# M. Tech. in Electrical Engineering (Power Systems)

## Program Outcomes (PO's):

The Program Outcomes (PO's) for Post Graduate (PG) engineering programs are:

1. Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications.
2. Design the modern electric machines, drives, power converters, and control circuits for specific application.
3. Use modern tools, professional software platforms, embedded systems for the diversified applications.
4. Solve the problems which need critical and independent thinking to show reflective learning.
5. Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies
6. Visualize the larger picture and correlate the domain knowledge with the global industrial problems
7. Understanding of the impact of electronics & communications in an economic, social and environment context.
8. Understanding of intellectual property rights and overall professional & ethical responsibility.
9. Ability to communicate effectively with a wide range of audience.
10. Ability to learn independently and engage in life-long learning.

## Program Educational Objectives (PEO's):

1. To provide students with a foundation in mathematics, physics and core electrical and electronic areas required to formulate, solve and analyse engineering problems. **(Fundamental Knowledge)**
2. To analyse real life problems; apply the knowledge gained from modern design methodologies to address issues in a manner i.e., technically sound, economically feasible and socially acceptable. **(Professional Skill & Society)**
3. To inculcate ethical attitude, effective communication skills, teamwork in their profession and adapt to current trends by engaging in lifelong learning needed for a successful professional career. **(Ethics & Lifelong Learning)**

## Program Specific Outcomes (PSO's):

PSO1. Apply engineering fundamental knowledge to identify, formulate, design and investigate complex engineering problems of electric circuits, power electronics, electrical machines and power systems and to succeed in competitive exams. **(Engineering Knowledge and Analysis)**

PSO2. Apply appropriate techniques and modern engineering hardware and software tools in power systems and power electronics to meet desired needs within realistic constraints such as economical, environmental, social, political, ethical, health and safety, manufacturability and sustainability. **(System Design & Professionalism)**

PSO3. Function effectively as an individual or a leader in a team to manage different projects in multidisciplinary environment and appreciate the need for, and an ability to engage in life-long learning. (**Leadership & Life-long Learning**)

# Detailed Curriculum

## First Year

| Semester - I | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type | Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| PC | | Computational Methods for Power Systems Engineering | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | | Power Systems Analysis | 3 | 0 | 0 | 3 | 0 | 0 |
| PC | | Power Systems Dynamics | 3 | 0 | 0 | 3 | 0 | 0 |
| PE | | Professional Elective-I | 3 | 0 | 0 | 3 | 0 | 0 |
| CC | | Research Methodology & IPR | 2 | 0 | 0 | 2 | 0 | 0 |
| AC | | Stress Management by Yoga | 2 | 0 | 0 | 0 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| PC | | Power Systems Lab -I | 0 | 0 | 4 | 0 | 0 | 2 |
| PE | | Renewable Energy Lab | 0 | 0 | 4 | 0 | 0 | 2 |
| | | ***SUB-TOTAL*** | **16** | **0** | **8** | **14** | **0** | **4** |
| | | ***TOTAL*** | **24** | | | **18** | | |

| Semester - II | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type | Course Code | Course Title | WCH L-T-P | | | Credits L-T-P | | |
| THEORY | | | | | | | | |
| PC | | Digital Protection of Power System | 3 | 0 | 0 | 3 | 0 | 0 |
| PE | | Professional Elective-II | 3 | 0 | 0 | 3 | 0 | 0 |
| PE | | Professional Elective-III | 3 | 0 | 0 | 3 | 0 | 0 |
| PE | | Professional Elective-IV | 3 | 0 | 0 | 3 | 0 | 0 |
| AC | | English for Research Paper Writing | 2 | 0 | 0 | 0 | 0 | 0 |
| PRACTICAL | | | | | | | | |
| PC | | Power Systems Lab-II | 0 | 0 | 4 | 0 | 0 | 2 |
| PE | | Power Electronics Applications to Power Systems Lab | 0 | 0 | 4 | 0 | 0 | 2 |
| PJ | | Mini Project & Seminar | 0 | 0 | 4 | 0 | 0 | 2 |
| | | ***SUB-TOTAL*** | **14** | **0** | **12** | **12** | **0** | **6** |
| | | ***TOTAL*** | **26** | | | **18** | | |

**List of Electives**

| | |
|---|---|
| Professional Elective - I | Smart Grids/ High Power Converters/Wind and Solar Systems/Renewable Energy System |
| Professional Elective – II | Electrical Power Distribution System / PWM for PE Converters /Electric and Hybrid Vehicles |
| Professional Elective – III | Restructured Power Systems /Advanced Digital Signal Processing /Dynamics of Electrical Machines / Power Apparatus Design |
| Professional Elective – IV | Advanced Micro-Controller Based Systems / SCADA System and Applications / Power Quality / AI Techniques |

# Second Year

| Semester - III | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Type** | **Code** | **Course Title** | **WCH L-T-P** | | | **Credits L-T-P** | | |
| **THEORY** | | | | | | | | |
| PE | | Professional Elective-V | 3 | 0 | 0 | 3 | 0 | 0 |
| OE | | Open Elective | 3 | 0 | 0 | 3 | 0 | 0 |
| **PRACTICAL** | | | | | | | | |
| PJ | | Thesis (Part - I) & Seminar | 0 | 0 | 20 | 0 | 0 | 10 |
| | | ***SUB-TOTAL*** | **6** | **0** | **20** | **6** | **0** | **10** |
| | | ***TOTAL*** | **26** | | | **16** | | |

| Semester - IV | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Type** | **Course Code** | **Course Title** | **WCH L-T-P** | | | **Credits L-T-P** | | |
| **PRACTICAL** | | | | | | | | |
| PJ | | Thesis (Part-II) & Seminar | 0 | 0 | 32 | 0 | 0 | 16 |
| | | ***SUB-TOTAL*** | **0** | **0** | **32** | **0** | **0** | **16** |
| | | ***TOTAL*** | **32** | | | **16** | | |

### List of Electives

| | |
|---|---|
| Professional Elective - V | Power System Transients / FACTS and Custom Power Devices /Industrial Load Modeling & Control /Dynamics of Linear Systems |
| Open Elective | Business Analytics / Industrial Safety / Operations Research / Cost Management of Engineering Projects / Composite Materials / Waste to Energy |

# DETAIL SYLLABUS

*for*

# 1ST YEAR M.TECH.

# ELECTRICAL ENGINEERING

# (POWER SYSTEMS)

| Type | Code | Computational Methods for Power Systems Engineering | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce the students to basic concepts of mathematics, optimization and soft computing methods. The course will cover different optimization technique for linear and nonlinear programming. The course will train the students about the basic tools of soft computing like fuzzy logic and neural networks and their application to different electrical and power systems problems. |
| **Pre-Requisites (if any)** | Basic knowledge of engineering mathematics & Power systems. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Linear Programming: Graphical Method, Simplex Method, Methods of Artificial Variables, Alternate optima, redundancy & degeneracy, Integer Linear Programming: Gomory's cutting Plane Method for All Integer & Mixed Integer Programming, Branch & Bound Method | **9 Hours** |
| **Module 2** | Optimality Conditions, Lagrangian & Lagrange Multipliers, KKT Necessary/sufficient optimality conditions, duality in non-linear programming<br>Unconstrained optimization: Line search methods for uni-modal functions, the steepest descent method, Newton's method, Modified Newton's Method, The Conjugate Gradient Method | **9 Hours** |
| **Module 3** | Constrained Optimization: Frank Wolfe's Method, Rosen's Gradient Projection Method, Penalty function method, Barrier Function Method<br>Karmakar's Algorithm for Linear Programming, centering transformation, projection matrix and the complete Algorithm. | **7 Hours** |
| **Module 4** | Fuzzy logic: Basic concepts of Fuzzy logic, Fuzzy Vs crisp set, Linguistic variables, membership functions, operation of fuzzy sets, fuzzy if then rules, Variable inference techniques, De fuzzification, basic fuzzy inference algorithm, fuzzy system design, FKBC and PID control, control of electrical drive using fuzzy controller and other industrial application. | **10 Hours** |
| **Module 5** | Neural networks: Artificial neural network and introduction, learning rules, knowledge representation and acquisition, different methods of learning,<br>Algorithm of neural network: feed forward back propagation , Hopfield model, kohonen's feature map, K-means clustering, ART networks, RBFN, application of neural network to electrical problems. | **10 Hours** |
| | **Total** | **45 Hours** |

**Text Books:**

T1. Suresh Chandra, Jayadeva & Aparna Mehera, Numerical Optimization with Applications, Narosa.

T2. J. S. R. Jang. C. T. SUN and E. Mizutani, "Neuro-fuzzy and soft-computing". PHI Pvt. Ltd., New Delhi

**Reference Books:**

R1. S. S. Rao, Engineering Optimization, New Age
R2. K. Dev , Optimization for Engineering Design , PHI
R3. S. Haykins, "Neural networks: a comprehensive foundation". Pearson Education, India.
R4. V. Keeman, "Learning and Soft computing", Pearson Education, India.

**Course Outcomes:**

At the end of this course, students will demonstrate the ability

| | |
|---|---|
| CO1 | To apply linear programming methods to engineering problems |
| CO2 | Understand and apply methods of solutions for unconstrained optimization problems |
| CO3 | Understand and apply methods of solutions for constrained optimization problems |
| CO4 | To study and design fuzzy logic controllers for different electrical applications |
| CO5 | To Understand different neural networks and its application to solve different electrical problems. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:**(1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 2 | 2 | - | - | - | - | - |
| **CO2** | 3 | 3 | 2 | 3 | 2 | - | - | - | - | - |
| **CO3** | 3 | 3 | 2 | 3 | 2 | - | - | - | - | - |
| **CO4** | 3 | 3 | 3 | 2 | 2 | - | - | - | - | 1 |
| **CO5** | 3 | 3 | 3 | 2 | 2 | - | - | - | - | 1 |

| Type | Code | Power System Analysis | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | Students will be able to:<br>1. Study various methods of load flow and their advantages and disadvantages<br>2. Understand how to analyze various types of faults in power system<br>3. Understand power system security concepts and study the methods to rank the contingencies<br>4. Understand need of state estimation and study simple algorithms for state estimation<br>5. Study voltage instability phenomenon |
| **Pre-Requisites (if any)** | Basic knowledge of Mathematics such as Calculus, ordinary differential equations, Matrix. solving circuit problem using nodal and mesh current method, Synchronous Machines |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | **Load flow:** Overview of Newton-Raphson, Gauss-Seidel, fast decoupled methods, convergence properties, Sparsity techniques, handling Qmax violations in constant matrix, inclusion in frequency effects, AVR in load flow, handling of discrete variable in load flow. | **10 Hours** |
| **Module 2** | **Fault Analysis:** Simultaneous faults, open conductors' faults, generalized method of fault analysis. | **8 Hours** |
| **Module 3** | **Security Analysis:** Security state diagram, contingency analysis, generator shift distribution factors, line outage distribution factor, multiple line outages, overload index ranking | **8 Hours** |
| **Module 4** | **Power System Equivalents:** WARD, REI, equivalents; **State Estimation:** Sources of errors in measurement, Virtual and Pseudo, Measurement, Observability, Tracking state estimation, WSL method, bad data correction | **8 Hours** |
| **Module 5** | **Voltage Stability:** Voltage collapse, P-V curve, multiple power flow solution, continuation power flow, optimal multiplies load flow, voltage collapse proximity indices. | **8 Hours** |
| | **Total** | **42 Hours** |

**Text Books:**

T1. J.J. Grainger & W.D.Stevenson, "Power system analysis ", McGraw Hill ,2003

T2. A. R. Bergen & Vijay Vittal , "Power System Analysis" Pearson , 2000

T3. L.P. Singh , "Advanced Power System Analysis and Dynamics", New Age International, 2006

T4. G.L. Kusic, "Computer aided power system analysis" ,Prentice Hall India, 1986

T5. A.J. Wood, " Power generation, operation and control" , John Wiley, 1994

T6. P.M. Anderson, "Faulted power system analysis" , IEEE Press , 1995Reference Books:

**Online Reference Material(s):**

1. http://nptel.ac.in/courses/108102047/26
2. https://courses.engr.illinois.edu/ece476/fa2016/Lecture%20Notes/

3. https://onlinecourses.nptel.ac.in/noc18_ee16/preview

**Course Outcomes:**

| | |
|---|---|
| CO1 | To calculate voltage phasor at all buses , given the data using various methods of load flow |
| CO2 | To calculate fault currents in each phase for symmetrical and unsymmetrical faults in power system |
| CO3 | To rank various contingencies according to their severity in terms of bus voltage and line loading |
| CO4 | To estimate the bus voltage phasor given various quantities viz. power flow, voltages, taps , CB status etc |
| CO5 | To estimate closeness to voltage collapse and calculate PV curves using continuation power flow |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |
| PO8 | Understanding of intellectual property rights and overall professional & ethical responsibility. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | - | - | - | - | - | - |
| CO2 | 3 | 3 | 2 | 2 | - | - | - | - | - | - |
| CO3 | 3 | 2 | 1 | 1 | - | - | 1 | 1 | - | - |
| CO4 | 3 | 2 | 2 | 1 | - | - | 1 | 1 | - | - |
| CO5 | 3 | 3 | 2 | 1 | - | - | - | - | - | - |

| Type | Code | Power System Dynamics | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce the students to basic concepts of power system dynamics. This course will introduce the dynamic behavior of the system and its effect on the stability of the power system. The course will cover different types of stability analysis and methods for improving the stability. |
| **Pre-Requisites (if any)** | Basic knowledge of power systems and operating characteristics of different power system components. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Basic Concepts of Dynamic Systems and Stability Definition, Small Signal Stability (Low Frequency Oscillations) of Unregulated and Regulated System | **8 Hours** |
| **Module 2** | Effect of Damper, Flux Linkage Variation and AVR, Dynamic Analysis of Voltage Stability Voltage Collapse | **10 Hours** |
| **Module 3** | Large Signal Rotor Angle Stability, Dynamic Equivalents and Coherency, Direct Method of Stability Assessment, Stability Enhancing Techniques, Mitigation Using Power System Stabilizer | **10 Hours** |
| **Module 4** | Asynchronous Operation and Resynchronization, Multi-Machine Stability | **8 Hours** |
| **Module 5** | Frequency Stability, Automatic Generation Control, Primary and Secondary Control Sub-Synchronous Resonance and Counter Measures | **8 Hours** |
| | **Total** | **44 Hours** |

**Text Books:**

T1. P. Kundur, "Power System Stability and Control", McGraw Hill Inc, 1994 4. V. Ajjarapu, "Computational Techniques for voltage stability assessment & control"; Springer, 2006

T2. J. Machowski, Bialek, Bumby, "Power System Dynamics and Stability", John Wiley & Sons, 1997

**Reference Books:**

R1. L. Leonard Grigsby (Ed.); "Power System Stability and Control", Second edition, CRC Press, 2007

R2. V. Ajjarapu, "Computational Techniques for voltage stability assessment & control"; Springer, 2006

**Course Outcomes:**

At the end of this course, students will demonstrate the ability

| | |
|---|---|
| CO1 | To analyze the small signal stability of the power system |
| CO2 | study the effect of excitation system and voltage stability of the power system. |
| CO3 | To analyze the rotor angle stability and design techniques to improve the stability of the system. |
| CO4 | To explain the multi machine stability and asynchronous operation . |
| CO5 | To Understand the modelling of automatic generation control of single area and multiarea system and sub |

| | |
|---|---|
| | synchronous resonance in power systems |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:**(1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 1 | 2 | - | - | - | - | - | - |
| CO2 | 3 | 3 | 2 | 2 | - | - | - | - | - | - |
| CO3 | 3 | 2 | 1 | 1 | - | - | 1 | 1 | - | - |
| CO4 | 3 | 2 | 2 | 1 | - | - | 1 | 1 | - | - |
| CO5 | 3 | 3 | 2 | 1 | - | - | - | - | - | - |

| Type | Code | Smart Grid | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | Students will be able to:<br>1. Understand concept of smart grid and its advantages over conventional grid<br>2. Know smart metering technique<br>3. Learn wide area measurement technique<br>4.Understanding the problems associated with integration of distributed generation and its solution through smart grid |
| **Pre-Requisites (if any)** | Basic knowledge of conventional grid, renewable energy systems, power electronics converters |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

### Detailed Syllabus

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | **Smart Grid:** Introduction to Smart Grid, Evolution of Electric Grid. Concept of Smart Grid, Definitions, Need of Smart Grid. Concept of Robust &Self-Healing Grid, Present development & International policies in Smart Grid | **6 Hours** |
| **Module 2** | **Smart meters and sensors:** Introduction to Smart Meters, Real Time Prizing, Smart Appliances. Automatic Meter Reading (AMR). Outage Management System (OMS). Plug in Hybrid Electric Vehicles (PHEV). Vehicle to Grid, Smart Sensors. Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation. Advanced Metering Infrastructure (AMI), Home Area Network (HAN) (HAN). Neighbour hood Area Network (NAN), Wide Area Network (WAN). | **10 Hours** |
| **Module 3** | **Some advance techniques used in Smart grid:** Geographic Information System (GIS). Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro. Compressed Air Energy Storage. Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication. Wireless Mesh Network. Basics of CLOUD Computing &Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols | **12 Hours** |
| **Module 4** | **Micro Grid:** Concept of micro-grid, need & applications of micro-grid Formation of micro-grid, Issues of interconnection. Protection & control of micro-grid. Plastic & Organic solar cells, Thin film solar cells. Variable speed wind generators, fuel-cells, micro-turbines. Captive power plants, Integration of renewable energy sources | **8 Hours** |
| **Module 5** | **Power Quality:** Power Quality & EMC in Smart Grid. Power Quality issues of Grid connected Renewable Energy Sources. Power Quality Conditioners for Smart Grid. Web based Power Quality monitoring, Power Quality Audit | **8 Hours** |
| | **Total** | **44 Hours** |

**Text Books:**

T1. Ali Keyhani, "Design of smart power grid renewable energy systems", Wiley IEEE, 2011.

T2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press, 2009.

T3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, "Smart Grid: Technology and Applications", Wiley 2012.

T4. Stuart Borlas'e, "Smart Grid: Infrastructure, Technology and solutions "CRC Press.

T5. A.G.Phadke , "Synchronized Phasor Measurement and their Applications", Springer.

**Online Reference Material(s):**

https://www.smartgrid.gov/
http://www.nsgm.gov.in/
https://smartgrid.ieee.org/

**Course Outcomes:**

At the end of this course, students will demonstrate the ability

| | |
|---|---|
| CO1 | Appreciate the difference between smart grid & conventional grid. |
| CO2 | Apply smart metering concepts to industrial and commercial installations. |
| CO3 | Formulate solutions in the areas of smart substations, distributed generation and wide area measurements. |
| CO4 | Come up with smart grid solutions using modern communication technologies |
| CO5 | To study the power quality problems associated with integration of renewable energy sources in smart grid . |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Ability to apply the enhanced knowledge in advanced technologies for modeling, analyzing and solving contemporary issues in power sector with a global perspective. |
| PO2 | Ability to identify, analyze and solve real-life engineering problems in the area of Power Systems and provide strategic solutions satisfying the safety, cultural, societal and environmental aspects/ needs. |
| PO3 | Ability for continued pursuance of research and to design, develop and propose theoretical and practical methodologies towards research and development support for the Power System infrastructure. |
| PO4 | Ability to develop and utilize modern tools for modeling, analyzing and solving various Engineering problems related to Power Systems. |
| PO7 | Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| PO8 | Solve professional, legal and ethical issues pertaining to core engineering and its related fields |

**Mapping of CO's to PO's:**(1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | - | - | - | - | - | - | - | - |
| **CO2** | 2 | 3 | 2 | 1 | - | - | - | - | - | - | - | - |
| **CO3** | 3 | 2 | 1 | 2 | - | - | 1 | 1 | - | - | - | - |
| **CO4** | 2 | 2 | 2 | 1 | - | - | 1 | 1 | - | - | - | - |
| **CO5** | 2 | 2 | 1 | 2 | - | - | 1 | - | | - | - | - |

| Type | Code | High Power Converters | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce the students to different type of Power Electronics converters. The students will know about various design aspects as well as protection schemes of the converters. |
| **Pre-Requisites (if any)** | Knowledge of Basic Electronics and semiconductor devices |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Power Electronics Systems: Power Electronics versus Linear Electronics, Classification of power processors and converters, Scope and Applications. Overview of Power Semiconductor Devices: Characteristics of controllable switches; Thyristor, GTO, BJT, IGBT, MCT, Comparison of controllable switches; Rectifiers: Multi pulse Diode rectifiers and multi pulse SCR rectifiers.<br>Multi-level Inverters: two-level voltage source inverter; cascaded, H bridge multilevel inverter, Diode clamped multilevel inverters, flying capacitor multilevel inverter. PWM Current Source Inverter. | **16 Hours** |
| **Module 2** | DC-DC Switch mode Converters: Step-up and Step down converters, Buck-Boost Converters, Cuk converter, half bridge and full bridge converter, forward converter, Flyback converter, control of dc-dc converters.<br>AC Voltage Controllers: AC voltage controllers with PWM control, Cycloconverters: Mid point type and Bridge type with R and RL load, Matrix Converter. | **16 Hours** |
| **Module 3** | Power Conditioners and Uninterruptible Power Supplies: Power line disturbances, power conditioners, UPS.<br>Practical Converter Design and Protection: Snubber Circuits for Thyristor, Transistors, Overvoltage Snubber, Turn –On and Turn-Off Snubber. Gate and Base Drive Circuits: Design considerations, dc coupled drive circuits, Thyristor drive circuits, Cascaded Drive Circuits. | **10 Hours** |
| | **Total** | **42 Hours** |

**Text Books:**

T1. N. Mohan, T. M. Undeland and W. P. Robbins, "Power Electronics: Converter, Applications and Design", John Wiley and Sons, 1989

T2. M.H. Rashid, "Power Electronics", Prentice Hall of India, 1994

**Reference Books:**

R1. B. K .Bose, "Power Electronics and A.C. Drives", Prentice Hall, 1986

R2. Bin Wu, "High power converters and drives", IEEE press, Wiley Enter science

**Course Outcomes:**

| | |
|---|---|
| CO1 | Understand the characteristics of different semiconductor devices and their applications in different converter circuits |
| CO2 | Learn about different topologies of multi-level inverters and also PWM techniques used in VSI and CSI. |
| CO3 | Learn about different dc-dc switch mode converters and their control techniques. |
| CO4 | Acquire knowledge about different AC voltage controllers and their control. |
| CO5 | Know about the requirement of power conditioners and UPS and understand their working. |
| CO6 | Design gate drive circuits and protective circuits for semiconductor devices |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |
| PO8 | Understanding of intellectual property rights and overall professional & ethical responsibility. |
| PO9 | Ability to communicate effectively with a wide range of audience. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | - | - | - | 1 | 1 | - | - | - |
| CO2 | 3 | 3 | 2 | - | 1 | 2 | 1 | - | - | - |
| CO3 | 3 | 3 | 3 | - | 1 | 1 | 1 | - | - | - |
| CO4 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | - | - | - |
| CO5 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | - | - | - |
| CO6 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | - | 1 |

| Type | Code | Wind and Solar Systems | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of the course is to appreciate the importance of energy growth of the power generation from the renewable energy sources and participate in solving these problems. Demonstrate the knowledge of the physics of wind power and solar power generation and all associated issues so as to solve practical problems. To understand the factors involved in installation and commissioning of a Solar or Wind plant. To Learn the dynamics involved when interconnected with power system grid. |
| **Pre-Requisites (if any)** | Basic knowledge of intermediate physics, knowledge of network theory, control system, electrical machines, power electronics. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

### Detailed Syllabus

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Historical development, current status, Network integration issues of wind power generation. | **4 Hours** |
| **Module 2** | Generators and power electronics for wind turbines, power quality standards for wind turbines, Technical regulations for interconnections of wind farm with power systems. | **8 Hours** |
| **Module 3** | Isolated wind systems, reactive power and voltage control, economic aspects. | **8 Hours** |
| **Module 4** | Impacts on power systems dynamics, power systems interconnection | **8 Hours** |
| **Module 5** | Introduction of solar systems, merits and demerits, concentrators, Solar thermal power generation, various applications. | **8 Hours** |
| **Module 6** | PV power generation, Energy Storage device. Designing the solar systems for small installations. | **6 Hours** |
| | **Total** | **42 Hours** |

**Text Books:**

T1. Thomas Ackermann, Editor, "Wind power in Power Systems", John Willy and sons ltd.2005Etamadi Amir, Microgrids: Operation, Control, and Protection, LAP Lambert Academic Publishing.
T2. Siegfried Heier, "Grid integration of wind energy conversion systems", John Willy and sons ltd. 2006
T3. K. Sukhatme and S.P. Sukhatme, "Solar Energy". Tata MacGraw Hill, Second Edition, 1996

**Course Outcomes:**

| | |
|---|---|
| CO1 | To understand Historical development, current status, Network integration issues of wind power generation |
| CO2 | To understand generation, power quality standards & technical regulations for wind energy systems. |
| CO3 | To understand isolated wind systems, reactive power and voltage control |
| CO4 | To analyze dynamic performance of interconnected power system with wind energy systems. |
| CO5 | To learn about solar concentrators, Solar thermal power generation, various applications |
| CO6 | To learn about PV power generation, Energy Storage devices. |

| | |
|---|---|
| CO7 | To Design the solar systems for small installations. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 1 | - | - | 2 | - | - | - |
| CO2 | 3 | 2 | 1 | 1 | - | - | 2 | - | - | - |
| CO3 | 3 | 2 | 1 | 2 | - | - | - | - | - | - |
| CO4 | 3 | 2 | 2 | 2 | - | - | - | - | - | - |
| CO5 | 3 | 3 | 3 | 2 | - | - | - | - | - | - |
| CO6 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |
| CO7 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |

| Type | Code | Renewable Energy Systems | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of the course in to expose the students to real time working principles of distributed generation systems with renewable energy sources. The Students will gain understanding of sizing, economics, dynamics of off-grid and grid-connected renewable energy based distributed generation schemes. |
| **Pre-Requisites (if any)** | Basic knowledge of intermediate physics, knowledge of network theory, control system, electrical machines, power electronics. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Need for Distributed generation. Renewable sources in distributed generation and current scenario in Distributed Generation. | **6 Hours** |
| **Module 2** | Planning of DGs. Sitting and sizing of DGs optimal placement of DG sources in distribution systems. Grid integration of DGs Different types of interfaces, Inverter based DGs and rotating machine-based interfaces. Aggregation of multiple DG units. | **8 Hours** |
| **Module 3** | Technical impacts of DGs. Transmission & Distribution Systems, De-regulation Impact of DGs upon protective relaying. Impact of DGs upon transient and dynamic stability of existing distribution systems, Steady-state and Dynamic analysis. | **8 Hours** |
| **Module 4** | Economic and control aspects of DGs Market facts. Issues and challenges Limitations of DGs, Voltage control techniques. Reactive power control, Harmonics Power quality issues, Reliability of DG based systems. | **8 Hours** |
| **Module 5** | Introduction to micro-grids. Types of micro-grids: autonomous and non-autonomous grids Sizing of micro-grids. Modelling & analysis of Micro-grids with multiple DGs. Micro-grids with power electronic interfacing units. | **8 Hours** |
| **Module 6** | Transients in micro-grids, Protection of micro-grids, Case studies, Advanced topics. | **6 Hours** |
| | **Total** | **44 Hours** |

**Text Books:**

T1. H. Lee Willis, Walter G. Scott, "Distributed Power Generation – Planning and Evaluation", Principles and Applications of Electrical Engg., Rizzoni, McGrawHill

T2. Etamadi Amir, Microgrids: Operation, Control, and Protection, LAP Lambert Academic Publishing

T3. M.GodoySimoes, Felix A.Farret, "Renewable Energy Systems – Design and Analysis with Induction Generators", CRC press.

**Reference Books:**

R1. Stuart Borlase. "Smart Grid: Infrastructure Technology Solutions" CRC

**Course Outcomes:**

| | |
|---|---|
| CO1 | To understand renewable sources in distributed generation (DG) |

| | |
|---|---|
| CO2 | To understand sitting, sizing, optimal placement & grid integration of DG sources in distribution and transmission systems. |
| CO3 | To analyze the steady state and dynamic performance in control of DG systems. |
| CO4 | To study the economics, reliability aspects of DGs. |
| CO5 | To apply modeling techniques to micro grid with multiple DGs and study the transients. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 2 | - | - | 2 | - | - | - |
| CO2 | 3 | 3 | 2 | 2 | - | - | 1 | - | - | - |
| CO3 | 3 | 3 | 2 | 3 | - | - | 2 | - | - | - |
| CO4 | 3 | 3 | 1 | 1 | - | - | 1 | - | - | - |
| CO5 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |

| Type | Code | Research Methodology & IPR | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| CC | | | 2-0-0 | 0 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce students to the principles and practices involved in conducting scientific research. The course is designed to cover three broad areas - The Scientific Method and Hypothesis Testing, Review of Literature and writing Technical Reports, and the elements of Intellectual Property Rights (IPR). |
| **Pre-Requisites** | Basic knowledge of probability & statistics will be helpful. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

### Detailed Syllabus

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Introduction to research, its significance and meaning. Types of research - fundamental, pure, theoretical, applied and experimental. Identification of the research problem and formulation of hypothesis. Research design and errors in research, error analysis. The Scientific Method as the established way of doing research. Data collection, measurement and scaling techniques. | **8 Hours** |
| **Module 2** | Meaning and need for hypothesis, types of hypothesis, functions and characteristics of a good hypothesis. Statistical Testing of Hypothesis - T-test, Chi-squared test. Sampling methods, types of sampling, probability and non-probability sampling. One-sample and Two-sample tests. Regression analysis. | **8 Hours** |
| **Module 3** | Literature - types and review. Literature survey using the web, search engines. Journal, report and thesis writing. Types of reports, structure of the research report and presentation of results. | **8 Hours** |
| **Module 4** | Code of ethics in research - Intellectual Property Rights. Details of Patents, Copyrights, Trademarks and Trade Secrets. | **6 Hours** |
| | **Total** | **30 Hours** |

### Text Books:

T1. C.R. Kothari & G.Garg, ***Research Methodology Methods and Techniques***, 2nd Edition, New Age International Publishers, 2004

T2. D. Chawla & N.Sodhi, ***Research Methodology: Concepts and Cases***, 2nd Edition, Vikas Publishing, 2016

### Reference Books:

R1. E. L. Lehman & J. P. Romano, ***Testing Statistical Hypothesis***, 3rd Edition, Springer, 2008

R2. R. Panneerselvam, ***Research Methodology***, 2nd Edition, Prentice Hall India, 2013

### Online Reference Materials:

1. http://nptel.ac.in/courses/107108011: NPTEL Course on Methodology for Design Research, IISc Bangalore
2. https://ocw.mit.edu/courses/sloan-school-of-management/15-347-doctoral-seminar-in-research-methods-i-fall-2004/readings/: MIT Open Courseware (MIT-OCW), valuable link to a wealth of quality free material.

### Course Outcomes:

| | |
|---|---|
| CO1 | Disseminate the scientific method as a structured way of conducing scientific research. |

| | |
|---|---|
| CO2 | Apply statistical principles for conducting hypothesis testing. |
| CO3 | Conduct effective review of literature and write technical reports. |
| CO4 | Acquire knowledge of the various intellectual property rights. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO8 | Understanding of intellectual property rights and overall professional & ethical responsibility. |
| PO9 | Ability to communicate effectively with a wide range of audience. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 | 1 | - | - | - | - | 1 |
| CO2 | 2 | 2 | 1 | 1 | 1 | - | - | - | - | 1 |
| CO3 | - | - | - | - | 3 | - | - | - | 2 | 1 |
| CO4 | - | - | - | - | - | - | - | 3 | - | 1 |

| Type | Code | Stress Management by Yoga | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| AC | | | 2-0-0 | 0 | 100 |

| | |
|---|---|
| **Objectives** | The art of practicing yoga helps in controlling an individual's mind, body and soul. It brings together physical and mental disciplines to achieve a peaceful body and mind; it helps manage stress and anxiety and keeps you relaxing. It also helps in increasing flexibility, muscle strength and body tone. It improves respiration, energy and vitality. Practicing yoga might seem like just stretching, but it can do much more for your body from the way you feel, look and move.<br>This course aims towards<br>• Attainment of perfect equilibrium and harmony<br>• Promotes self- healing.<br>• Removes negative blocks from the mind and toxins from the body<br>• Enhances personal power<br>• Increases self-awareness<br>• Helps in attention, focus and concentration, especially important for children<br>• Reduces stress and tension in the physical body by activating the parasympathetic nervous system |
| **Pre-Requisites** | Sound state of mind and body |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Introduction, Pranayama, Mudra, Bandha and Chakra | **6 Hours** |
| **Module 2** | Pawanmuktasana Part 1, Standing asana samuha | **6 Hours** |
| **Module 3** | Surya Namskar set | **6 Hours** |
| **Module 4** | Asanas in sitting posture | **6 Hours** |
| **Module 5** | Asanas in Sleeping posture and relaxation asana | **6 Hours** |
| | **Total** | **30 Hours** |

## Text Books:

T1. Edwin F Bryant, **The Yoga Sutra of Patanjali**, 1st edition, North Point Press, 2009

## Reference Books:

R1. Swami SatyanandaSaraswati,**Asana Pranayama Mudra Bandha**, 4th edition, Bihar School Of Yoga (Munger), 2008

## Course Outcomes:

| | |
|---|---|
| CO1 | Promote positive health, prevention of stress related health problems and rehabilitation through Yoga |
| CO2 | Achieve integral approach of Yoga Therapy to common ailments |
| CO3 | Impart skills in them to introduce Yoga for health to general public |
| CO4 | Develop personality of self. |
| CO5 | Invoke scientific attitude and team spirit to channelize energies in to creative and constructive endeavors. |

## Program Outcomes Relevant to the Course:

| | |
|---|---|
| PO6 | Ability to function effectively individually or as a part of a team to accomplish a stated goal. |
| PO9 | Ability to communicate effectively with a wide range of audience. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | - | - | - | 1 | - | - | 3 | 2 |
| CO2 | - | - | - | - | - | - | - | - | - | 3 |
| CO3 | - | - | - | - | - | 2 | - | - | 3 | 3 |
| CO4 | - | - | - | - | - | - | - | - | 3 | 3 |
| CO5 | - | - | - | - | - | 2 | - | - | 2 | 3 |

| Type | Code | Power Systems Laboratory – I | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Practical | | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce the students to advanced concepts of power systems. The course will cover the calculation of performance parameters of transmission systems, their improvement strategies. The course will train the students for performance analysis & their improvement to power systems through software & modern tools. |
| **Pre-Requisites (if any)** | Basic knowledge of Network Theory, Power Systems analysis, Engineering Mathematics. |
| **Teaching Scheme** | Demonstration will be given for each experiment and it is to be executed by students. |

**Evaluation Scheme**

| Attendance | Daily Performance | Record | Lab Test/ Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

**Detailed Syllabus**

| Experiment # | Assignment / Experiment |
|---|---|
| 1 | Study of corona discharge & measurement of breakdown strength of air. |
| 2 | Study of Ferranti effect, voltage profile & determination of A, B, C, D parameters. |
| 3 | Determination of voltage regulation of a HV transmission line with different loading & study different types of compensator used in HV Transmission line to improve voltage regulation |
| 4 | Determination of Bus admittance & impedance matrices for a given power system network. |
| 5 | Load flow study for a given power system using NR & Fast decoupled method. |
| 6 | Optimal generator scheduling for thermal power plants. |
| 7 | Load-frequency control of a single area power system. |
| 8 | Load-frequency control of a two-area power system. |
| 9 | Economic load dispatch in power system. |
| 10 | Transient and Small Signal Stability Analysis: Single-Machine Infinite Bus System. |
| 11 | Transient and Small Signal Stability Analysis: Multi-Machine Power system. |

**Reference books:**

R1. Hadi Sadat-power system analysis – TMH
R2. T.K. Nagsarkar and M.S.Sukhija – power system analysis – Oxford University Press

**Course Outcomes:**

| | |
|---|---|
| CO1 | To understand and model a transmission line. |
| CO2 | To measure performance parameters of a power transmission system. |
| CO3 | To understand load flow analysis of a given power system. |
| CO4 | To understand the concept of load frequency control & economic load dispatch. |
| CO5 | To understand the concept of generator scheduling. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing for various power systems |
| PO2 | Design a modern power system |

| | |
|---|---|
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | - | - | - | - | - | - | - | - |
| CO2 | 3 | 1 | 3 | 3 | 3 | - | - | - | - | 1 |
| CO3 | 3 | 2 | 3 | 2 | 1 | - | - | - | - | 1 |
| CO4 | 3 | 1 | 1 | - | - | - | - | - | - | - |
| CO5 | 3 | 3 | 3 | 1 | 1 | 1 | - | - | - | 1 |

| Type | Code | Renewable Energy Laboratory | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Practical | | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | The objective of the course in to expose the students to real time working principles of renewable energy systems and distributed generation systems |
| **Pre-Requisites (if any)** | Basic knowledge of intermediate physics, knowledge of network theory, control system, electrical machines, power electronics. |
| **Teaching Scheme** | Demonstration will be given for each experiment and it is to be executed by students. |

**Evaluation Scheme**

| Attendance | Daily Performance | Record | Lab Test/ Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

**List of Experiments**

| Sl.No | Topics | Hours |
|---|---|---|
| **1** | To study single PV module, I-V and P-V characteristics with radiation and temperature changing effect | **2 Hours** |
| **2** | To study I-V and P-V characteristics with series and parallel combination of modules. | **2 Hours** |
| **3** | Effect of shading and Effect of tilt angle on I-V and P-V characteristics of solar module. | **2 Hours** |
| **4** | To find MPP by varying the resistive load by varying the duty cycle of DC-DC converter | **2 Hours** |
| **5** | To Determine the efficiency of Wind Energy System | **2 Hours** |
| **6** | To study the effect of Load on Solar Panel Output | **2 Hours** |
| **7** | To determine the output of a biogas plant | **2 Hours** |
| **8** | To determine the efficiency of mini hydro plant | **2 Hours** |
| **9** | To determine the efficiency of grid tied solar PV system | **2 Hours** |
| **10** | To build a wind farm | **2 Hours** |
| **11** | To study power curves of a wind turbine system | **2 Hours** |
| **12** | To study the effect of load on wind turbine output | **2 Hours** |
| **13** | To test the capabilities of Hydrogen fuel cell | **2 Hours** |
| **14** | To study of grid integration of multiple renewable energy sources | **2 Hours** |
| **15** | To Determine the efficiency of a fuel cell | **2 Hours** |

**Course Outcomes:**

At the end of this course, students will demonstrate the ability

| | |
|---|---|
| CO1 | To understand operating characteristics of Solar PV systems |
| CO2 | To analyze various factors affecting the performance of solar PV systems |
| CO3 | To understand operating characteristics of wind energy systems |
| CO4 | To analyze various factors affecting the performance of wind energy systems |

| | |
|---|---|
| CO5 | To understand operating characteristics of Fuel Cell |
| CO6 | To understand operating characteristics of Biogas Plants |
| CO7 | To apply modeling techniques to micro grid with multiple renewable energy system |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing for various power systems |
| PO2 | Design a modern power system |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |
| PO9 | Ability to communicate effectively with a wide range of audience. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 2 | 1 | - | 3 | - | 1 | - |
| **CO2** | 3 | 3 | 3 | 3 | 2 | - | 3 | - | 1 | - |
| **CO3** | 3 | 3 | 3 | 2 | 1 | - | 3 | - | 1 | - |
| **CO4** | 3 | 3 | 3 | 3 | 2 | - | 3 | - | 1 | - |
| **CO5** | 3 | 3 | 3 | 3 | 1 | - | 3 | - | 1 | - |
| **CO6** | 3 | 3 | 3 | 3 | 1 | | 3 | | 1 | |
| **CO7** | 3 | 3 | 3 | 3 | 1 | | 3 | | 1 | |

| Type | Code | Digital Protection of Power System | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to study numerical relays, develop mathematical approach towards protection & study algorithms for numerical protection. |
| **Pre-Requisites (if any)** | Basic knowledge on power systems & power system protection. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

### Detailed Syllabus

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Evolution of digital relays from electromechanical relays, Performance and operational characteristics of digital protection | **4 Hours** |
| **Module 2** | Mathematical background to protection algorithms: Finite difference techniques | **4 Hours** |
| **Module 3** | Interpolation formulae: Forward, backward and central difference interpolation Numerical differentiation, Curve fitting and smoothing, Least squares method, Fourier analysis, Fourier series and Fourier transform, Walsh function analysis | **6 Hours** |
| **Module 4** | Basic elements of digital protection: Signal conditioning: transducers, surge protection, analog filtering, analog multiplexers, Conversion subsystem: the sampling theorem, signal aliasing error, sample and hold circuits, multiplexers, analog to digital conversion, Digital filtering concepts, the digital relay as a unit consisting of hardware and software | **8 Hours** |
| **Module 5** | Sinusoidal wave-based algorithms: Sample and first derivative (Mann and Morrison) algorithm. Fourier and Walsh based algorithms | **4 Hours** |
| **Module 6** | Fourier Algorithm: Full cycle window algorithm, fractional cycle window algorithm. Walsh function-based algorithm. Least Squares based algorithms. Differential equation-based algorithms. Traveling Wave based Techniques. Digital Differential Protection of Transformers. Digital Line Differential Protection. Recent Advances in Digital Protection of Power Systems. | **8 Hours** |
| | **Total** | **34 Hours** |

**Text Books:**

T1. A.G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems”, Wiley/Research studies Press, 2009

T2. S.R. Bhide “Digital Power System Protection” PHI Learning Pvt. Ltd. 2014

**Reference Books:**

R1. A.T. Johns and S. K. Salman, “Digital Protection of Power Systems”, IEEE Press,1999

R2. Gerhard Zeigler, “Numerical Distance Protection”, Siemens Publicis Corporate Publishing, 2006

**Course Outcomes:**

| | |
|---|---|
| CO1 | Learn the importance of Digital Relays. |
| CO2 | Apply Mathematical approach towards protection |
| CO3 | Learn to develop various Protection algorithms |
| CO4 | Lear the basic requirements of digital protection |
| CO5 | Learn numerical protection on various power system elements |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern protective system for power system |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | - | - | - | - | - | - | - | - |
| CO2 | 3 | 1 | 3 | 3 | 3 | - | - | - | - | 1 |
| CO3 | 3 | 2 | 3 | 2 | 1 | - | - | - | - | 1 |
| CO4 | 3 | 1 | 1 | - | - | - | - | - | - | - |
| CO5 | 3 | 3 | 3 | 1 | 1 | 1 | - | - | - | 1 |

| Type | Code | Electrical Power Distribution System | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | To familiarize students with rudimentary concepts and design of modern power distribution system, technologies adopted for its automation, maintenance and protection |
| **Pre-Requisites (if any)** | Basic concepts of power flow, power system operation & control |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Distribution of power, management, power loads, Short term and long term load forecasting, Methods of load forecasting, Power system loading , Technological forecasting | **8 Hours** |
| **Module 2** | Advantages of distribution management system (DMS), Distribution automation, Restoration/ Reconfiguration of distribution network, Different methods and constraints, Power factor correction | **8 Hours** |
| **Module 3** | Interconnection of distribution, Control and communication systems, Remote metering, Automatic meter reading and its implementation | **8 Hours** |
| **Module 4** | SCADA: Introduction and block diagram, Application of SCADA in distribution automation, Common functions of SCADA, Advantages of distribution automation through SCADA | **8 Hours** |
| **Module 5** | Calculation of optimum number of switches, capacitors, Optimum switching device placement in radial distribution systems, Sectionalizing switches: Types and benefits, Bellman's optimality principle, Remote terminal units, Energy efficiency in electrical distribution and monitoring | **6 Hours** |
| **Module 6** | Maintenance of automated distribution system, Difficulties in implementing distribution, Automation in actual practice , Urban / rural distribution, Energy management, Artificial Intelligence techniques applied to distribution automation | **6 Hours** |
| | **Total** | **44 Hours** |

**Text Books:**

T1. "Electric Power Distribution", A.S. Pabla, Tata McGraw Hill Publishing Co. Ltd., 4th Edition

T2. "A Text Book of Electrical Power Distribution Automation", M.K.Khedkar, G.M. Dhole, University Science Press, New Delhi

T3. "Electrical Distribution Engineering", Anthony J Panseni, CRC Press.

T4. "Electric Power Distribution, Automation, Protection & Control", James Momoh, CRC Press.

**Course Outcomes:**

| | |
|---|---|
| CO1 | Provides nitty gritty of distribution of electrical power and methods of load forecasting |

| | |
|---|---|
| CO2 | Provides a brief idea regarding distribution management system, interconnected power system and power system automation |
| CO3 | Introduces students to SCADA and its application |
| CO4 | Discusses various applications of artificial intelligence technique in distribution automation |
| CO5 | To find the optimal placement of switching devices in distribution network to minimize losses and improve the performance |
| CO6 | To study different aspects of distribution system maintenance and energy management. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern protective system for power system |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |

**Mapping of CO's to PO's:**(1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | - | 2 | 3 | - | - | - | - |
| **CO2** | 3 | 3 | - | - | 2 | 3 | - | - | - | - |
| **CO3** | 2 | 2 | 2 | - | 3 | 2 | - | - | - | - |
| **CO4** | 2 | 2 | 2 | - | 3 | 3 | - | - | - | - |
| **CO5** | 3 | 2 | 2 | - | 2 | 2 | | - | - | - |
| **CO6** | 2 | 3 | 3 | - | 2 | 2 | - | - | - | - |

| Type | Code | Pulse Width Modulation for PE converters | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce the necessary knowledge to understand the PWM techniques and implementation of various PWM controllers. |
| **Pre-Requisites (if any)** | Basic concepts of converter topology, PE converters and its analysis of PWM switching schemes and some knowledge of MATLAB. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

### Detailed Syllabus

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Introduction to power electronics converters, Modulation scheme of one inverter phase leg, Modulation strategy of single phase converter, voltage source inverter and its analysis. | **8 Hours** |
| **Module 2** | Modulation strategies based on zero space vector placement, Losses-discontinuous modulation technique, Modulation technique for CSI. | **8 Hours** |
| **Module 3** | Analysis of converters with over modulation technique, programme modulation strategies applied to converters. | **8 Hours** |
| **Module 4** | Different modulation schemes for multilevel inverters, Implementation of modulation controller. | **8 Hours** |
| **Module 5** | Developments in modulation as random PWM, Application of PWM for voltage unbalance system. | **6 Hours** |
| **Module 6** | Minimum pulse width and its effect, necessity of providing dead time | **6 Hours** |
| | **Total** | **44 Hours** |

**Text Books:**

T1. D. Grahame Holmes, Thomas A. Lipo, "Pulse width modulation of Power Converter: Principles and Practice", John Wiley & Sons, 03-Oct-2003.

T2. Ned Mohan, Tore M. Undeland and William P. Robbins**, "**Power Electronics: Converters, Applications, and Design", John Wiley & Sons.

T3. Bin Vew, "High Power Converter", Wiley Publication

**Reference Books:**

R1. Marian K. Kazimicrczuk, "Pulse width modulated dc-dc power converter", Wiley Publication.

R2. **Dokić**, Branko L., **Blanuša**, Branko, "Power Electronics: Converters and Regulators", Springer Publication.

**Course Outcomes:**

| | |
|---|---|
| CO1 | To provide the students a deep insight in to the power electronics converters and its modulation techniques. |
| CO2 | To study advanced modulation strategies such as zero space vector placement, loss discontinuous and modulation applied to current source inverter. |
| CO3 | To analyze the concept of over modulation and programmed modulation techniques applied to converters. |

| | |
|---|---|
| CO4 | To study advanced switching (modulation) techniques implemented in multilevel inverter and its control strategies. |
| CO5 | To study development in modulation scheme and its application for unbalanced voltage system. |
| CO6 | To study the necessity of providing minimum pulse width and its effect. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 1 | 2 | - | - | - | - |
| CO2 | 3 | 2 | 2 | 1 | 2 | 1 | - | - | - | - |
| CO3 | 3 | 2 | 1 | 1 | 1 | 2 | - | - | - | - |
| CO4 | 2 | 2 | 3 | 1 | 2 | 2 | - | - | - | - |
| CO5 | 2 | 2 | 2 | 1 | 2 | 2 | - | - | - | - |
| CO6 | 2 | 1 | 2 | 1 | 1 | 1 | - | - | - | - |

| Type | Code | Electric and Hybrid Vehicles | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of the course is to learn upcoming technology of hybrid systems, different aspects of drive applications and electric Traction. |
| **Pre-Requisites (if any)** | Basic knowledge on drives and power system operations. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization Transmission characteristics, Mathematical models to describe vehicle performance | **8 Hours** |
| **Module 2** | Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis. | **8 Hours** |
| **Module 3** | Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives configuration and control of Permanent Magnet Motor drives Configuration and control of Switch Reluctance, Motor drives, drive system efficiency | **8 Hours** |
| **Module 4** | Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics Selecting the energy storage technology, Communications, supporting subsystems | **8 Hours** |
| **Module 5** | Introduction to energy management and their strategies used in hybrid and electric vehicle, Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies | **6 Hours** |
| | **Total** | **38 Hours** |

**Text Books:**

T1. Sira -Ramirez, R. Silva Ortigoza, "Control Design Techniques in Power Electronics Devices", Springer.

T2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, "Sliding mode control of switching Power Converters"

**Reference Books:**

R1. Advanced Hybrid and Electric Vehicles: System Optimization and Vehicle Integration

**Online Reference Material(s):**

1. https://nptel.ac.in/downloads/108103009/
2. https://www1.eere.energy.gov/hydrogenandfuelcells/tech_validation/.../fcm08r0.pdf

**Course Outcomes:**

| | |
|---|---|
| CO1 | To learn the basic concepts, mathematical models and social/environmental importance of hybrid and electric vehicles |
| CO2 | To learn fundamental concepts of hybrid tractions, hybrid drive-train topologies and hybrid drive-train topologies |
| CO3 | To understand and learn about different drive applications |
| CO4 | Learn about energy management in hybrid and electric vehicle |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | 3 | 1 | 2 | - | - | - |
| CO2 | 2 | 2 | 1 | 1 | 2 | 1 | - | - | - | - |
| CO3 | 3 | 1 | - | - | 1 | 1 | - | - | - | - |
| CO4 | 1 | 1 | 1 | - | 2 | 3 | 2 | - | - | - |

| Type | Code | Restructured Power Systems | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to make the students understand what is meant by restructuring of the electricity market. The course will also help the students understand the need behind requirement for deregulation of the electricity market. The course will train the students about the basic money, power & information flow in a deregulated power system. |
| **Pre-Requisites (if any)** | Basic knowledge of Power Systems. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Fundamentals of restructured system, Market architecture, Load elasticity, Social welfare maximization. | **8 Hours** |
| **Module 2** | OPF: Role in vertically integrated systems and in restructured markets, congestion management. | **8 Hours** |
| **Module 3** | Optimal bidding, Risk assessment, Hedging, Transmission pricing, Tracing of power. | **8 Hours** |
| **Module 4** | Ancillary services, Standard market design, Distributed generation in restructured markets. | **8 Hours** |
| **Module 5** | Developments in India, IT applications in restructured markets. | **6 Hours** |
| **Module 6** | Working of restructured power systems, PJM, Recent trends in Restructuring. | **6 Hours** |
| | **Total** | **44 Hours** |

**Text Books:**

T1. Lorrin Philipson, H. Lee Willis, "Understanding electric utilities and de-regulation", Marcel Dekker Pub.,1998

T2. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley and Sons, 2002

**Reference Books:**

R1. Kankar Bhattacharya, Jaap E. Daadler, Math H.J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub.,2001

R2. Mohammad Shahidehpour, MuwaffaqAlomoush, "Restructured electrical power systems: operation, trading and volatility", MarcelDekker

**Online Reference Material(s):**

1. http://nptel.ac.in/courses/108101005/
2. http://nptel.ac.in/courses/108101005/2
3. https://ieeexplore.ieee.org/stamp/sta/mp.jsp?arnumber=993762
4. https://www.slideshare.net/sarapluto999/restructuring-of-power-grid

**Course Outcomes:**

| | |
|---|---|
| CO1 | Describe the Technical and Non-technical issues in Deregulated Power Industry. |
| CO2 | Identify the need of regulation and deregulation. |
| CO3 | Describe the working and various other aspects of restructured power system. |
| CO4 | Discuss the recent trends and applications in restructured markets. |
| CO5 | Classify different market mechanisms and summarize the role of various entities in the market. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies. |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | - | - | 2 | 2 | - | - | - | - |
| CO2 | - | - | - | - | - | 2 | - | - | - | - |
| CO3 | - | - | - | - | - | - | - | - | - | - |
| CO4 | - | - | - | - | 2 | 2 | - | - | - | - |
| CO5 | - | - | - | - | - | 1 | - | - | - | - |

| Type | Code | Advanced Digital Signal Processing | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| PC | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | 1) To make students comprehend mathematical description and modeling of discrete time random signals.<br>2) Choose filter structures according to their performance characteristics: sensitivity, complexity, delay, etc<br>3) To make students familiar with the estimation, prediction and filtering concepts and techniques.<br>4) To develop a good understanding of the DSP based real time data processing system for various DSP based high speed applications. |
| **Pre-Requisites (if any)** | Knowledge about Signals & Systems & Digital Signal Processing. |
| **Teaching Scheme** | Regular classroom lectures with use of signal processing tools as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | **Total** |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| | ***Introduction and pre-requisites** | **2 Hours** |
| **Module 1** | Overview of DSP, Characterization in time and frequency, FFT Algorithms, Digital filter design and structures: Basic FIR/IIR filter design &structures, design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures, parallel realization of IIR. | **10 Hours** |
| **Module 2** | Multi rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator & interpolator, poly phase filters, QMF, digital filter banks, Applications in subband coding. | **5 Hours** |
| **Module 3** | Linear prediction & optimum linear filters, stationary random process, forward-backward linear prediction filters, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction. | **8 Hours** |
| **Module 4** | Adaptive Filters, Applications, Gradient Adaptive Lattice, Minimum mean square criterion, LMS algorithm, Recursive Least Square algorithm | **6 Hours** |
| **Module 5** | Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for Power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation. | **8 Hours** |
| **Module 6** | Application of DSP & Multi rate DSP, Application to Radar, introduction to wavelets, application to image processing, design of phase shifters, DSP in speech processing & other applications | **5 Hours** |
| | **Total** | **44 Hours** |

**Reference Books:**

1. J.G.Proakis and D.G.Manolakis"Digital signal processing: Principles, Algorithm and Applications, 4th Edition, Prentice Hall, 2007.
2. N. J. Fliege, "Multirate Digital Signal Processing: Multirate Systems -Filter Banks- Wavelets, 1st Edition, John Wiley and Sons Ltd, 1999.
3. Bruce W. Suter, "Multirate and Wavelet Signal Processing",1st Edition, Academic Press, 1997.

4. M. H. Hayes, “Statistical Digital Signal Processing and Modeling”, John Wiley & Sons Inc., 2002.
5. S.Haykin, “Adaptive Filter Theory”, 4th Edition, Prentice Hall, 2001.
6. D.G.Manolakis, V.K. Ingle and S.M.Kogon, “Statistical and Adaptive Signal Processing, McGraw Hill, 2000

**Course Outcomes:**

| | |
|---|---|
| CO1 | Analyze, design and implement digital systems using the DFT and (FFT). |
| CO2 | Design and analyze frequency-selective digital filters using various filtering methods. |
| CO3 | Acquire the basics of multi rate digital signal processing. |
| CO4 | Analyze and implement power spectrum estimation techniques. |
| CO5 | Learn the Principles of adaptive filtering and implement algorithms of adaptation |
| CO6 | Apply signal processing techniques in different areas such as image processing, wireless communication, biomedical engineering, speech processing, video processing, etc. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO’s to PO’s:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | | 1 | 3 | 2 | 1 | 2 | | | 3 |
| CO2 | 3 | | 1 | 3 | 2 | 1 | 2 | | | 3 |
| CO3 | 3 | | 2 | 3 | 2 | 1 | 1 | | | 3 |
| CO4 | 3 | | 1 | 3 | 2 | 2 | 3 | | | 3 |
| CO5 | 3 | | 2 | 3 | 3 | 2 | 3 | | | 3 |

| Type | Code | Dynamics of Electrical Machines | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | Students will be able to Learn Performance characteristics and dynamics of machine and its stability studies. |
| **Pre-Requisites (if any)** | Basic knowledge of Electrical machines and its dynamic equations and some knowledge of MATLAB. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Primitive four winding Commutator machine, Commutator primitive machine, complete voltage equation of primitive four winding Commutator machine and its stability studies. | **8 Hours** |
| **Module 2** | Torque dynamics of simple DC machines using the primitive model, the three phase induction motor, transformed equations, and different reference frames theories for analysis induction motor, transfer function model. | **8 Hours** |
| **Module 3** | Three phase salient pole synchronous machine, three phase to two phase transformation theory (Parks Transformation), Clerk transformation, , steady state analysis | **8 Hours** |
| **Module 4** | Large signal transient study, State variable analysis of small oscillation equations Dynamics of interconnected machines. | **8 Hours** |
| **Module 5** | Using transformed equations for large signal transient study, DC generator and DC motor system and its performance analysis. | **6 Hours** |
| **Module 6** | Alternator and synchronous motor system and its dynamics as well as steady state analysis. | **6 Hours** |
| | **Total** | **44 Hours** |

**Text Books:**

T1. Bernard Adkins and Ronald G. Harley, "The General Theory of Alternating Current Machines: Application to Practical Problems", Springer.

T2. D.P. Sengupta & J.B. Lynn," Electrical Machine Dynamics", The Macmillan Press Ltd. 1980

T3. R Krishnan "Electric Motor Drives, Modeling, Analysis, and Control", Pearson Education., 2001

**Reference Books:**

R1. P.C. Kraus, "Analysis of Electrical Machines", McGraw Hill Book Company, 1987

R2. I. Boldia& S.A. Nasar, "Electrical Machine Dynamics", The Macmillan Press Ltd. 1992

R3. C.V. Jones, "The Unified Theory of Electrical Machines", Butterworth, London. 1967

**Course Outcomes:**

| | |
|---|---|
| CO1 | To provide the students a thorough concept of performance characteristics of primitive machine and its stability studies. |

| | |
|---|---|
| CO2 | To study the torque dynamics of primitive modeled DC machine, induction motor dynamics, transformed equation and various reference frame theories of induction motor. |
| CO3 | To analyze the concept of synchronous machine and its analysis. |
| CO4 | To study the machine dynamics and its stability analysis. |
| CO5 | To understand the transient study using transformed equation and to study the DC generator and DC motor system |
| CO6 | To study the concept of synchronous machine system. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 2 | 2 | 1 | 1 | 2 | - | - | - | - |
| CO2 | 2 | 2 | 1 | 1 | 2 | 1 | - | - | - | - |
| CO3 | 1 | 2 | 1 | 1 | 2 | 2 | - | - | - | - |
| CO4 | 2 | 2 | 2 | 1 | 2 | 2 | - | - | - | - |
| CO5 | 2 | 2 | 2 | 1 | 2 | 2 | - | - | - | - |
| CO6 | 2 | 1 | 2 | 2 | 2 | 1 | - | - | - | - |

| Type | Code | Power Apparatus Design | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | PE3 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The Students will be able to:<br>1. Study the modeling analysis of rotating machine.<br>2. Learning electromagnetic energy conversion<br>3. To know about rating of machines |
| **Pre-Requisites (if any)** | Knowledge of Basic electrical engineering, electrical machine and design. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Principles of Design of Machines -Specific loadings, choice of magnetic and electric loadings, Real and apparent flux densities, temperature rise calculation, Separation of main dimension for DC machines, Induction machines and synchronous machines, Design of Transformers-General considerations, Output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling. | **8 Hours** |
| **Module 2** | Specific loadings, choice of magnetic and electric loadings Real and apparent flux -densities, temperature rise calculation, Separation of main dimension for DC machines, Induction machines and synchronous machines, Heating and cooling of machines, types of ventilation, continuous and intermittent rating. | **8 Hours** |
| **Module 3** | General considerations, output equation, emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size, design of tank and cooling tubes, Calculation of losses, efficiency and regulation, Forces winding during short circuit | **8 Hours** |
| **Module 4** | General considerations, output equation, Choice of specific electric and magnetic loadings, efficiency, power factor, Number of slots in stator and rotor, Elimination of harmonic torques | **8 Hours** |
| **Module 5** | Design of stator and rotor winding, slot leakage flux, Leakage reactance, Equivalent resistance of squirrel cage rotor, Magnetizing current, efficiency from design data | **6 Hours** |
| **Module 6** | Types of alternators, comparison, specific loadings, output co-efficient, design of main dimensions, Introduction to Computer Aided Electrical Machine Design Energy efficient machines | **6 Hours** |
| | **Total** | **44 Hours** |

**Reference Books:**

R1. Clayton A.E, "The Performance and Design of D.C. Machines", Sir I. Pitman & sons, Ltd.
R2. M.G. Say, "The Performance and Design of A.C. Machines ", Pitman
R3. Sawhney A.K, "A course in Electrical Machine Design", Dhanpat Rai & Sons, 5th Edition

**Online Reference Material(s):**

1. https://www.slideshare.net/.../lecture-1-fundamental-of-electricity

2. https://www.tutorialspoint.com/gate_syllabus/gate_electrical
3. https://www.tutorialspoint.com/theory_of_machines
4. https://www.smartzworld.com/notes/electrical-measurements-em
5. https://lecturenotes.in/subject/113/electrical-power-transmission...
6. https://onlinecourses.nptel.ac.in
7. https://en.wikipedia.org/wiki
8. https://www.electrical4u.com/

**Course Outcomes:**

| | |
|---|---|
| CO1 | To model all rotating machines under both transient and steady state conditions with the dimensions and material used. |
| CO2 | To model and design all types of rotating machines including special machines. |
| CO3 | To analyze and design a transformer with general considerations such as emf per turn, choice of flux density and current density, main dimensions, leakage reactance and conductor size etc. |
| CO4 | To design Computer Aided Electrical Machine. |
| CO5 | To apply the knowledge of the electrical apparatus in industry oriented applications. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO8 | Understanding of intellectual property rights and overall professional & ethical responsibility. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO’s to PO’s:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | 1 | 1 | - | - | - | 1 |
| CO2 | 3 | 3 | 3 | 3 | 1 | 1 | - | - | - | - |
| CO3 | 3 | 3 | 2 | 2 | 1 | 1 | - | - | - | - |
| CO4 | 3 | 2 | 2 | 2 | 1 | 1 | - | - | - | 1 |
| CO5 | 3 | 2 | 2 | 2 | 1 | 2 | - | 1 | - | 1 |

| Type | Code | Advanced Microcontroller based Systems | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | Students will be able to:<br>1. To understand the architecture of advance microcontrollers<br>2. To understand the applications of these controllers<br>3. To get some introduction to FPGA |
| **Pre-Requisites (if any)** | Basic knowledge of electrical and electronics, programming in any language |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Basic Computer Organization, Accumulator based Processes-Architecture, Memory Organization-I/O Organization | **6 Hours** |
| **Module 2** | Micro-Controllers-Intel 8051, Intel 8056- Registers, Memories, I/O Ports, Serial Communication, Timers, Interrupts, Programming | **8 Hours** |
| **Module 3** | Intel 8051 – Assembly language programming, Addressing-Operations, Stack & Subroutines, Interrupts-DMA | **8 Hours** |
| **Module 4** | PIC 16F877- Architecture Programming, Interfacing Memory/ I/O Devices, Serial I/O and data communication | **8 Hours** |
| **Module 5** | Digital Signal Processor (DSP), Architecture – Programming, Introduction to FPGA | **6 Hours** |
| **Module 6** | Microcontroller development for motor control applications, Stepper motor control using micro controller | **6 Hours** |
| | **Total** | **42 Hours** |

**Text Books:**

T1. John.F.Wakerly: “Microcomputer Architecture and Programming”, John Wiley and Sons 1981
T2. Ramesh S.Gaonker: “Microprocessor Architecture, Programming and Applications with the 8085”, Penram International Publishing (India), 1994
T3. John Morton,” The PIC microcontroller: your personal introductory course”, Elsevier, 2005

**Reference Books:**

R1. Raj Kamal: “The Concepts and Features of Microcontrollers”, Wheeler Publishing, 2005
R2. Kenneth J. Ayala, “The 8051 microcontrollers”, Cengage Learning, 2004
R3. Dogan Ibrahim,” Advanced PIC microcontroller projects in C: from USB to RTOS with the PIC18F Series”, Elsevier, 2008
R4. Microchip datasheets for PIC16F877

**Course Outcomes:**

| | |
|---|---|
| CO1 | To Understand the architecture and organization of a microcontroller or microprocessor |
| CO2 | To understand the operation of different microcontrollers as well as DSP based systems |
| CO3 | To program a microcontroller or microprocessor using assembly language |
| CO4 | To compile and debug a program and generate an executable file and use it |
| CO5 | To configure and use different peripherals in a digital system |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | - | - | - | - | - | - | - | - | - |
| CO2 | 1 | - | - | - | - | - | - | - | - | - |
| CO3 | 1 | - | 2 | 1 | - | - | - | - | - | - |
| CO4 | - | - | 1 | - | - | - | - | - | - | - |
| CO5 | 1 | 2 | 3 | 1 | - | 1 | - | - | - | - |

| Type | Code | SCADA System and Applications | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of the course is to know the SCADA communication, Operations and applications. |
| **Pre-Requisites (if any)** | Basic knowledge on communication, automation and power system operation and control. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

### Detailed Syllabus

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Introduction to SCADA, Data acquisition systems, Evolution of SCADA, Communication technologies | **8 Hours** |
| **Module 2** | Monitoring and supervisory functions, SCADA applications in Utility Automation, Industries SCADA | **6 Hours** |
| **Module 3** | Industries SCADA System Components, Schemes- Remote Terminal Unit (RTU), Intelligent Electronic Devices(IED), Programmable Logic Controller (PLC), Communication Network, SCADA Server, SCADA/HMI Systems | **8 Hours** |
| **Module 4** | SCADA Architecture, Various SCADA architectures, advantages and disadvantages of each system, Single unified standard architecture -IEC 61850. | **8 Hours** |
| **Module 5** | SCADA Communication, Various industrial communication technologies, Wired and wireless methods and fiber optics, Open standard communication protocols | **8 Hours** |
| **Module 6** | SCADA Applications: Utility applications, Transmission and Distribution sector operations, monitoring, analysis and improvement, Industries - oil, gas and water, Case studies, Implementation, Simulation Exercises | **6 Hours** |
| | **Total** | **44 Hours** |

**Text Books:**

T1. Stuart A. Boyer: "SCADA-Supervisory Control and Data Acquisition", Instrument Society of America Publications, USA, 2004.

T2. Gordon Clarke, Deon Reynders: "Practical Modern SCADA Protocols: DNP3, 60870.5 and Related Systems", Newnes Publications, Oxford, UK, 2004.

T3. William T. Shaw, "Cybersecurity for SCADA systems", PennWell Books, 2006.

**Reference Books:**

R1. David Bailey, Edwin Wright, "Practical SCADA for industry", Newnes, 2003.

R2. Wiebe "A guide to utility automation: AMR, SCADA, and IT systems for electric power", PennWell 1999.

**Online Reference Material(s):**

1. https://nptel.ac.in/courses/108106022/8

2. https://electrical-engineering-portal.com/an-introduction-to-scada-for-electrical-engineers-beginners
3. https://www.scribd.com/document/246856029/Study-Material-Forplc-Scada

**Course Outcomes:**

| | |
|---|---|
| CO1 | Basic knowledge on supervisory control and their applications |
| CO2 | Various architectures of SCADA systems with their advantages and limitations |
| CO3 | Overview on single unified standard architecture IEC 61850 |
| CO4 | Learn about remote terminal units, PLCs, intelligent electronic devices, HMI systems, SCADA server. |
| CO5 | Knowledge on applications of SCADA systems on distribution sector and in various industries. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 1 | 1 | 2 | 1 | - | - | - | - |
| CO2 | 0 | 1 | - | - | 1 | 1 | - | - | - | - |
| CO3 | 0 | 1 | - | - | 1 | 1 | - | - | - | - |
| CO4 | 3 | 2 | 1 | 1 | 2 | 3 | - | - | - | - |
| CO5 | 3 | 2 | 1 | - | 1 | 3 | - | - | - | - |

| Type | Code | Power Quality | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Theory | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of EPQ is to introduce students to the fundamentals of electrical power quality, its effect on cost of electrical power, learn the definitions of power quality problems based on various standards understand the principles of mitigation and learn about mitigating and monitoring equipments. |
| **Pre-Requisites (if any)** | Basic knowledge of intermediate physics, knowledge of network theory, control system, electrical machines, power electronics. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

### Detailed Syllabus

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Introduction-power quality-voltage quality-overview of power, Quality phenomena classification of power quality issues, Power quality measures and standards-THD-TIF-DIN-C-message weights, Flicker factor transient phenomena-occurrence of power quality problems, Power acceptability curves-IEEE guides, Standards and recommended practices. | **5 Hours** |
| **Module 2** | Harmonics-individual and total harmonic distortion, RMS value of a harmonic waveform, Triplex harmonics, Important harmonic introducing devices, SMPS Three phase power converters-arcing devices saturable devices, Harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads. | **8 Hours** |
| **Module 3** | Modelling of networks and components under non-sinusoidal conditions, Transmission and distribution systems, Shunt capacitors-transformers, Electric machines, Ground systems loads that cause power quality problems. Power quality problems created by drives and its impact on drive. | **6 Hours** |
| **Module 4** | Power factor improvement- Passive Compensation, Passive Filtering. Harmonic Resonance. Impedance Scan Analysis, Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC based on Bilateral Single Phase and Three Phase Converter. | **6 Hours** |
| **Module 5** | Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - Design hypothesis. | **8 Hours** |
| **Module 6** | Introduction to design method based on the use of Lyapunov function. Design and simulation of variable structure adaptive model following control. | **8 Hours** |
| | **Total** | **42 Hours** |

**Text Books:**

T1. G.T. Heydt, "Electric power quality", McGraw-Hill Professional, 2007
T2. Math H. Bollen, "Understanding Power Quality Problems", IEEE Press, 2000
T3. "Electrical Power Systems Quality" By Roger C. Dugan, Mark F. Mcgranaghan, Surya Santoso & H.WayneBeaty, 2nd Edition, TMH Education Private Ltd., New Delhi.

**Reference Books:**

R1. J. Arrillaga, "Power System Quality Assessment", John wiley, 2000
R2. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,"Power system Harmonic Analysis", Wiley, 1997

**Course Outcomes:**

| | |
|---|---|
| CO1 | To understand importance of power quality with power quality issues & standards |
| CO2 | To understand Harmonics and its sources in power systems |
| CO3 | To model power systems under non-sinusoidal condition for transient studies. |
| CO4 | To understand and analyze the solutions to mitigate power quality problems |
| CO5 | To design model reference adaptive systems for power quality problems |
| CO6 | To design variable structure control for power quality systems |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | - | - | 1 | - | - | - |
| CO2 | 3 | 2 | 2 | 2 | - | - | 1 | - | - | - |
| CO3 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |
| CO4 | 3 | 2 | 3 | 2 | - | - | 1 | - | - | - |
| CO5 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |
| CO6 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |
| CO7 | 3 | 3 | 3 | 3 | - | - | - | - | - | - |

| Type | Code | AI Techniques | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| PE | | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The aim of this course is to introduce to the field of Artificial Intelligence(AI) with emphasis on its use to solve real world problems for which solutions are difficult to express using the traditional algorithmic approach. It explores the essential theory behind methodologies for developing systems that demonstrate intelligent behavior including dealing with uncertainty. |
| **Pre-Requisites (if any)** | Data structures and Data Management |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Biological foundations to intelligent systems I: Artificial neural networks, Back propagation networks, Radial basis function networks, and recurrent networks. | **10 Hours** |
| **Module 2** | Biological foundations to intelligent systems II: Fuzzy logic, knowledge Representation and inference mechanism, genetic algorithm, and fuzzy neural networks. | **8 Hours** |
| **Module 3** | Search Methods Basic concepts of graph and tree search. Three simple search methods: breadth-first search, depth-first search, iterative deepening search. Heuristic search methods: best-first search, admissible evaluation functions, hillclimbing search. Optimization and search such as stochastic annealing and genetic algorithm. | **8 Hours** |
| **Module 4** | Knowledge representation and logical inference Issues in knowledge representation. Structured representation, such as frames, and scripts, semantic networks and conceptual graphs. Formal logic and logical inference. Knowledge-based systems structures, its basic components. Ideas of Blackboard architectures. | **9 Hours** |
| **Module 5** | Reasoning under uncertainty and Learning Techniques on uncertainty reasoning such as Bayesian reasoning, Certainty factors and Dempster-Shafer Theory of Evidential reasoning, A study of different learning and evolutionary algorithms, such as statistical learning and induction learning. | **8 Hours** |
| **Module 6** | Recent trends in Fuzzy logic, Knowledge Representation | **5 Hours** |
| | **Total** | **48 Hours** |

**Text Books:**

T1. Stuart Russell and Peter Norvig, ***Artificial Intelligence: A Modern Approach***, 2nd Edition, Prentice-Hal, 2011

**Reference Books:**

R1. Nils J. Nilsson, ***Artificial Intelligence: A New Sythesis***, Morgan-Kaufmann, 2003

R2. G. F. Luger and W. A. Stubblefield, ***Artificial Intelligence: Structures and strategies for Complex Problem Solving***. 6th Edition, Addison Wesley, 2008

**Online Reference Materials:**

1. http://www.princeton.edu/~stengel/MAE345.html : Online reference material Robotics and Intelligent Systems from Princeton University, New Jersy, USA

2. http://nptel.ac.in/courses/108104049/: Online reference material from IIT Kanpur (NPTEL – E-Learning Courses from IIT & IISc)

**Course Outcomes:**

| | |
|---|---|
| CO1 | Demonstrate the fundamental principles of intelligent systems. |
| CO2 | Conceive the concepts of knowledge representation and inference mechanism. |
| CO3 | Explore different techniques to solve artificial intelligence problems by searching. |
| CO4 | Grasp the concepts of adversarial search and constraint satisfaction problems. |
| CO5 | Envisage the need of quantifying uncertainty and probabilistic reasoning. |
| CO6 | Apply the fuzzy reasoning rules and knowledge representation in real life problem solving. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |
| PO8 | Understanding of intellectual property rights and overall professional & ethical responsibility. |
| PO9 | Ability to communicate effectively with a wide range of audience. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | - | 2 | 1 | 1 | 1 | - | - | - | 2 |
| CO2 | 3 | - | 2 | 2 | 2 | 2 | - | - | - | 3 |
| CO3 | 2 | - | 3 | 2 | 3 | 1 | - | - | - | 2 |
| CO4 | 2 | - | 2 | 1 | 2 | 1 | - | - | - | 1 |
| CO5 | 2 | - | 2 | 2 | 2 | 2 | - | - | - | 2 |
| CO6 | 2 | - | 2 | 2 | 2 | 3 | - | - | - | 3 |

| Type | Code | English for Research Paper Writing | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| AC | | | 2-0-0 | 0 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to give learners an exposure to different aspects of research related writing and to help them write such matter effectively through practice. |
| **Pre-Requisites (if any)** | Basic knowledge of English grammar and the ability to read and write using the English language |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

**Evaluation Scheme**

| Teacher's Assessment | | | Institute Assessment | | Total |
|---|---|---|---|---|---|
| Quiz | Surprise Test(s) | Assignment(s) | Mid-Semester | End-Semester | |
| 05 | 05 | 05 | 25 | 60 | 100 |

**Detailed Syllabus**

| Module # | Topics | Hours |
|---|---|---|
| **Module 1** | Technical Communication: Differentiating between general and technical writing, purpose of writing, plain English, mechanics of writing, elements of style. Essentials of English Grammar: basic word order, tense forms, reported speech, use of passives, conditionals, concord, clauses, common errors. | **12 Hours** |
| **Module 2** | Elements of Writing: Process writing, developing an effective paragraph, qualities of a paragraph, structuring a paragraph, types of essays, writing reports. | **8 Hours** |
| **Module 3** | Key Reading Skills: sub-skills of reading, local and global comprehension, types of technical texts, critical analysis of technical texts, note-making, the purpose and importance of literature review, evaluating literature. | **10 Hours** |
| **Module 4** | Developing Writing Skills: writing abstracts, technical letters, project reports, elements of proposal writing. | **12 Hours** |
| **Module 5** | Research and Writing: The research paper as a form of communication, Writing a review of Literature, developing a hypothesis, formulating a thesis statement, plagiarism issues. | **6 Hours** |
| | **Total** | **48 Hours** |

**Text Books:**

T1. Carol Ellison, McGraw-Hills Concise Guide to Writing Research Papers, McGraw-Hills, 2010.

T2. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg, London, 2011

T3. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

**Reference Books:**

R1. Goldbort R (2006) Writing for Science, Yale University Press (Available on Google books)

R2. Highman N (1998) Handbook of Writing for the Mathematical Sciences, SIAN, Highman's book

R3. Kothari C.R. (2004) Research Methodology: methods and techniques, New Age International (P) limited, Publishers

**Online Reference Material(s):**

1. https://msu.edu/course/be/485/bewritingguideV2.0.pdf Michigan State University Press, USA, Technical Writing Guide, 2007.
2. http://web.mit.edu/me-ugoffice/communication/technical-writing.pdf Sentence Structure of Technical Writing, Nicole Kelley, MIT, USA, 2006.

3. http://www.inf.ed.ac.uk/teaching/courses/pi/2017_2018/slides/Technical-Writing-Basics.pdfNotes from Pocketbook of Technical Writing for Engineers and Scientists by Leo Finkelstein, NY, NY 2007.
4. https://www.shs-conferences.org/articles/shsconf/pdf/2016/04/shsconf_erpa2016_01090.pdf A need analysis of technical writing skill of engineering students in India , JCK Evangeline & K. Ganesh, DOI: 10.1051/ shsconf/20162601090, 2016

**Course Outcomes:**

| | |
|---|---|
| CO1 | Understand the importance and application of technical communication and apply essentials of English grammar to make research writing effective |
| CO2 | Apply the elements of technical writing to produce effective research papers |
| CO3 | read and analyse technical texts |
| CO4 | Develop the ability to write technical articles. |
| CO5 | develop research acumen by understanding the key skills of research |

**Programme Outcomes relevant to the course:**

| | |
|---|---|
| PO6 | Ability to function effectively individually or as a part of a team to accomplish a stated goal. |
| PO7 | Understanding of the impact of IT related solutions in an economic, social and environment context. |
| PO8 | Understanding of intellectual property rights and overall professional & ethical responsibility. |
| PO9 | Ability to communicate effectively with a wide range of audience. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | - | - | - | - | - | 3 | 1 | 1 | 3 | 3 |
| CO2 | - | - | - | - | - | 3 | - | - | 3 | 3 |
| CO3 | - | - | - | - | - | 3 | 1 | 1 | 3 | 3 |
| CO4 | - | - | - | - | - | 2 | - | 1 | 3 | 3 |
| CO5 | - | - | - | - | - | 2 | 1 | 3 | 3 | 3 |

| Type | Code | Power Systems Laboratory – II | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Practical | | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce conventional electromagnetic relay. The course will cover various fault analysis along with their transient & dynamic studies. |
| **Pre-Requisites (if any)** | Basic knowledge on power systems & power system protection. |
| **Teaching Scheme** | Demonstration will be given for each experiments and it is to be executed by students. |

**Evaluation Scheme**

| Attendance | Daily Performance | Record | Lab Test/ Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

**Detailed Syllabus**

| Experiment # | Assignment / Experiment |
|---|---|
| 1 | Determination of positive, negative & zero sequence reactance of an alternator to make analysis of various faults in an unloaded alternator. |
| 2 | Study of an over current & 3-ø differential relay. |
| 3 | Study of various lightning arresters. |
| 4 | Fault studies for a given power system. |
| 5 | Obtain swing curve for given power system when a fault is cleared. |
| 6 | Calculation of fault clearing time for a (i) SLG fault and (ii) 3-phase fault |
| 7 | Computation of fault level at different buses in a power system for a (i) SLG fault and (ii) 3-phase fault |
| 8 | Calculation of L-index for determining most sensitive bus in a power system. Also obtain the followings: (i) Plotting of PV curve, (ii) Calculation of centroid |
| 9 | Impact on voltage with variation of wind integration in a power system. |

**Reference books:**

R1. A.G. Phadke and J. S. Thorp, "Computer Relaying for Power Systems", Wiley/Research studies Press, 2009

R2. S.R. Bhide "Digital Power System Protection" PHI Learning Pvt. Ltd. 2014 .

**Course Outcomes:**

| | |
|---|---|
| CO1 | Learn the importance of Relays, Lightning arresters & various protective elements |
| CO2 | Apply Mathematical approach towards protection |
| CO3 | Learn to develop various Protection algorithms |
| CO4 | Lear the basic requirements of digital protection |
| CO5 | Learn transient& dynamic studies of a power system |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power system protection for various industrial and domestic applications. |
| PO2 | Design the modern protective system for power system |

| | |
|---|---|
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | - | - | - | - | - | - | - | - |
| CO2 | 3 | 1 | 3 | 3 | 3 | - | - | - | - | 1 |
| CO3 | 3 | 2 | 3 | 2 | 1 | - | - | - | - | 1 |
| CO4 | 3 | 1 | 1 | - | - | - | - | - | - | - |
| CO5 | 3 | 3 | 3 | 1 | 1 | 1 | - | - | - | 1 |

| Type | Code | Power Electronics Application to Power Systems Laboratory | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Practical | | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | This laboratory course shall introduce the students to power electronics control to power system. The course will give some practical exposure along with some simulated analysis of different aspect of power electronics in power system like power electronics and drives, FACTs control in power system, power quality problem, etc. The laboratory experiments shall go hand-in-hand with the topics taught in the theory class. |
| **Pre-Requisites (if any)** | Basic concepts of converter topology, analysis of PWM switching schemes, some control theories and knowledge of MATLAB. |
| **Teaching Scheme** | Demonstration will be given for each experiments and it is to be executed by students. |

### Evaluation Scheme

| Attendance | Daily Performance | Record | Lab Test/ Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

### Detailed Syllabus

| Experiment # | Assignment / Experiment |
|---|---|
| 1 | To study single-phase ac voltage regulator with resistive and inductive loads. |
| 2 | To study single phase cyclo-converter. |
| 3 | To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor. |
| 4 | Study of Chopper Fed DC Motor drive. |
| 5 | PWM inverter fed three phase induction motor control using software. |
| 6 | VSI/CSI fed induction motor drive analysis using software. |
| 7 | Study of V/f control operation of three phase induction motor. |
| 8 | Study of static VAR compensator (SVC). |
| 9 | Study and analysis of STATCOM using software |
| 10 | To study the operation and control of Unified Power flow Controller (UPFC) |
| 11 | To study the single-phase series-resonant inverter |
| 12 | To study the ZCS and ZVS-resonant converter using software |
| 13 | To study MOSFET/IGBT based single-phase bridge inverter |
| 14 | Regenerative/ Dynamic breaking operation for DC motor study using software. |
| 15 | Regenerative/ Dynamic breaking operation for AC motor study using software. |
| 16 | PLC based AC/DC motor control operation. |
| 17 | To study of speed control of IM by using Kramer drive method. |
| 18 | To study the vector control of IM drive using DSP 2812 controller. |
| 19 | Study of Thyristor-Controlled Series Compensator (TCSC) |
| 20 | Study of active power filter in distributed system for power quality improvement |

**Reference books:**

R1. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics: Converters, Applications, and Design”, John Wiley & Sons.
R2. M H Rashid, “power Electronics: Circuits, Devices and Applications, Pearson.
R3. Modern Power Electronics and AC Drives, Bimal K Bose, PHI.
R4. K R Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International Publishers, 2007.

**Course Outcomes:**

| | |
|---|---|
| CO1 | Able to design various PE converters, voltage controllers, triggering circuit of different semiconductor switches and resonant inverters. |
| CO2 | Analyze the control of various drives and its performance analysis. |
| CO3 | To learn the active and reactive power flow control in power system. |
| CO4 | To understand the need for static compensators. |
| CO5 | To develop the different control strategies used for compensation in power system. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO1 | Apply the knowledge of science and mathematics in designing, analyzing and using power converters for various industrial and domestic applications. |
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |
| PO8 | Understanding of intellectual property rights and overall professional & ethical responsibility. |
| PO9 | Ability to communicate effectively with a wide range of audience. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 1 | 1 | - | - | - | 1 |
| CO2 | 2 | 3 | 2 | 1 | 1 | 2 | - | - | - | 2 |
| CO3 | 2 | - | 2 | 2 | 1 | 1 | - | - | - | 2 |
| CO4 | 3 | - | 2 | 2 | 1 | 1 | - | - | - | 1 |
| CO5 | 3 | - | 2 | 1 | 1 | 1 | - | - | - | 1 |

| Type | Code | Mini Project & Seminar | L-T-P | Credits | Marks |
|---|---|---|---|---|---|
| Practical | | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives:** | The objective of this course is to familiarize with the different research works going on in real-life work in electrical and electronics engineering discipline. Also one can know the use of modern tools like the softwares, programming, Simulink, hardware based interfacing equipments. Mini-projects can help to prepare students for open ended investigative work. |

**Detailed Syllabus**

| Process # | Topics |
|---|---|
| 1 | Review of different Research topics/fields |
| 2 | Submission of Project Title |
| 3 | Literature Review |
| 4 | Interim Presentation |
| 5 | Hardware/Software Project Execution |
| 6 | Seminar/Presentation of the Project |

**Course Outcomes:**

| | |
|---|---|
| CO1 | Acquire practical knowledge within the chosen area of technology for project development. |
| CO2 | Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach. |
| CO3 | Contribute as an individual or in a team in development of technical projects. |
| CO4 | Develop effective communication skills for presentation of project related activities. |

**Program Outcomes Relevant to the Course:**

| | |
|---|---|
| PO2 | Design the modern electric machines, drives, power converters, and control circuits for specific application. |
| PO3 | Use modern tools, professional software platforms, embedded systems for the diversified applications. |
| PO4 | Solve the problems which need critical and independent thinking to show reflective learning. |
| PO5 | Explore ideas for inculcating research skills and undertake independent research in cutting edge technologies |
| PO6 | Visualize the larger picture and correlate the domain knowledge with the global industrial problems |
| PO7 | Understanding of the impact of electronics & communications in an economic, social and environment context. |
| PO8 | Understanding of intellectual property rights and overall professional & ethical responsibility. |
| PO9 | Ability to communicate effectively with a wide range of audience. |
| PO10 | Ability to learn independently and engage in life-long learning. |

**Mapping of CO's to PO's:** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | - | 2 | 2 | 2 | 2 | - | - |
| CO2 | 1 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | - | 1 |
| CO3 | 1 | - | 2 | - | 1 | 2 | 1 | 1 | 3 | 1 |
| CO4 | - | 1 | 1 | 1 | 2 | 1 | 1 | - | 3 | 2 |