.

5. Zdenko Kovacic, Stjepan Bogdan, ‘Fuzzy Controller Design Theory and Applications’, CRC Press, 1st Edition, 2006.

6. Riza C. Berkaan, Sheldon L. Trubatch, ’Fuzzy Systems Design Principles – Building Fuzzy IF THEN Rule Based’, IEEE Press, 1997.

Artificial Neural Networks

Course Code: **L.T.P**

Rationale:

Course Outcome:

Course Content

Unit-Introduction to Neural Networks - Biological Inspiration- Biological Neural Networks to Artificial Neural Networks – Classification of ANN Networks – Development of neural network models – Perceptron Network – Linear Separability.

Unit-II

Adaline Network – Madaline Network – Back propagation Neural Networks – Kohenen Neural Network – Learning Vector Quantization – Hamming Neural Network-applications

Unit-III

Adaptive Resonance Theory Neural Networks – Boltzmann Machine Neural Networks – Radial Basis Function Neural Networks – Bi-directional Associative Memory-applications

Unit-IV

Hopfield Neural Networks – Support Vector Machines – Introduction to Spiking Neural Networks –Spike Neuron Models – Hybrid Neural Networks-applications

Unit-V

Deep Neural Networks- Recurrent Neural Networks- Backpropagation through time (BPTT)- Vanishing and Exploding Gradients- Truncated BPTT-LSTM (Long Short-Term Memory) Bilinear LSTM- Gated Recurrent Units-applications

Measurements and Sensors Technology

Course Code: **L.T.P**

Rationale:

Course Outcome

Introduction to Electrical Measurement

Moving Iron type instrument, extension of range, Electrodynamometer type meter, Induction type

wattmeter, VAR meter, Induction type energy meter, Electrodynamometer type power factor meter,

Current transformers: Ratio and phase angle errors, phasor diagrams, uses.

DC and AC Bridge

General equation of bridge balance, Wheatstone bridge, Kelvin's double bridge. Maxwell's inductance,

Anderson's bridge, Schering bridge, Errors.

Electronic and Biomedical Instruments

Electronic voltmeter: Block diagram, principle of operation, CRO: Block Diagram, Sweep Generator, use

of CRO for measurement of frequency, phase, amplitude and rise time. Digital Frequency meter, Digital

Multi-meter,Digital Energy Meter. Biomedical Instruments: ECG, Blood Pressure, Sonography.

Strain, Pressure and Motion Sensors

Resistance strain gauge, piezoelectric pressure gauge, characteristics. Capacitor plate sensor, inductive

sensor, LDVT Accelerometer systems, rotation sensors, piezoelectric devices, Rotary encoders,

Tachometers.

Heat and Temperature Sensors

Bimetallic strip, Bourdon temperature gauge, thermocouples, Resistance thermometers, thermostats, PTC

thermistors, bolometer, Pyroelectric detector.

Industrial Sensors

Proximity detectors- inductive and capacitive, Ultrasonic photo beam detectors, Reed switch, magnet and

Hall–effect units, Doppler detectors, liquid level detectors, flow sensors, smoke sensors.

Text Books:

1. A Course in Electrical and Electronics Measurement and Instrumentation by A. K. Sawhney,

10thedition, Dhanpat Rai, 1994.

2. Ian R Sinclair, "Sensors and transducers", Third Edition, Newness Publishers, 2001.

Reference Books:

1. Electronics Instruments and Measurements – David A. Bell – PHI, 2012.

2. Electronic Instrumentation and Measurement Techniques, By William David Cooper, PHI, 2010.

3. . Jack P Holman, "Experimental Methods for Engineers", Seventh Edition, McGraw Hill, USA,

2001.

4. . Robert G Seippel, "Transducers, Sensors and detectors", Reston Publishing Company, USA, 1983 .

Digital Control Systems

CO1	Understand the fundamental differences between continuous time control and digital control
CO2	Analyse the advantages of digital control over the continuous time control.
CO3	Develop digital controllers explicitly compared to continuous time controller.

Course Content:

Unit-I

Introduction- Comparison between analog and digital control-Importance of digital control-Structure of digital control- Examples of digital control system- Difference equations- Z-transform- MATLAB examples. Frequency response of discrete-time systems- Properties of frequency response of discrete-time systems-Sampling theorem.

Unit-II

ADC model-DAC model-Transfer function of zero order hold-DAC, Analog Subsystem, and ADC Combination Transfer Function-Closed loop transfer function–Steady state error and its constants (MATLAB commands).

Unit_III

Definitions of stability (Asymptotic stability, exponential stability etc) – stable z-domain pole placement locations-stability conditions-Stability determination (Routh array)-Nyquist criterion.

Unit-IV

Root locus-root locus design (P-control, PI -control, PD) - Z-domain root locus- z-domain root locus design-digital implementation of analog controller design (differencing methods forward and backward)- bilinear transformation-direct z- domain controller design-frequency response design-Finite time response settling time.

Unit-V

Concept of state space method-state space representations of discrete time systems- solving discrete time state space equations- Pulse transfer function matrix- Discretization of continuous state space equations-Liapunov stability analysis (discrete time) Controllability – observability-design via pole placement-state observers.

References

1.Kannan M. Moudgalya, ’Digital Control’, Wiley Publishers, 1st Illustrated Edition, 2007.

2.M.Gopal, ‘Digital Control Engineering’, New Age International (ltd) Publishers, 1st Edition Reprint (2003), 1998.

3.M. Sam Fadalli, ‘Digital Control Engineering Analysis and Design’, Elsevier Publication, 1st Edition, 2012.

4.Katsuhiko Ogata, ‘Discrete Time Control Systems’, Pearson Education Publications, 2nd Edition, 2005

Solar Power Technology

Course Code: L.T.P

Rationale:

Course Outcome:

Unit-I

Introduction

Basics of solar energy, Brief History of solar energy utilization, various approaches of utilizing solar energy, Blackbody radiation, Relation between radiation field energy density and radiation spectrum, Planck's formula in energy unit, Maximum spectral density, Planck's formula in wavelength unit, Wien displacement law, Stefan Boltzmann law, Photoelectric effect, Einstein's theory of photons, Einstein's derivation of the black-body formula.

Unit-II

Solar Cells

Formation of a p-n junction, Space charge and internal field, Quasi - Fermi levels, The Shockley diode equation - Structure of a solar cell, The solar cell equation, Fill factor and maximum power, Various electron, hole-pair recombination mechanisms, Crystalline silicon solar cells, Thin film solar cells, organic solar cells.

Unit-III

Solar Photovoltaic System

Solar PV modules from solar cells, Balance of solar PV system, Inverters (DC/DC, DC/AC), Power conditioning, Maximum power point operation Balance of System (BOS) for PV module installation, Concentrated solar power (CSP) systems.Standalone PV system design, Grid-connected PV system

Unit-IV.

Solar thermal systems

Solar Collectors, Solar Water Heater, Solar Passive Space – Heating and Cooling Systems, Solar Refrigeration and Air Conditioning Systems, Solar Cookers, Solar Furnaces, Solar Green House, Solar Dryer, Solar Distillation. Solar Thermo-Mechanical Systems, Balance of System Components.

Text Books :

1. Solar Photovoltaics, fundamentals Technoloies and Applications, by Chetan Singh Solanki, PHI, 2nd edition 2012

2. Jui Sheng Hsieh, Solar Energy Engineering, Prentice-Hall, 2007.

Reference Books :

1. Micheal Boxwell , Solar Electricity Handbook, Green Stream publishing (2010).

2. Rai G.D, Non-Conventional Energy Sources, Khanna Publishers, 4th Edition 2000.

3. Kothari D.P., Renewable energy resources and emerging technologies, Prentice Hall of India Pvt. Ltd,2006.

Basics of Electrical Circuits

Course Code: **L.T.P**

Rationale:

Course Outcome:

Unit-: I

Review of Electrical elements and circuits, Kirchhoff's laws, voltage and current sources, controlled sources, RMS and average values for typical waveforms, power and energy in electrical elements, phasor representation, series and parallel RLC circuits -simple examples.

Unit-: II

Self and mutual inductance, coefficient of coupling, Capacitance, Series-parallel combination of inductance and capacitance, Series and parallel resonant circuits.

Unit: III

Circuit analysis using Node voltage and Mesh current methods, analysis with dependent source and special case.

Unit-: IV

Equivalent circuits, star-delta transformation, source transformation, Thevenin, Norton, Superposition and Maximum power transfer theorems.

Unit-V

Three-phase circuits balanced three-phase voltages, analysis of three-phase star and delta connected circuits, balanced and unbalanced systems, power calculations, power measurement using two wattmeter method.

References

1.James W. Nilsson and Susan A. Riedel, “Electric Circuits”, International Edition Adapted by Lalit Goel, Pearson Education, 8th Edition, Seventh Impression, 2012.

2.A. Sudhakar and Shyammohan S Pillai, “Circuits and Networks”, Tata McGraw Hill, New Delhi, 4th Edition, 2010.

3.William H. Hayt, Jack Kemmerly, Steven Durbin, “Engineering Circuit Analysis”, McGraw Hill, 8th Edition, 2012.

4.Mahmood Nahvi, Joseph Edminister, “Schaum’s Outline of Electric Circuits”, McGraw Hill Education, 6th Edition, 2014.

Electrical Machines

Course Code: **L.T.P**

Rationale:

Course Outcome:

CO1	To disseminate an overview of various electric machines used in industries, power generation and home appliances with a technical know-how on the control techniques

Unit-I

DC motors: Construction and working principle, emf equation, torque equation, starting and running characteristics, speed control, braking, duty of operation, choice of motors.

Unit-II

Transformers: Construction and working principle, equivalent circuit, regulation and efficiency, auto-transformers, industrial applications – welding transformer and furnace transformer.

Unit-III

Three-phase induction machines: Construction and working principle. Induction motors - torque-equation, torque–slip characteristics, starting and running characteristics, speed control, braking, choice of motor for industrial applications and traction.

Unit-IV

Synchronous Machines: Construction, principle of operation and types, various types of excitation systems, stand alone and grid connected modes of operation, voltage and frequency control.

Unit-V

Fractional horsepower machines: Single phase induction motors – Construction and principle of operation, types, applications in home appliances. Construction, operation and applications of Brushless DC motors, Stepper motors, Servomotors and AC Series motors.

References

1.D.P.Kothari and I.J.Nagrath, 'Electric Machines', McGraw Hill Education Private Limited, 4th Edition, 2010.

2.Gopal K. Dubey, ‘Fundamentals of Electrical Drives’, Narosa publishing house, 2nd Edition, 2011.

3.A Fitzgerald , Charles Kingsley , Stephen Umans, ‘Electric Machinery’, McGraw Hill Education Private Limited, 6th Edition, 2002.

4.K. Murugesh Kumar, ‘Induction & Synchronous Machines’, Vikas Publishing House Pvt Ltd., 2009.

5.Edward Hughes, ‘Electrical and Electronic Technology’, Dorling Kindersley (India) Pvt. Ltd., 10th Edition, 2011.

6.Ashfaq Husain, ‘Electric machines’, Dhanpat Rai & Company, 2nd Edition, 2002.

Control Systems Engineering

Course Code: **L.T.P**

Rationale:

Course Outcome:

CO1	To equip the students with the fundamental concepts in control systems

Unit-I

Modelling of physical systems – Time-domain specifications - Generalized error series – various test signals and its importance- Routh-Hurwitz stability criterion

Unit-II

Root Locus Technique – Definitions - Root locus diagram - Rules for construction of root loci - Effect of pole zero additions on the root loci - root contours.

Unit-III

Frequency domain analysis – Bode plot - Polar plot - Nyquist plot.

Unit-IV

Phase margin - gain margin - Nyquist stability criterion.

Unit-V

Controller design - P, PI, PID, lag, lead, lead-lag compensator design.

References

1.Katsuhiko Ogata, 'Modern Control Engineering ', Pearson Education Publishers, 5th Edition, 2010.

2.Nagrath I.J. and Gopal M, 'Control Systems Engineering', New Age International Publications, 5th Edition, 2010.

3.Richard C. Dorf and Robert H. Bishop. 'Modern Control Systems', Pearson Prentice Hall Publications, 12th Edition, 2010.

4.Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, 'Feedback Control of Dynamic Systems', Pearson Education India Publications, 6th Edition, 2008.

5.Benjamin C.Kuo and Farid Golnaraghi, ‘Automatic Control Systems’, John Wiley & Sons Publications, 8th Edition, 2002.

Analog and Digital Electronics

Course Code: **L.T.P**

Rationale:

Course Outcome

CO1	To understand the concepts of analog and digital circuits
CO2	To impart knowledge on signal generation and measuring equipment

Unit-I

Review of analog devices – Rectifier circuits - Wave shaping circuits - Clippers and Clampers – Regulators - Zener and op-amp based regulator circuits - Introduction to switched mode power supplies.

Unit-II

Review of digital components - Code converters- Programmable logic devices- CPLDs and FPGAs- Introduction to hardware description languages

Unit-III.

Oscillators & signal generator circuits - Function generator circuit - Pulse generator circuit - AM/FM signal generator circuit – Qualitative analysis.

Display Units - optoelectronic devices – Seven-segment displays - LCD and LED display units and applications.

Unit-IV

Special electronic circuits – UJT Sawtooth generator circuit – Schmitt trigger – Analog-to-digital converter – Digital-to-analog converter circuits.

References

1.David A Bell, 'Fundamentals of Electronic Devices and Circuits', Oxford University Press, Incorporated, 25- Jun-2009.

2.Bouwens A. J., ‘Digital Instrumentation’, Tata McGraw Hill Publications, 16th Reprint (2008).

3.Kalsi H.S, ‘Electronic Instrumentation’, Tata McGraw-Hill Education, 3rdEdition, 2010.

4.Morris Mano.M, ’Digital Logic and Computer Design’, Prentice Hall of India, 3rdEdition, 2005.

Fuel Technology

Course Code: **L.T.P**

Rationale:

Course Outcome

Unit-I

Introduction

Types of fuels, solid, liquid and gaseous fuels, History of solid liquid and gaseous fuels, production, present scenario and consumption pattern of fuels, fundamental definitions, properties and various measurements, properties of solid liquid fuels and their measurement techniques.

Unit-II

Solid Fuels

Coal origin, its classification, composition, and properties. Coal mining,preparation, and washing. Combustion of coal and coke making, different types of coalcombustion techniques, coal tar distillation, coal liquefaction: direct and Indirectliquefaction, coal gasification, oxidation and hydrogenation. Efficient use of solidfuels, Applications.

Unit-III

Liquid Fuels

Origin and classification of petroleum, refining, properties & testing ofpetroleum products, various petroleum products, petroleum refining in India, liquidfuels from other sources, storage and handling of liquid fuels, Applications.

Unit-IV

Gaseous Fuels

Types of gaseous fuels: natural gases, methane from coal mines,manufactured gases, producer gas, water gas, biogas, refinery gas, LPG, hydrogen, acetylene, other fuel gases. Cleaning, purification and quality enhancement of gaseous fuels, Applications.

Text Book

1. Irvin Glassman, “Combustion” nd ed., Academic Press.

2. John Griswold, “Fuels Combustion and Furnaces” Mc-Graw Hill Book Company Inc.

3. S.P. Sharma & Chander Mohan, “Fuels and Combustion”, Tata McGraw Hill Publishing Co. Ltd.

Reference Books

1. Gupta O.P, “Elements of Fuels, Furnacesand Refractories”, rd ed., Khanna Publishers.

2. Dr. Samir Sarkar, “Fuels and Combustion”, nd ed., Orient Longman

Renewable Power Generation Systems

Course Code: **L.T.P**

Rationale:

Course Outcome:

CO1	To impart the knowledge on various forms of renewable energy sources and the process of electric energy conversion

Unit-I

Environmental aspects of electric power generation from conventional sources: Limitation of fossil fuels - Atmospheric pollution – effects of hydro-electric projects – disposal of nuclear waste – GHG emission from various energy sources and its effects – need for renewable energy sources.

Unit-II

Solar Photo-Voltaic system: Solar radiation and its measurement – Angle of sun rays on solar collector – optimal angle for fixed collector – sun tracking, an introduction to solar cell, solar PV module, PV system design and applications – stand-alone and grid connected systems, environmental impacts.

Unit-III

Wind power generation: Wind energy, classification of wind turbines – aerodynamic operation of wind turbine, extraction of wind turbine power, wind turbine power curve, horizontal axis wind turbine generator – modes of wind power generation – stand-alone and grid connected system, environmental impacts.

Unit-IV

Fuel cell system: Principle of operation of fuel cell, technical parameters of fuel cell, Type of fuel cell – advantages of fuel cell power plants, energy output, efficiency and emf of fuel cell – operating characteristics, applications and environmental impacts.

Unit-V

Hybrid energy systems: Need for hybrid systems, types, configuration and coordination, electrical interface – PV-Diesel, Wind-diesel, wind-PV, wind-PV- fuel cell.

References

1.G D Rai, ‘Non-conventional Energy sources’, Khanna Publishers, 5th Edition, 2014.

2.D P Kothari, K C Singal and Rakesh Ranjan, ‘Renewable Energy Sources and Emerging Technologies’ 2nd Edition, 2012.

3.C S Solanki, ‘Solar Photo-voltaics – Fundamentals, Technologies and Applications’, PHI Pvt., Ltd., 2nd Edition, 2011.

4.S N Bhadra, D Kastha and S Banerjee, ‘Wind Electric Systems’, Oxford Publications, 2nd Edition, 2007.

Design Thinking

Course Code: **L.T.P**

Rationale: To understand the design philosophy of growth-oriented business ideas by creative thinking.

Course Outcome:

CO1	Conceive need for an enterprise
CO2	Carry out strategic planning
CO3	Evolve methodology for innovative implementation

Unit-I

Understanding human needs

Creating, Delivering and Sustaining values, empathy and understanding, opportunities.

Concept visualization

Unit-II

Methods and Mind sets – outcome formation – case studies

Strategies

Unit-III

Principles and framework, scalability, Assessing current stage, framing opportunities

Transformation

Unit-III

Enterprise innovation, preparing quests, competency mapping, team charters and articulation

Data Mining and Analysis

Unit-IV

Data mining, soft data conversion, creating human archetypes, experience mapping, creating activity systems

References

1.Heather M.A. Fraser, Design Works, University of Toronto Press, 2012

2.Nigel Cross, Design Thinking, Bloomsbury Academic, 2016

Optimal and Robust Control

Course Code: **L.T.P**

Rationale:

Course Outcome:

CO1	Perform problem formulation, performance measure and mathematical treatment of optimal control problems so as to apply the same to engineering control problems with the possibility to do further research in this area.
CO2	Solve optimal control design problems by taking into consideration the physical constraints on practical control systems.
CO3	Produce optimal solutions to controller design problems taking into consideration the limitation on control energy and robustness in the real practical world

Unit-I

Linear dynamical system – concept of observers – observers-based controllers – state space realizations for transfer matrices – Lyapunov equations – Balanced realizations – Hidden modes and pole zero cancellation – multivariable system poles and zeros

Unit-II

Normed spaces, Hilbert spaces - Hardly spaces - power and spectral signals – induced system gains – computing norms - feedback structure - well-posedness of feedback loop – Internal stability – Coprime factorization – concept of loop shaping – weighted performance

Unit-III

Model reduction by balanced truncation – frequency and weighted balanced model reduction – relative and multiplicative model reduction – optimal Hankel norm approximation – Toeplitz operators – Nehari's theorem – Model uncertainty – small gain theorem – stability under stable unstructured uncertainties - unstructured robust performance

Unit-IV

Structure singular value – structured robust stability and performance – overview on μ synthesis – existence stabilizing controllers – parametrization of all stabilizing controllers – Youla parameterization – co-prime factorization – stabilizing solutions – Riccatti equation

Unit-V

Regulator problem – standard LQR problem – Extended LQR problem – Guaranteed stability margins of LQR – standard H2 problems- separation theory – output feed H∞ control – disturbance feedback – optimal controller H∞ loop shaping – controller order reduction – discrete time control

References

1.Robust and Optimal Control, K. Zhou, J. Doyle, and K. Glover, Prentice Hall, 1st edition, 1995, ISBN-13: 978- 0134565675.

2.Optimal Control, F. L. Lewis, D. Vrabie, V. L. Syrmos, Wiley, 3rd edition, 2012, ISBN-10: 0136024580.

3.Optimal Control Theory for Applications, D. G. Hull, Springer, 2010, ISBN-13: 9781441922991.

4.Donald E. Kirk, Optimal Control Theory, An introduction, Prentice Hall Inc., 2004.

5.A.P. Sage, Optimum Systems Control, Prentice Hall, 1977.

Robotics

Course Code: **L.T.P**

Rationale:

Course Outcome:

CO1	Understand basic concept of robotics
CO2	Analyze instrumentation systems and their applications to various robot models.
CO3	choose different sensors and measuring devices according to the applications
CO4	explain about the differential motion add statics in robotics
CO5	model various path planning techniques.
CO6	explain about the dynamics and control in robotics industries

Unit-I

Robot classifications - Mathematical representation of Robots - Position and orientation – Homogeneous transformation- Various joints- Representation using the Denavit Hattenberg parameters -Degrees of freedom-Direct kinematics-Inverse kinematics- SCARA robots- Solvability – Solution methods-Closed form solution.

Unit-II

Linear and angular velocities-Manipulator Jacobian-Prismatic and rotary joints–Inverse -Wrist and arm singularity - Static analysis - Force and moment Balance - Joint space technique - Use of p-degree polynomial-Cubic polynomial-Cartesian space technique - Parametric descriptions - Straight line and circular paths - Position and orientation planning.

Unit-III

Lagrangian mechanics-2DOF Manipulator-Lagrange Euler Formulation-Dynamic model – Manipulator control problem-Linear control schemes-PID control scheme-Force control of robotic manipulator.

Unit-IV

Sensors Classification, sensor characterization, wheel/motor encoders, heading/orientation sensors, ground-based beacons, active ranging, motion/speed sensors, vision-based sensors. Low level control, Control architectures, software frameworks, Robot Learning, case studies of learning robots.

Unit-V

Robot Anatomy and Related Attributes – Classification of Robots- Robot Control systems – End Effectors – Sensors in Robotics – Robot Accuracy and Repeatability - Industrial Robot Applications – Robot Part Programming – Robot Accuracy and Repeatability – Simple Problems.

References

1.R.K.Mittal and I.J.Nagrath, Robotics and Control, Tata McGraw Hill, New Delhi,4th Reprint, 2005.

2.JohnJ.Craig, Introduction to Robotics Mechanics and Control, Third edition, Pearson Education, 2009.

3.M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, Industrial Robotics, McGraw-Hill Singapore, 1996.

Energy Audit and Management

Course Code: **L.T.P**

Rationale:

Course Outcome

Unit-I

General Energy scenario

Energy consumption – world energy reserves – prices – Types of energy sources, Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach energy policies, Energy security, Demand side Management, Supply side management, Energy cconservation and its importance, Energy strategy for the future, Energy conservation Act-2001 and its features. Energy and environment:Air pollution, Industrial safety.

Unit-II

Electrical system

Electricity tariff, Load management, types of power: firm power, dump power, secondary power, load curve, load distribution curve, Power factor improvement, Electrical losses and efficiency, Light source, Choice of lighting. Industrial energy use – Energy index – Cost index, Representation of energy consumption: Pie charts – Sankey diagrams – Load Profile.

Unit-III

Energy Utilization and conversion system

Unit-IV

Classification of furnace, controlled atmosphere in furnace, efficiency of energy in furnace, Heat – Heat content – Rate of heat transfer – Heat transfer coefficient – Conduction – Convention and radiation. Thermal insulation & its importance – space heating – HVAC system – Heating of Buildings – District heating – Factors & affecting the choice of district heating. Energy performance assessment of compressor, HVAC system and Lighting system

Unit-V

Energy Management and Audit

Data collection and data analysis methodologies, understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments, Payback period, CUSUM analysis, energy audit-reporting format.

Text Book

1. Abbi, Y.P. and Jain, S., Handbook on Energy Audit and Environment Management, Teri

Bookstore (2006).

2. W.R. Murphy and G. McKay, “Energy management”, Butterworth & Co Publishers, Oxford,

UK, 2001.

Reference Books

1. A Workbook for Energy Management in building by: Tarik Al-Shemmeri, Wiley-Blackwell.

2. Energy audit: Thermal power, combined cycle, and co-generation plants, by: Y.PAbbi, TERI,

2011.

3. Diwan, P., Energy Conservation, Pentagon Press (2008).

4. Younger, W., Handbook of Energy Audits, CRC Press (2008)

Electronic System Design

Course Code: **L.T.P**

Rationale:

Course Outcome

Unit-I

Introduction to electronic circuit design, characteristics of diode and mosfet, manufacturing process of CMOS integrated circuits, packaging types.

Unit-II

Interconnection parameters - resistance - capacitance - inductance, electrical wire models, transmission line models in SPICE, CMOS Inverter.

Unit-III

Designing combinational logic gates in CMOS, designing sequential logic circuits, effect of parasitic in the design – Industry standards

Unit-IV

Understanding the printed circuit board (PCB) – single layer – multi layer – holes – vias – layers limitations – track widths – design rules – issues of EMC and EMI.

Unit-V

Design of PCB – creation of footprint – schematics – components placement – routing – labels and identifiers – design files – examples

References

1 J. M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic 'Digital Integrated Circuits' Pearson, 2nd Edition, 2016.

2 K. Mitzner, Bob Doe, Alexander Akulin, Anton Suponin and Dirk Muller, 'Complete PCB Design Using OrCAD Capture and Layout', Academic Press, 2nd Edition, 2019.

3 Neil Weste, David Harris, 'CMOS VLSI Design: A Circuits and Systems Perspective', Addison-Wesley, 4th Edition, 2010.

4 Thomas L Floyd, ‘Digital fundamentals’, Pearson Education Limited, 11th Edition, 2015.

Power System Engineering

Course code: **L.T.P**

Rationale:

Course Outcome:

CO1	To impart knowledge on power generation, transmission, distribution and protection systems, and overview of power system economics and regulations

Unit-I

Overview of generation systems: Sources of Energy, Steam, Diesel, Nuclear and Hydro power plants – site selection - Layout – essential components and operation

Unit-II.

Modes of Transmission and Distribution: HVAC and HVDC Transmission system – over-head lines – towers, conductors and insulators, underground cables – types – laying methods and fault location, comparison of over-head and underground systems, distribution system – classification – components, power factor correction.

Unit-III

Basic protection and switchgears: System faults and abnormal conditions, system grounding, need for protection system, overview of apparatus protection, switch gear mechanisms – fuse, switch, isolator and circuit breakers.

Unit-III

Economics on power systems: Factors affecting cost of generation – load curve – load factor – diversity, base load and peak load stations – reduction of generation cost by interconnection of stations, price of electricity – types of tariff for HT and LT consumers.

Unit-IV

Regulation / Electricity Act: Evolution of Indian electricity act – regulator commissions, grid code, Introduction to restructuring of power system – GenCo, TransCo and DisCo, Independent power producers, Introduction to smart grid.

References

1.R K Rajput, 'Power System Engineering', Laxmi Publications Ltd., 2006.

2.A Chakrabarti, M L Soni, P V Gupta and U S Bhatnagar, 'Power System Engineering', Dhanpat Rai & Co., Ltd., 2010.

3.S N Singh. ‘Electric Power Generation, Transmission and Distribution’, PHI Publications, 2008.

4.B.R. Gupta, ‘Power System Analysis and Design’, S. Chand Limited, 5th Edition, 2008.

Vehicle Charging Technology

Course code: **L.T.P**

Rationale:

Course Outcome:

Unit-I

Introduction

History of EV, Components of Electric Vehicle, EV classification, and their electrification levels

Unit-II

Types of EV Chargers

Unit-III

Charging Equipment, Basic charging Block Diagram of Charger, Difference between Slow charger and fast charger, Slow charger design rating, Fast charger design rating, AC charging and DC charging Inboard and off-board charger specification, Types of Mode of charger Mode -2, Mode-3 and Mode-4, Wireless Charging: static charging and dynamic charging

Unit-IV

Selection and sizing of the fast and slow chargers (AC and DC)

Unit-V

AC Pile Charger, DC Pile Charger, EVSE Power Module selection and technical specification, Selection of EVSE Communication Protocol (PLC / Ethernet / Modbus/ CAN Module), Communication gateway, Specification of open charge point protocol (OCCP 1.6/2.0), Bharat DC001 & AC001 Charger specification, Communication Interface between charger and CMS (central management system) Selection and sizing of Common types of connectors and applications Selection of AC charger type-1 type -2 and type -3, Communication between AC charger and EV, Selection of DC charger connector GB/T, CHAdeMO CCS-1 and CSS-2, Communication methodology of DC fast chargers, IS/ IEC/ARAI/ standard of Charging topology Communication and connectors (IEC 61851-1, IEC 61851-24,62196-2), Selection sizing of Charger connector cable

Public Charging infrastructure

Basic Requirements for Charging System, Charger Architectures Preparation of EV Charger Single Line Diagram, Assessment of site Location for Public charging station, Selection and Sizing of Distribution transformer, HT Equipment (VCB, CT, PT, Metering), HT Cables and LT cables, Selection and sizing of Distribution Board/feeders, Sizing calculation of LT and HT cable, Selection and of Compact Substation (CSS for EV CS).

Text Books

1. Rim, C. T., & Mi, C. (2017). Wireless power transfer for electric vehicles and mobile devices.

John Wiley & Sons.

2. Code of Practice for Electric Vehicle Charging Equipment Installation. (2018). United

Kingdom: Institution of Engineering & Technology.

Reference Books

1. Chan, C. C., & Chau, K. T. (2001). Modern electric vehicle technology (Vol. 47). Oxford University Press on Demand.

2. Vahidinasab, V., &Mohammadi-Ivatloo, B. (Eds.). (2022). Electric vehicle integration via smart charging: technology, standards, implementation, and applications. Springer Nature.

3. Hayes, J. G., &Goodarzi, G. A. (2018). Electric powertrain: energy systems, power electronics, and drives for hybrid, electric, and fuel cell vehicles.

4. Husain, I. (2021). Electric and hybrid vehicles: design fundamentals. CRC press.

Energy Storage Technology

Course code: **L.T.P**

Rationale:

Course Outcome:

CO1	Describe application of different energy storage systems.
CO2	Understand the performance of different types of energy storage device.
CO3	Analyze the principle of different types of fuel cell.
CO4	Understand different types of battery technology
CO5	Solve the state of charge of batteries using different techniques.
CO6	Know super capacitor, green house heating.

Unit-I

Introduction

Energy availability, Demand and storage, Need for energy storage, Different types of energy storage; Mechanical, Chemical, Electrical, Electrochemical, Biological, Magnetic, Electromagnetic, Thermal, Comparison of energy storage technologies.

Unit-II

Mechanical, Thermal Energy Storage

Unit-III

Flywheel storage, Hydro storage, Capacitor, Principles and applications, Thermal energy storage, principles and applications, Phase change materials; Energy analysis of thermal energy storage, solar energy and thermal energy storage.

Unit-IV

Electrochemical Energy Storage

Electrochemical energy storage: Battery fundamentals and technologies, characteristics and performance comparison of Lead-acid, Nickel-Metal hydride, Lithium Ion; Battery system model, emerging trends in batteries, Voltages and Capacities of Electro-chemical Cells, Equivalent Circuit of an Electrochemical Cell, Charging and discharging operation of batteries, State-of-charge (SOC) of batteries, battery management systems.

Unit-V

Fuel Cells

Hydrogen as energy carrier and storage; Hydrogen resources and production; Basic principles; Fuel cell types: AFC, PEMFC, MCFC, SOFC, Microbial Fuel cell; Fuel cell performance; Fuel cell applications for power and transportation.

Application of Energy Storage

Food preservation, Waste heat recovery, Solar energy storage: Greenhouse heating; Drying and heating for process industries.

Text Books:

1. Huggins R. A., Energy Storage: Fundamentals, Materials and Applications, second edition, Springer International Publishing, 2015.

2. Dincer I., and Rosen M. A., Thermal Energy Storage: Systems and Applications, second edition, Wiley, 2011.

Reference Books:

1. Fuel Cell Fundamentals, O'Hayre R., Cha S., Colella W., and Prinz F. B., Wiley, Second Edition, 2009.

2. Chemical and Electrochemical Energy System, Narayan R. and Viswanathan B., Universities Press, (1998).

3. Battery Systems Engineering, Rahn C. D. and Wang C., First Edition, Wiley, 2013.

4. Electrochemical Energy Storage for Renewable Sources and Grid Balancing, Moseley P. T., and Garche J., Elsevier Science, 2014.

5. Compressed Air Energy Storage, Miller F. P., Vandome A. F., and John M. B., VDM Publishing, 2010.

Special Machines and Controls

Course code: **L.T.P**

Rationale:

Course Outcome:

Unit-I

Stepper Motors

Introduction, Hybrid stepping motor, construction, principles of operation, energization with two phase at a time, essential conditions for the satisfactory operation of a 2-phase hybrid steper motor ,very slow speed synchronous motor for servo control-different configurations for switching the phase windingscontrol circuits for stepping motors,an open-loop controller for a 2-phase stepping motor.

Unit-II

Linear Induction Motor

Development of a double-sided LIM from rotary type IM- A schematic of LIM drive for electric traction development of one-sided LIM with back iron-field analysis of a DSLIM fundamental assumptions.

Unit-III

Synchronous Motors

Construction- Principle of operation of Permanent Magnet Synchronous Motors – EMF and torque equations – Starting – Rotor configurations –Dynamic model, Synchronous Reluctance Motors: Constructional features–axial and radial flux motors – operating principle – characteristics.

Unit-IV

Control of PMSM, BLDC and Switched Reluctance Motor Bipolar optical sensor based control of Trapezoidal BLDC Motor, Sensorless control of BLDC motor, Torque ripple control of BLDC motor,Unipolar control for SRM, Torque ripple control of SRM.

Smart Inverters

Selection of power conditioning unit (PCU), Sizing of solar inverter for roof top and grid connected projects, Passive and active protection, IEC/IEEE /Grid Compliance of inverters, Grid-Connected Inverters vs. Stand-Alone Inverters.

Text Book

1. Miller, T. J. E., Brushless Permanent Magnet and Reluctance Motor Drives, Oxford Science

Publications, 1989.

2. Kenjo, T., and Sugawara, A., Stepping Motors and their Microprocessor Controls, Oxford Science Publications, 1984.

Reference Books

1. Krishnan, R., Electric Motor Drives: Modeling, Analysis, and Control. Prentice Hall, (2001).

2. Krishnan, R., “Permanent Magnet and BLDC Motor Drives”, CRC Press, .

3. Chang-liang, X., "Permanent Magnet Brushless DC Motor Drives and Controls", Jun 2012.