# GOVERNMENT COLLEGE OF ENGINEERING
# SALEM - 636 011

**(An Autonomous Institution Affiliated to Anna University, Chennai)**


# DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

## B.E. ELECTRICAL AND ELECTRONICS ENGINEERING
### (PART TIME PROGRAMME)

## REGULATIONS - 2022

### CURRICULAM AND SYLLABUS

**(For Candidates Admitted during 2022 - 2023)**

**VISION OF THE DEPARTMENT:**

- To make ethically and emotionally strong Electrical Engineers of high caliber capable of meeting the national and global technological challenges for the well-being of the Society.

**MISSION OF THE DEPARTMENT:**

- To Impart state of the art Knowledge in Electrical Science and Technology through under-graduate and graduate programmes.
- To develop the Electrical Engineering Department as a Centre of Excellence in Power Electronics and Industrial Drives.
- To provide Knowledge base and Consultancy services to the society at large and in particular for the upliftment and well-being of the rural and tribal communities.

**VISION AND MISSION OF THE INSTITUTION:**

**Vision**

- We envision our students as excellent Engineers not only in the field of Science and Technology, but also in good citizenship and discipline.
- Our commitment lies in producing comprehensive knowledge seekers and humane individuals, capable of building a strong and developed nation.

**Mission**

- To impart update technical education and knowledge.
- To groom our young students to become professionally and morally sound engineers.
- To teach global standards in production and value based living through honest and scientific approach.

**PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):**

**PEO 1:** Graduates will be employed electrical engineering profession as experts in solving electrical engineering problems by their depth of understanding in core electrical knowledge and/or completed/pursuing post graduate study or research.

**PEO 2:** Graduates will have awareness for lifelong learning and continued professional development

**PEO 3:** Graduates will demonstrate creativity in their engineering practices including entrepreneurial and collaborative ventures with strategic thinking, planning and execution

**PEO 4:** Graduates will communicate effectively, recognize and incorporate societal needs and constraints in their professional endeavors and practice their profession with high regard to legal and ethical responsibilities

**PEO 5:** Graduates will have necessary foundation on computational platforms and software applications related to the field of electrical and electronics engineering

**PROGRAM OUTCOMES (POs):**

**Engineering Graduates will be able to**

**PO 1:** Apply knowledge of mathematics and engineering sciences to the solution of complex electrical engineering problems

**PO 2:** Identify, formulate, and solve complex engineering problems using multidisciplinary knowledge.

**PO 3:** Design solutions for complex engineering problems and system design to meet the needs of public considering the health, safety, cultural, societal, and environmental factors.

**PO 4:** Apply research-based knowledge and research methods to complex problems including design, analysis, interpretation of data, and synthesis of the information to provide valid conclusions.

**PO 5:** Create, select, and apply appropriate techniques, simulation tools for prediction and modeling of engineering activities with their limitations.

**PO 6:** Assess societal, health, safety, legal and cultural issues relevant to the electrical engineering profession.

**PO 7:** Provide the electrical engineering solutions for sustainable development.

**PO 8:** Apply ethical principles and responsibilities for electrical engineering practice.

**PO 9:** Function effectively as an individual member or leader in diverse teams, and in multidisciplinary projects.

**PO 10:** Communicate effectively with the engineering community and with society at large, such as, write effective reports and design documentation, and make effective presentations.

**PO 11:** Apply engineering and management principles to one's own work, or in a team, to manage projects in multidisciplinary environments.

**PO 12:** Recognize the need of lifelong learning for professional development and personnel growth.

**PROGRAM SPECIFIC OUTCOMES (PSOs):**

**Electrical and Electronics Engineering Graduates will be able to**

**PSO 1:** Apply knowledge of mathematics, engineering sciences and multidisciplinary knowledge to the solution of electrical and electronics engineering problems

**PSO 2:** Apply research-based knowledge, appropriate techniques, IT tools to complex Electrical and Electronics Engineering problems including design, analysis, interpretation of data, and synthesis of the information to provide valid conclusions.

**PSO 3:** Apply ethical principles, management skills, and lifelong learning for professional development and personnel growth.

**B.E. - Electrical and Electronics Engineering – Part Time**
**Regulations – 2022**

| SEMESTER - I | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Category** | **Contact Periods** | **Hours per week & Credit** | | | | **Maximum Marks** | | |
| | | | | **L** | **T** | **P** | **C** | **CA** | **FE** | **Total** |
| **THEORY** | | | | | | | | | | |
| 22PTMA101 | Mathematics-I | BS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE101 | Electric Circuit Analysis | PC | 3 | 2 | 1 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE102 | DC Machines and Transformers | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE103 | Electron Devices and Circuits | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTCS101 | Fundamental of Problem Solving and C Programming | ES | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **TOTAL** | | | | | | | **15** | | | **500** |

| SEMESTER - II | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Category** | **Contact periods** | **Hours per week & Credit** | | | | **Maximum Marks** | | |
| | | | | **L** | **T** | **P** | **C** | **CA** | **FE** | **Total** |
| **THEORY** | | | | | | | | | | |
| 22PTMA201 | Mathematics-II | BS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE201 | Electromagnetic Theory | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE202 | Synchronous and Induction Machines | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE203 | Measurements and Instrumentation | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICAL** | | | | | | | | | | |
| 22PTEE204 | Electrical Machines Laboratory | PC | 3 | 0 | 0 | 3 | 1.5 | 60 | 40 | 100 |
| **TOTAL** | | | | | | | **13.5** | | | **500** |

| SEMESTER - III | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **Course Title** | **Category** | **Contact Periods** | **Hours per week & Credit** | | | | **Maximum Marks** | | |
| | | | | **L** | **T** | **P** | **C** | **CA** | **FE** | **Total** |
| **THEORY** | | | | | | | | | | |
| 22PTEE301 | Electrical Machine Design | PC | 3 | 2 | 1 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE302 | Linear Integrated Circuits | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE303 | Digital Logic Circuits | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE304 | Power Electronics | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTCY301 | Environmental Science and Engineering | ES | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **TOTAL** | | | | | | | **15** | | | **500** |
| | | | | | | | | | | |
| **SEMESTER - IV** | | | | | | | | | | |
| **Course Code** | **Course Title** | **Category** | **Contact periods** | **Hours per week & Credit** | | | | **Maximum Marks** | | |
| | | | | **L** | **T** | **P** | **C** | **CA** | **FE** | **Total** |
| **THEORY** | | | | | | | | | | |
| 22PTEE401 | Control Systems | PC | 3 | 2 | 1 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE402 | Power Generation, Transmission, and Distribution System | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE403 | Protection and Switchgear | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE404 | Electrical Drives and Control | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICAL** | | | | | | | | | | |
| 22PTEE405 | Power Electronics and Drives Laboratory | PC | 3 | 0 | 0 | 3 | 1.5 | 60 | 40 | 100 |
| **TOTAL** | | | | | | | **13.5** | | | **500** |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| **SEMESTER - V** | | | | | | | | | | |

| Course Code | Course Title | Category | Contact Periods | Hours per week & Credit | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | C | CA | FE | Total |
| **THEORY** | | | | | | | | | | |
| 22PTEE501 | Microprocessors and Microcontrollers | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE502 | Power System Analysis and Stability | PC | 3 | 2 | 1 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE503 | Total Quality Management | HS | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEEE1X | Professional Elective-I | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEEE2X | Professional Elective-II | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **TOTAL** | | | | | | | **15** | | | **500** |
| | | | | | | | | | | |
| **SEMESTER – VI** | | | | | | | | | | |
| **Course Code** | **Course Title** | **Category** | **Contact periods** | **Hours per week & Credit** | | | | **Maximum Marks** | | |
| | | | | **L** | **T** | **P** | **C** | **CA** | **FE** | **Total** |
| **THEORY** | | | | | | | | | | |
| 22PTEE601 | Solar and Wind Energy Conversion System | PC | 3 | 2 | 1 | 0 | 3 | 40 | 60 | 100 |
| 22PTEEE3X | Professional Elective-III | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEEE4X | Professional Elective-IV | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEEE5X | Professional Elective-V | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICAL** | | | | | | | | | | |
| 22PTEE602 | Microprocessor and Microcontroller Laboratory | PC | 2 | 0 | 0 | 2 | 1 | 60 | 40 | 100 |
| **TOTAL** | | | | | | | **13** | | | **500** |
| | | | | | | | | | | |
| | | | | | | | | | | |
| **SEMESTER – VII** | | | | | | | | | | |
| **Course Code** | **Course Title** | **Ca teg** | **Co nta** | **Hours per week & Credit** | | | | **Maximum Marks** | | |

| | | | | L | T | P | C | CA | FE | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | | | | |
| 22PTEE701 | Smart Grid | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEE702 | High Voltage Engineering | PC | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEEE6X | Professional Elective-VI | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 22PTEEE7X | Professional Elective-VII | PE | 3 | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **PRACTICAL** | | | | | | | | | | |
| 22PTEE703 | Project work | EEC | 6 | 0 | 0 | 6 | **3** | **120** | **80** | **200** |
| **TOTAL** | | | | | | | **15** | | | **600** |
| **GRAND TOTAL** | | | | | | | **100** | | | |

**B.E. Electrical and Electronics Engineering - Part Time**

**Professional Electives**

| Sl. No. | Course Code | Course Title | Category | Hours per Week & Credit | | | | Maximum Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | C | CA | FE | Total |
| **ELECTIVE – I ( V SEMESTER)** | | | | | | | | | | |
| 1 | 22PTEEE11 | Network Analysis and Synthesis | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | 22PTEEE12 | Advanced Control Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | 22PTEEE13 | Discrete Control Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | 22PTEEE14 | Biomedical Instrumentation | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | 22PTEEE15 | Computer Relaying and Wide Area Measurement Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | 22PTEEE16 | Digital Controller in Power Electronics Applications | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **ELECTIVE – II ( V SEMESTER)** | | | | | | | | | | |
| 1 | 22PTEEE21 | HVDC Transmission System | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | 22PTEEE22 | EHVAC Transmission Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | 22PTEEE23 | Flexible AC Transmission System | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | 22PTEEE24 | Power System Operation and Control | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | 22PTEEE25 | Substation Engineering and Automation | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | 22PTEEE26 | Power System Automation | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | 22PTEEE27 | High Voltage Insulation Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **ELECTIVE – III (VI SEMESTER)** | | | | | | | | | | |
| 1 | 22PTEEE31 | Power System Transients | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | 22PTEEE32 | Power Quality | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | 22PTEEE33 | Distributed Generation and Micro Grid | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | 22PTEEE34 | Restructured Power System | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | 22PTEEE35 | Power System Planning and Reliability | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | 22PTEEE36 | Power Plant Engineering | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **ELECTIVE – IV (VI SEMESTER)** | | | | | | | | | | |
| 1 | 22PTEEE41 | Special Electrical Machines | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

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|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 22PTEEE42 | Industrial Electrical System | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | 22PTEEE43 | Modern Electrical Drives | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | 22PTEEE44 | Analysis of Electrical Machines | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | 22PTEEE45 | Multilevel Power Converters | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | 22PTEEE46 | Modelling and Control of Power Converters | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | 22PTEEE47 | Grid Converters for Renewable Energy Applications | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | 22PTEEE48 | Control and Integration of Renewable Energy Sources | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **ELECTIVE – V (VI SEMESTER)** | | | | | | | | | | |
| 1 | 22PTEEE51 | Digital Signal Processing | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | 22PTEEE52 | Embedded System Design | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | 22PTEEE53 | Artificial Intelligence and Computer Vision | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | 22PTEEE54 | Soft Computing | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | 22PTEE55 | Internet of Things for Electrical System | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | 22PTEE56 | Computer Architecture | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | 22PTEE57 | Robotics and Automation | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **ELECTIVE – VI (VII SEMESTER)** | | | | | | | | | | |
| 1 | 22PTEEE61 | Utilization of Electrical Energy | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | 22PTEEE62 | Electrical Energy Conservation and Auditing | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3 | 22PTEEE63 | Electrical Wiring Estimation and Costing | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | 22PTEEE64 | Renewable Energy Sources | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | 22PTEEE65 | Energy Management System and SCADA | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | 22PTEEE66 | Digital Protection of Electrical System | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | 22PTEEE67 | Traction Engineering | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| **ELECTIVE – VII (VII SEMESTER)** | | | | | | | | | | |
| 1 | 22PTEEE71 | Electric Vehicles and Control | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2 | 22PTEEE72 | Electric Vehicle Architecture | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

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|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 22PTEEE73 | Design of Motor and Power Converters for Electric Vehicles | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4 | 22PTEEE74 | Design of Electric Vehicle Charging System | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5 | 22PTEEE75 | Testing of Electric Vehicles | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6 | 22PTEEE76 | Intelligent Control of Electric Vehicles | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7 | 22PTEEE77 | Hybrid Electric vehicles | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 8 | 22PTEEE78 | Battery Management Systems | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 9 | 22PTEEE79 | Energy Storage Systems and Applications | PE | 3 | 0 | 0 | 3 | 40 | 60 | 100 |

| 22PTMA101 | MATHEMATICS – I<br>(Common to Part Time B.E. - CIVIL, ECE, EEE & MECH branches) | SEMESTER I | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Basic 12th level knowledge of ODE, PDE, Vector algebra and Complex Analysis. | **BS** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To make the student acquire sound knowledge of techniques in solving ordinary differential equations that model engineering problems. |
| 2. | To make the student to understand the techniques in solving partial differential equations that model engineering problems. |
| 3. | To acquaint the student with the concepts of vector calculus needed for solving engineering problems. |
| 4. | To understand the concept of analytic functions. |
| 5. | To obtain the knowledge of complex integration |

| **UNIT I** | **ORDINARY DIFFERENTIAL EQUATIONS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Higher order linear differential equations with constant coefficients – Method of variation of parameters – Cauchy's and Legendre's linear equations.

| **UNIT II** | **PARTIAL DIFFERENTIAL EQUATIONS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions – Lagrange's linear equation – Homogeneous Linear partial differential equations of second order with constant coefficients.

| **UNIT III** | **VECTOR CALCULUS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Gradient, divergence and curl – Directional derivative – Irrotational and solenoidal vector fields – Vector integration – Statement of Gauss divergence theorem and Stokes theorem – Simple applications involving cubes and rectangular parallelopipeds.

| **UNIT IV** | **ANALYTIC FUNCTIONS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Functions of a complex variable – Analytic functions – Necessary conditions, Cauchy – Riemann equation and sufficient conditions (excluding proofs) – Properties of analytic function – Harmonic conjugate – construction of analytic functions – Conformal mapping: $w = z + c,\ cz,\ \frac{1}{z}$ and bilinear transformation.

| **UNIT V** | **COMPLEX INTEGRATION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Complex integration – Statement and applications of Cauchy's integral theorem and Cauchy's integral formula – Taylor's and Laurent's expansions – Singular points – residues – Residue theorem – Application of residue theorem to evaluate real integrals over semi-circular contours (excluding poles on boundaries).

**Total (45 L+0 T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Grewal. B.S, "Higher Engineering Mathematics", 43rd Edition, Khanna Publications, Delhi, 2015. |
| 2. | P. Kandasamy, K. Thilagavathy and K. Gunavathy, "Engineering Mathematics (For I year B. E, B. Tech)", Ninth Edition, S. Chand & Co. Ltd., New Delhi, 2010. |

**Reference Books:**

| | |
|---|---|
| 1. | James Stewart, "Calculus with Early Transcendental Functions", Cengage Learning, New Delhi, 2008. |
| 2. | Veerarajan T., "Engineering Mathematics (For semester I and II)", 5th Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009. |
| 3. | Erwin Kreyszig, "Advanced Engineering Mathematics", 7th Edition, Wiley India, 2007. |
| 4. | Jain R.K. and Iyengar S.R.K, "Advanced Engineering Mathematics", 3rd Edition, Narosa Publishing House Pvt. Ltd., 2007. |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Find the techniques of solving ordinary differential equations that arise in engineering problems. | L3: Applying |
| CO2 | : | Find the techniques of solving partial differential equations that arise in engineering problems. | L3: Applying |
| CO3 | : | Apply the concept of vector calculus and vector integration. | L3: Applying |
| CO4 | : | Understand analytic function and its properties. | L2: Understanding |
| CO5 | : | Evaluate various integrals by using Cauchy's residue theorem. | L5: Evaluating |

| 22PTEE101 | ELECTRIC CIRCUIT ANALYSIS | SEMESTER I |
|---|---|---|

| PREREQUISITES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Mathematics, Physics | PC | 2 | 1 | 0 | 3 |

**Course Objectives:**

1. To introduce electric circuits and its analysis.
2. To impart knowledge on solving circuits using network theorems.
3. To introduce the phenomenon of resonance in coupled circuits.
4. To educate on obtaining the transient response of circuits.
5. To learn phasor diagrams and analysis of three phase circuits.

| UNIT I | BASIC CIRCUITS ANALYSIS | 6 | 3 | 0 | 9 |
|---|---|---|---|---|---|

Ohm"s Law – Kirchoffs laws – DC and AC Circuits – Resistors in series and parallel circuits –Mesh current and node voltage method of analysis for DC and AC Circuits – Phasor diagram - power, power factor and energy.

| UNIT II | NETWORK REDUCTION AND NETWORK THEOREMS FOR DC AND AC CIRCUITS | 6 | 3 | 0 | 9 |
|---|---|---|---|---|---|

Network reduction: voltage and current division, source transformation- star and delta transformation, superposition Theorem - Thevenin's and Norton's Theorem — Maximum power transfer theorem – Reciprocity Theorem - substitution theorem.

| UNIT III | RESONANCE AND COUPLED CIRCUITS | 6 | 3 | 0 | 9 |
|---|---|---|---|---|---|

Series and parallel resonance – frequency response – Quality factor and Bandwidth - Self and mutual inductance – Coefficient of coupling- dot rule – analysis of coupled circuits –coupled circuits in series and parallel – Tuned circuits – analysis of Single and double tuned circuits.

| UNIT IV | TRANSIENT ANALYSIS | 6 | 3 | 0 | 9 |
|---|---|---|---|---|---|

Transient response of RL, RC and RLC Circuits using Laplace transform for DC input and AC sinusoidal input.

| UNIT V | THREE PHASE CIRCUITS | 6 | 3 | 0 | 9 |
|---|---|---|---|---|---|

Three phase balanced/ unbalanced voltage sources – analysis of three phase three wire and four wire circuits with star and delta connected with balanced and unbalanced loads – phasor diagrams of voltages and currents –power and power factor measurements in three phase circuits

**Total (30 L+15 T)= 45 Periods**

**Text Books:**


1. William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, "Engineering Circuits Analysis",TMH publishers, 6th edition, New Delhi, 2002.
2. Joseph A. Edminister, Mahmood Nahri, "Electric circuits", Schaum"s series, Tata McGraw-Hill, New Delhi, 2001.


**Course Outcomes:**

| Upon completion of this course, the students will be able to: | | | Bloom's Taxonomy Level |
|---|---|---|---|
| CO1 | : | Understand the basic concept of circuit elements, circuit laws and network reduction technique | L2: Understanding |
| CO2 | : | Solve the electrical network using mesh and nodal analysis by applying network theorems. | L3:Applying |
| CO3 | : | Analysis of AC and Dc circuits using various network theorems. | L4:Analyzing |
| CO4 | : | Understand the resonance in series and parallel circuits and basic concepts of coupled circuits. | L4: Understanding |
| CO5 | : | Analyse the transient response of series and parallel A.C. circuits and to solve problems in time domain using Laplace Transform. | L4: Analyzing |

| 22PTEE102 | DC MACHINES AND TRANSFORMERS | SEMESTER I |
|---|---|---|

| PREREQUISTIES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Nil | PC | 2 | 1 | 0 | 3 |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the concepts of electromechanical energy conversion and to gain the knowledge on single and multiply-excited magnetic systems. |
| 2. | To gain the knowledge on construction and principles of operation of DC machines and transformers. |
| 3. | To analyze the performance characteristics of different types of DC machines and transformers. |
| 4. | To appreciate the applications of DC machines and transformers. |
| 5. | To analyze the performance of DC machines and transformers by conducting various tests. |

| | | | | | |
|---|---|---|---|---|---|
| **Unit I** | **ELECTROMECHANICAL ENERGY CONVERSION** | **6** | **3** | **0** | **9** |

Magnetic circuits – Magnetically induced EMF and force – AC operation of magnetic circuits – Energy in magnetic systems – Field energy & mechanical force – Single and Multiply-excited magnetic field systems.

| | | | | | |
|---|---|---|---|---|---|
| **Unit II** | **DC GENERATORS** | **6** | **3** | **0** | **9** |

Constructional features of DC machine – Principle of operation of DC generator – EMF equation – Types of excitation – No load and load characteristics of DC generators – Commutation - Armature reaction – Parallel operation of DC generators - Applications.

| | | | | | |
|---|---|---|---|---|---|
| **Unit III** | **DC MOTORS** | **6** | **3** | **0** | **9** |

Principle of operation of DC motors - Back EMF – Torque equation – Types of DC motors - Speed – Torque characteristics of DC motors – Starting of DC motors: 3- point starter, 4- point starter – Speed control of shunt and series motor : Field current control and Armature voltage control – Applications.

| | | | | | |
|---|---|---|---|---|---|
| **Unit IV** | **TRANSFORMERS** | **6** | **3** | **0** | **9** |

Constructional features of single phase transformers–Principle of operation - EMF equation –ideal transformer characteristics - Practical Transformer working on No- load and Load with phasor diagram – Equivalent circuit – Regulation – Parallel operation - Autotransformers - Three phase transformer connections.

| | | | | | |
|---|---|---|---|---|---|
| **Unit V** | **TESTING OF DC MACHINES AND TRANSFORMERS** | **6** | **3** | **0** | **9** |

Losses and efficiency – Condition for maximum efficiency – Testing of DC machines: Swinburne's test and Hopkinson's test - Testing of transformers: open circuit and short circuit tests, Sumpner's test – All day efficiency.

**Total (30L+15T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | D.P. Kothari, I.J. Nagrath, "Electric Machines", Third Edition, Tata McGraw-Hill Company Ltd., New Delhi, 2010. |
| 2. | Dr. P.S. Bimbhra, "Electrical Machinery", Khanna Publishers, New Delhi, 2006. |


**Reference Books:**


| | |
|---|---|
| 1. | B.L. Theraja & A.K. Theraja, "Electrical Technology", Vol.II, S.Chand & Company Ltd., New Delhi, 2006. |
| 2. | A.E. Fitzgerald, Charles Kingsley, Stephen. D.Umans, 'Electric Machinery', Tata McGraw Hill Publishing Company Ltd, 2003. |
| 3. | Dr. K. Murugesh Kumar, "DC Machines & Transformers", Vikas Publishing House Pvt. Ltd., Second Edition, 2003. |


**E-References:**

| | |
|---|---|
| 1. | www.onlinecourses.nptel.ac.in |
| 2. | www.class-central.com |
| 3. | www.mooc-list.com |

| **Course Outcomes:** | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| Upon completion of this course, the students will be able to: | | | |
| CO1 | : | Recite the concepts of electromechanical energy conversion principles. | L1:Remembering |
| CO2 | : | Understand the basic concepts of DC machines and transformers. | L2:Understanding |
| CO3 | : | Evaluate the performance characteristics of DC machines and transformers. | L5:Evaluating |
| CO4 | : | Conduct various tests on DC machines. | L3: Applying |
| CO5 | : | Conduct various test on Transformers | L3: Applying |

| 22PTEE103 | ELECTRON DEVICES AND CIRCUITS | SEMESTER I | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Engineering physics | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the characteristics of diodes. |
| 2. | To understand the characteristics of transistors. |
| 3. | To design amplifier circuits |
| 4. | To design the oscillator circuits. |

| **UNIT I** | **DIODES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Structure – Equilibrium conditions – Energy Band Concepts – Zero bias – Forward Bias – Reverse bias – Junction capacitances – one sided and Non- uniformly doped junctions – Ideal PN junction current, P-N junction diode, V-I characteristics of a diode, review of half-wave and full-wave rectifiers, Zener diodes, voltage regulator using zener diode, clamping and clipping circuits.

| **UNIT II** | **TRANSISTORS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Physical behaviour of a BJT – Ebers - Moll model, large signal current gains. Modes of transistor operation - Common base, common emitter and common collector configurations, Input and output characteristics, Early effect, regions of operation. AC and DC load lines - Need for stability of Q-Point. Bias stability – fixed bias, collector to base bias, self bias. Transistor switching times-Transistor as a switch and an amplifier, small signal ac model, high frequency effects, hybrid –π model-BJT ratings, Junction field effect transistor – structure, JFET structure and characteristics -UJT- structure and characteristics.

| **UNIT III** | **SMALL SIGNAL AMPLIFIER CIRCUITS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Single stage BJT and FET amplifiers, Analysis at low, medium and high frequencies – BJT and FET Differential amplifier, Differential and Common mode gain with resistive load and active load, CMRR - Cascode and Darlington Amplifiers.

| **UNIT IV** | **LARGE SIGNAL AMPLIFIER CIRCIUTS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Power amplifiers– Classification, Single ended and Push-pull Configuration, Power dissipation, Output power and Conversion efficiency, Complementary symmetry power amplifiers, Class AB operation, Class C and Class D amplifiers, thermal considerations.

| **UNIT V** | **FEEDBACK AMPLIFIERS AND OSCILLATORS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Advantages of negative feedback – voltage / current, series, Shunt feedback –positive feedback – Condition for oscillations, phase shift – Wien bridge, Hartley, Colpitts and Crystal oscillators.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Millman J, Halkias C, SatyaBrata JIT, "Electronic Devices & Circuits", Tata McGraw-Hill, New Delhi, 2010. |
| 2. | David A. Bell, “Electronic Devices and Circuits”, New Delhi: Oxford University Press, 5th Edition, 2008. |
| 3. | Boylestead L R, Nashelsky L, "Electronic Devices and Circuit Theory", Pearson Education, New Delhi, 2009. |

**Reference Books:**

| | |
|---|---|
| 1. | Rashid, “Micro Electronic Circuits” Thomson publications, 1999. |
| 2. | Donald L.Schilling and Charles Belove, 'Electronic Circuits', 3 Edition, Tata McGraw Hill, 2010. |
| 3. | Adel Sedra, Kenneth.C Smith, "Microelectronics Circuits", Oxford University Press, New Delhi, 2010 |

**E-Reference**

| | |
|---|---|
| 1 | https://electronicsforu.com/resources/electronic-devices-and-circuit-theory |
| 2 | https://nptel.ac.in/courses/117103063/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | **Bloom’s TaxonomyMapped** |
|---|---|

| | | | |
|---|---|---|---|
| CO1 | : | Understand overview of semiconductor devices. | L2:Understanding |
| CO2 | : | Recognize the fundamentals and characteristics of BJT | L1:Remembering |
| CO3 | : | Analyze the fundamentals and characteristics of FET and UJT | L2:Understanding |
| CO4 | : | Design and analyze the amplifiers | L4: Analysing |
| CO5 | : | Design and analyze the differential amplifiers | L4: Analysing |

| 22PTCS101 | FUNDAMENTAL OF PROBLEM SOLVING AND C PROGRAMMING | SEMESTER I |
|---|---|---|

| PREREQUISTIES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| NIL | ES | 3 | 0 | 0 | 3 |

**Course Objectives:**

| | |
|---|---|
| 1. | To introduce the problem solving methodologies. |
| 2. | To learn the basic concepts of developing an algorithm and pseudo code. |
| 3. | To understand the concepts of C Programming. |

| UNIT I | INTRODUCTION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Characteristics of Computers – Evolution of Computers – Computer Generations – Classification of Computers – Basic Computer organization –Number System – Binary – Decimal – Conversion – Problems..

| UNIT II | PROBLEM SOLVING | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Problem formulation, Problem Solving methods, Need for logical analysis and thinking – Algorithm – Pseudo code – Flow Chart. C Character set, Identifies and Keywords, Data Types, Declarations, Expressions, Statements and Symbolic constants.

| UNIT III | C PROGRAMMING BASICS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Operators – Arithmetic Operators – Unary operators – Relational and Logical Operators – Assignment operators – Conditional operators. Managing Input and Output operations, pre-processor directives and storage classes.

| UNIT IV | CONTROL STATEMENTS, ARRAYS AND STRINGS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Conditional statements-branching and looping statements. Arrays – Initialization – Declaration – one dimensional and two dimensional arrays. Strings - String operations – String handling functions.

| UNIT V | FUNCTIONS, POINTERS STRUCTURES AND UNIONS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Function – Library functions and user-defined functions – Function prototypes and function definitions – Call by value –Call by reference – Recursion – Pointers definition - Structure definition and Examples – Union.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | RAnita Goel and Ajay Mittal, „Computer Fundamentals and Programming in C", Dorling Kindersley (India) Pvt. Ltd., Pearson Education in South Asia, 2011 |
| 2. | E Balagurusamy, „Programming in ANSI C", fourth Edition, Tata McGraw-Hill, 2008. |

**Reference Books:**

| | |
|---|---|
| 1. | Byron S Gottfried, „Programming with C", Schaum"s Outlines, Second Edition, Tata McGraw-. |

**E-Reference**

| | |
|---|---|
| 1 | https://nptel.ac.in/courses/106106210 |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | To Understand the basic terminology used in computer programming. | L2:Understanding |
| CO2 | : | To write, compile and debug programs in C language. | L1:Applying |
| CO3 | : | To Use different data types in a computer program | L1:Remembering |
| CO4 | : | To Understand, analyze and implement software development tools like algorithm, pseudocodes and programming structure | L2:Understanding |
| CO5 | : | To write programs related to simple/ moderate mathematical and logical problems in "C'. | L1:Applying |

| 22PTMA201 | MATHEMATICS – II<br>(Common To Part-Time B.E - CIVIL, ECE, EEE & MECH branches) | | SEMESTER II | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Basic 12th level knowledge of Differential Calculus, Integral Calculus and ODE. | | **BS** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To introduce the concept of Fourier series. |
| 2. | To understand the application of Fourier analysis in solving boundary value problems. |
| 3. | To obtain the knowledge of solving second order ODE using Laplace transform techniques and inverse Laplace transform using convolution theorem. |
| 4. | To familiarize with Fourier, transform of a function and its sine and cosine transforms. |
| 5. | To gain the skills to form difference equations and find its solution by using Z-transform method. |

| **UNIT I** | **FOURIER SERIES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Parseval's Identity.

| **UNIT II** | **BOUNDARY VALUE PROBLEMS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Classification of second order quasi linear partial differential equations – Solutions of one-dimensional wave equation – One dimensional heat equation – Steady state solution of two-dimensional heat equation for infinite plates (Insulated edges excluded) – Fourier series solutions in Cartesian coordinates.

| **UNIT III** | **LAPLACE TRANSFORM** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Laplace Transform- Conditions for existence – Transform of elementary functions – Basic Properties – Transform of derivatives and integrals – Initial and Final value theorems- Transform of periodic Functions – Inverse Laplace Transform-statement and application of convolution theorem.

| **UNIT IV** | **FOURIER TRANSFORM** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Statement of Fourier integral theorem – Fourier transforms pair – Sine and Cosine transforms Properties – Transforms of simple functions – Parseval's Identity.

| **UNIT V** | **Z -TRANSFORM AND DIFFERENCE EQUATIONS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Z-transform of simple functions and properties – Inverse Z – transform –initial and final value theorems- Convolution theorem - Solution of difference equations using Z – transform technique.

**Total (45 L+0 T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Veerarajan T, "Engineering Mathematics (For Semester III)", 3rd Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009. |
| 2. | P. Kandasamy, K. Thilagavathy and K. Gunavathy, "Engineering Mathematics, Volume III", S. Chand & Company Ltd., New Delhi, 1996. |

**Reference Books:**

| | |
|---|---|
| 1. | Grewal, B.S., "Higher Engineering Mathematics", 43rd Edition, Khanna Publishers, Delhi, 2014. |
| 2. | Wylie C. Ray and Barrett Louis, C., "Advanced Engineering Mathematics", Sixth Edition, McGraw-Hill, Inc., New York, 1995. |
| 3. | Andrews, L.A., and Shivamoggi B.K., "Integral Transforms for Engineers and Applied Mathematicians", MacMillan, New York, 1988. |

| | |
|---|---|
| 4. | Narayanan, S., Manicavachagom Pillai, T.K. and Ramaniah, G., "Advanced Mathematics for Engineering Students", Volumes II and III, S. Viswanathan (Printers and Publishers) Pvt. Ltd. Chennai, 2002. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Acquire the knowledge about Fourier series. | L2: Understanding |
| CO2 | : | Appreciate the physical significance of Fourier series techniques in solving one- and two-dimensional heat flow problems and one-dimensional wave equations. | L3: Applying |
| CO3 | : | Apply the knowledge of Laplace transforms method to solve second orderdifferential equations. | L3: Applying |
| CO4 | : | Apply the knowledge of Fourier transform in engineering problems. | L3: Applying |
| CO5 | : | Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems. | L3: Applying |

| 22PTEE201 | ELECTROMAGNETIC THEORY | | SEMESTER II | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Basic Electrical and Electronics Engineering | | **PC** | **2** | **1** | **0** | **3** |

**Course Objectives:**

To impart knowledge on the basic concepts of vectors, coordinate systems, static and dynamic electric and magnetic fields and apply maxwells equations for various engineering applications involving electromagnetic waves.

| **UNIT I** | **ELECTROSTATICS – I** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Vector fields: Components of a vector and Classification of vector fields - Coordinate Systems and transformation – Gradient, Divergence, Curl – theorems and applications - Coulomb's Law – Electric field intensity – Field due to discrete and continuous charges – Gauss's law and applications.

| **UNIT II** | **ELECTROSTATICS – II** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Electric flux density – Electric potential – Electric dipole – Electric field in free space, conductors, dielectrics, - Dielectric polarization- Dielectric strength- Electric field in multiple dielectrics-– Boundary conditions, Poisson's and Laplace's equations, Capacitance, Energy density, Applications.

| **UNIT III** | **MAGNETOSTATICS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

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

| **UNIT IV** | **ELECTRODYNAMIC FIELDS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Time-Varying Potentials - Time-Harmonic Fields - Relation between field theory and circuit theory

| **UNIT V** | **ELECTROMAGNETIC WAVES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

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

**Total (45 L+0T) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Mathew N. O. Sadiku, 'Principles of Electromagnetics', 6th Edition, Oxford University Press Inc. Asian edition, 2015. |
| 2. | William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition, 2014. |
| 3. | Kraus and Fleish, 'Electromagnetics with Applications', McGraw Hill International Editions, Fifth Edition, 2010. |


**Reference Books:**


| | |
|---|---|
| 1. | V.V.Sarwate, 'Electromagnetic fields and waves', First Edition, Newage Publishers, 1993. |
| 2. | J.P.Tewari, 'Engineering Electromagnetics - Theory, Problems and Applications', Second Edition, Khanna Publishers. |
| 3. | Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series), McGraw Hill, 2010. |
| 4. | S.P.Ghosh, LipikaDatta, 'Electromagnetic Field Theory', First Edition, McGraw Hill Education(India) Private Limited, 2012. |
| 5. | K A Gangadhar, 'Electromagnetic Field Theory', Khanna Publishers; Eighth Reprint : 2015. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Recognize the fundamental concept, laws and theorem of electric and magnetic fields. | L1:Remembering |
| CO2 | : | Review the concepts in electrostatic fields and magnetic fields. | L2:Understanding |
| CO3 | : | Analyze the Electric and magnetic Field in material space. | L4: Analysing |
| CO4 | : | Apply the boundary conditions to the applications in electrostatic fields and magnetostatic fields. . | L3: Applying |
| CO5 | : | Assessthe knowledge of electromagnetic waves and characterizing parameters. | L4: Analysing |

| 22PTEE202 | SYNCHRONOUS AND INDUCTION MACHINES | | SEMESTER II | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electrical Machines | | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

This course provides understanding of AC machinery fundamentals, machine parts and helps to develop the skills for operating AC machines, and equips students to analyze the equivalent circuits of Induction and Synchronous Machines.

| | | | | | |
|---|---|---|---|---|---|
| **Unit I** | **ALTERNATOR** | **9** | **0** | **0** | **9** |

Construction, types, practical rating of synchronous generators, winding factors, production of EMF, armature reaction, Synchronous reactance, phasor diagram, Methods of pre-determination of voltage regulation- Synchronous impedance, ampere turn, Potier triangle methods. Two reaction theory–Slip test, synchronization -Change of excitation and mechanical input

| | | | | | |
|---|---|---|---|---|---|
| **Unit II** | **SYNCHRONOUS MOTOR** | **9** | **0** | **0** | **9** |

Theory of operation–phasor diagrams, Torque equation – Operation on infinite bus bars, variation of current and power factor with excitation. Hunting and its suppression, V and inverted V curves, Synchronous condenser, method of starting.

| | | | | | |
|---|---|---|---|---|---|
| **Unit III** | **THREE PHASE INDUCTION MACHINES** | **9** | **0** | **0** | **9** |

Constructional details, types, production of rotating magnetic field-principle of operation and practical rating of induction motors. Need for starting – Types of starters – DOL, Rotor resistance and Auto transformer starters. Generator action: self-excitation, operation, and applications.

| | | | | | |
|---|---|---|---|---|---|
| **Unit IV** | **ANALYSIS AND TESTING OF THREE PHASE INDUCTION MOTORS** | **9** | **0** | **0** | **9** |

Phasor diagram, equivalent circuit, Torque equation-starting and maximum-torque, maximum-output, slip for maximum-output, Torque-slip characteristics, losses and efficiency. Testing-no load and blocked rotor tests- equivalent circuit parameters, circle diagram.

| | | | | | |
|---|---|---|---|---|---|
| **Unit V** | **SINGLE PHASE INDUCTION MOTOR** | **9** | **0** | **0** | **9** |

Constructional details of single-phase induction motor – Double field revolving theory and operation – Equivalent circuit – Starting methods of single-phase induction motors – Capacitor-start capacitor run Induction motor- Shaded pole induction motor.

**Total (45L+0T) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | D.P. Kothari, I.J. Nagrath, "Electric Machines", 4th edition, Tata McGraw-Hill Company Ltd., New Delhi, 2010. |
| 2. | Dr.P.S.Bimbhra, "Electrical Machinery", Khanna Publishers, Delhi, 2007. |
| 3. | A.E. Fitzgerald, Charles Kingsley, Stephen. D.Umans, 'Electric Machinery', Tata McGraw Hill Publishing Company Ltd, 2015. |


**References:**


| | |
|---|---|
| 1. | B.L.Theraja & A.K. Theraja, "Electrical Technology", Vol.II, S.Chand & Company Ltd., New Delhi, 2015. |
| 2 | Alexander S. Langsdorf, Theory of Alternating-Current Machinery, Tata McGraw Hill Publications, 2001. |

| **Course Outcomes:** | | | |
|---|---|---|---|
| Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
| CO1 | : | Familiarize with construction, working principle, synchronizing techniques and performance of Synchronous Generator. | L1:Remembering |
| CO2 | : | Understand the working principle, torque equation, and excitation control for Synchronous Motor. | L2:Understanding |
| CO3 | : | Operate three phase Induction machine as motor and as a generator. | L4:Analyzing |
| CO4 | : | Analyze the performance of three phase induction motor with testing. | L4:Analyzing |
| CO5 | : | Know double field revolving theory and starting mechanisms for single-phase induction motors | L5:Evaluating |
| CO6 | | Use synchronous and induction motors in practical domain with specified ratings. | L6:Creating |

| 22PTEE203 | MEASUREMENTS AND INSTRUMENTATION | | SEMESTER II | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| **ELECTRIC CIRCUIT ANALYSIS** | | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To educate the fundamental concepts and characteristics of measurement System. |
| 2. | To introduce the fundamentals of electrical and electronic instruments for measurement of Electrical and Non-electrical quantities. |
| 3. | To familiarize Oscilloscope and the bridge circuits for electrical parameters measurement. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |

Elements of a generalized measurement system - Static and dynamic characteristics - Errors in measurement. Measurement of voltage and current - permanent magnet moving coil and moving iron type meters.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **MEASUREMENT OF POWER , ENERGY AND FREQUENCY** | **9** | **0** | **0** | **9** |

Measurement of power - single and three phase- electrodynamometer type watt meters – Construction, operation – torque equation for deflection – errors. Measurement of energy-Single phase induction type energy meters, Instrument transformers – Current and Potential transformers, Power factor meters- Single phase electrodynamometer type power factor meter, frequency meter-Electrical resonance type frequency meter.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **DC AND AC BRIDGES** | **9** | **0** | **0** | **9** |

Balance equations - Wheatstone bridge – Kelvin double Bridge –Maxwell's inductance capacitance bridge – Hay's bridge – Anderson's bridge – Schering bridge and De Sauty's bridge.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **POTENTIOMETERS, OSCILLOSCOPES AND DIGITAL INSTRUMENTS** | **9** | **0** | **0** | **9** |

DC Potentiometer- Crompton's Potentiometer, AC potentiometer– Drysdale polar potentiometer- Gall Tinsley co-ordinate type potentiometer, Cathode Ray Oscilloscope and Digital storage Oscilloscope-Construction, operation and Applications, Digital multi-meters, Digital voltmeters.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **MEASUREMENT OF NON-ELECTRICAL QUANTITIES** | **9** | **0** | **0** | **9** |

Classification of transducers –Position transducers, Piezo-electric transducers and Hall effect transducers.
Measurement of pressure, temperature and displacement– Introduction to Smart Sensors

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | A.K. Sawhney, 'A Course in Electrical & Electronics Measurement & Instrumentation', Dhanpat Rai and Co, 2015 |
| 2. | E.O. Doebelin, 'Measurements Systems- Application and Design', Tata McGraw Hill publishing company, 2015. |

**Reference Books:**

| | |
|---|---|
| 1. | D.V.S. Moorthy, 'Transducers and Instrumentation', Prentice Hall of India Pvt. Ltd, 2010. |
| 2. | H.S. Kalsi, 'Electronic Instrumentation', Tata McGraw Hill, 2015. |
| 3. | Martin Reissland, ' Electrical Measurements', New Age International(P) Ltd., Delhi, 2011. |

**E-Reference**

| | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/108/105/108105153/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Level** |
|---|---|---|---|
| CO1 | : | Recall the fundamentals of measurement system in electrical engineering. | L1-Remembering |
| CO2 | : | Describe the working principle of different measuring instruments | L2-Understanding |
| CO3 | : | Choose appropriate instrument for measuring the electrical parameters | L3-Applying |
| CO4 | : | Employ the digital instruments in real time measurements. | L3-Applying |
| CO5 | : | Select an appropriate transducer for measurement of non-electrical quantities | L4-Analyzing |

| 22PTEE204 | ELECTRICAL MACHINES LABORATORY | | SEMESTER II | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES: NIL** | | **CATEGORY** | **L** | **T** | **P** | **C** |

| | | | | | |
|---|---|---|---|---|---|
| | **PC** | **0** | **0** | **3** | **1.5** |

**Course Objectives:**

| | |
|---|---|
| 1. | To expose the students to operate of DC and AC Machines and strength their experimental skill. |

**Experiments**

| | |
|---|---|
| 1. | Open circuit and load characteristics of DC shunt generator. |
| 2. | Load characteristics of DC long shunt and short shunt compound generator with cumulative and differential connections. |
| 3. | Load test on DC series motor. |
| 4. | Swinburne's test on DC machines. |
| 5. | Speed control of DC shunt motor. |
| 6. | Open circuit and Short tests on single phase Transformer. |
| 7. | Load test on single-phase transformer / three phase Transformer. |
| 8. | Predetermination of Voltage Regulation of three-phase alternator by EMF and MMF methods. |
| 9. | V and inverted V curves of synchronous motor. |
| 10. | Circle diagram for three phase induction motor with No load and blocked rotor test data. |
| 11. | Load test on three-phase induction motor/single phase Induction Motor. |
| 12. | Separation of losses in three phase induction motor. |

**Total (0+45)= 45 Periods**

**Reference Books:**

| | |
|---|---|
| 1. | G.P. Chhalotra, 'Experiments in Electrical Engineering', 3rd Ed., Khanna Publishers, Delhi, 2004. |
| 2. | C.S. Indulkar, 'Laboratory Experiments in Electrical Power', 3rd Ed., Khanna Publishers, Delhi, 2010. |
| 3. | DC machines and transformers laboratory manual prepared by the department. |
| 4. | Synchronous and Induction Machines manual prepared by the department. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's TaxonomyMapped** |
|---|---|---|---|
| CO1 | : | Understand the voltage regulation of a given alternator using different methodologies and Transformer | L2: Understanding |
| CO2 | : | Analyze the performance of a given synchronous motor under various excitation Conditions | L4: Analyzing |
| CO3 | : | Analyze the characteristics of a induction motor and DC machines under various load conditions | L4:Analyzing |
| CO4 | : | Develop the equivalent circuit and analyze the characteristics of AC machine | L5: Creating |
| CO5 | : | Do loss analysis in DC and AC machines. | L4: Analyzing |

| **22PTEE301** | **ELECTRICAL MACHINE DESIGN** | | **SEMESTER III** | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| 1.DC Machines and Transformers | **PC** | **3** | **0** | **0** | **3** |

| 2.Synchronous and Induction Machines | | | | | | |
|---|---|---|---|---|---|---|

**Course Objectives:**

| | |
|---|---|
| 1. | To Study mmf calculation and thermal rating of various types of electrical machines. |
| 2. | To Design armature and field systems for D.C. machines. |
| 3. | To Design core, yoke, windings and cooling systems of transformers. |
| 4. | To Design stator and rotor of induction machines. |
| 5. | To Design stator and rotor of synchronous machines and study their thermal behavior. |

| **UNIT I** | **INTRODCUTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Major considerations – Limitations – Electrical Engineering Materials – Space factor - Design of Magnetic Circuits: MMF calculation for Air gap and Teeth - Iron losses and Magnetizing current calculations. Design of lap winding and wave winding -Standard specification.

| **UNIT II** | **DC MACHINES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Design of rotating machines – D.C machines output equations – Main dimensions- Choice of Specific Electric and Magnetic Loading -Selection of number of poles – Armature design – Design of commutator and brushes-Design of slot, air gap, field coils.

| **UNIT III** | **TRANSFORMERS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

KVA output for single and three phase transformers – Window space factor – Overall dimensions – Operating characteristics – Regulation – No load current – Temperature rise of Transformers– Design of Tank with & without cooling tubes – Thermal rating – Methods of cooling of Transformers – Design of inductors.

| **UNIT IV** | **INDUCTION MOTORS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Output equation of Induction motor – Main dimensions –Choice of electrical and magnetic loadings-Length of air gap- Rules for selecting rotor slots of squirrel cage machines– Design of rotor bars & slots – Design of end rings – Design of wound rotor-Operating characteristics –Short circuit current –Circle diagram.

| **UNIT V** | **SYNCHRONOUS MOTORS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Runaway speed – construction – output equations – choice of loadings – Design of salient pole machines – Short circuit ratio – shape of pole face – Armature design – Armature parameters – Estimation of air gap length– Design of rotor –Design of damper winding – Determination of full load field mmf – Design of field winding – Computer Program – design of Stator main dimensions.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Sawhney, A.K., 'A Course in Electrical Machine Design', 6th edition,Dhanpat Rai & Sons, New Delhi, 2014.. |
| 2. | Sen.,S.K., 'PrinciplesofElectricalMachineDesignswithComputerProgrammes',Oxford and IBH PublishingCo.Pvt.Ltd. NewDelhi,2009. |

**Reference Books:**

| | |
|---|---|
| 1. | R.K.Agarwal, Principles of Electrical Machine design, S.K. Kataria and Sons, Delhi 2014. |
| 2. | V.N. Mittle, ' Design of Electrical Machines',5th edition, Standard Publications and Distributors, Delhi, 2013. |
| 3. | V Rajini, V.S Nagarajan, 'Electrical Machine Design', Pearson, first edition 2018. |

**E-Reference**

| | |
|---|---|
| 1 | http://cusp.umn.edu/machine_design.php |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | **Bloom's Taxonomy Mapped** |
|---|---|

| | | | |
|---|---|---|---|
| CO1 | : | Classify the materials used for the construction of electrical machines and be able to calculate the MMF in magnetic parts of rotating machines. | L4:Analyzing |
| CO2 | : | Familiarize the importance of magnetic ,thermal and electrical loading of AC and DC Machines. | L2:Understand |
| CO3 | : | Design and Analyze Armature and Field Systems for DC Machines. | L3&L4: Applying &Analyzing |
| CO4 | : | Design and Analyze core, windings and cooling system of transformers. | L3&L4: Applying &Analyzing |
| CO5 | : | Design and analyze Stator and rotor of Induction Machines and Synchronous machines. | L3&L4: Applying &Analyzing |

| 22PTEE302 | LINEAR INTEGRATED CIRCUITS | | | | SEMESTER III |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electron Devices and Circuits | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

To acquaint the students various process involved in manufacture of semiconductor devices, understand the theory of operational amplifier, to apply the concepts of operational amplifier for different applications, study of the operation and typical applications of special integrated circuits and Understand the concepts of power supply circuits and different integrated circuits meant forgalvanic isolation.

| **Unit I** | **IC FABRICATION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

IC classification, fundamental of monolithic IC technology, epitaxial growth, masking and etching diffusion of impurities. Realisation of monolithic ICs and packaging.

| **Unit II** | **CHARACTERISTICS OF OPAMP** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Ideal OP-AMP characteristics, DC characteristics, AC characteristics, offset voltage and current: voltage series feedback and shunt feedback amplifiers, differential amplifier; frequency response of OP-AMP; Basic applications of op-amp – summer, differentiator and integrator.

| **Unit III** | **APPLICATION OF OPAMP** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Instrumentation amplifier, first and second order active filters, V/I & I/V converters, comparators, multivibrators, waveform generators, clippers, clampers, peak detector, S/H circuit, D/A converter (R-2R ladder and weighted resistor types), A/D converter - Dual slope, successive approximation and flash types.

| **Unit IV** | **SPECIAL ICs** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

555 Timer circuit – Functional block, characteristics & applications; 566-voltage controlled oscillator circuit; 565-phase lock loop circuit functioning and applications, Analog multiplier ICs.

| **Unit V** | **APPLICATION ICs** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

IC voltage regulators - LM317, 723 regulators, switching regulator, MA 7840, LM 380 power amplifier, ICL 8038 function generator IC, isolation amplifiers, opto-coupler, opto-electronic ICs.

**Total (45L+0T) = 45 Periods**

**Text Books:**


1. Ramakant A. Gayakward, 'Op-amps and Linear Integrated Circuits', IV edition, Pearson Education, 2010 / HI.
2. D. Roy Choudhary, SheilB.Jani, 'Linear Integrated Circuits', II edition, New Age, 2012.


**Reference Books:**


1. Jacob Millman, Christos C.Halkias, 'Integrated Electronics - Analog and Digital circuits system', Tata McGraw Hill, 2011.
2. Robert F.Coughlin, Fredrick F.Driscoll, 'Op-amp and Linear ICs', Pearson Education, 4th edition,2012 / PHI.
3. David A.Bell, 'Op-amp & Linear ICs', Prentice Hall of India, 2nd edition, 2011


**Course Outcomes:**

| Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Apply the concept for the fabrication of basic semiconductor devices. | L3:Applying |
| CO2 | : | Apply the basic underlying theory and concepts of operational amplifier.. | L3:Applying |
| CO3 | : | Implement the construction and design of different application circuits using operationalamplifiers. | L6:Creating |
| CO4 | : | Implement the construction and operation of application circuits based on special ICs suchas 555 Timer, 565 PLL and 566 VCO. | L6:Creating |
| CO5 | : | Design and construct a linear or a switch mode power supply for his own needs. | L4:Analysing |

| 22PTEE303 | DIGITAL LOGIC CIRCUITS | SEMESTER III |
|---|---|---|

| PREREQUISTIES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Electron Devices and Circuits | PC | 3 | 0 | 0 | 3 |

**Course Objectives:**

| | |
|---|---|
| 1. | Provide an overview of Digital logic families. |
| 2. | Show how to simplify the switching functions. |
| 3. | Gain in depth knowledge about the design procedure and Implementation of combinational logic circuits. |
| 4. | Gain in depth knowledge about the design procedure and Implementation of sequential logic circuits. |
| 5. | Understand the fundamental concept used in memory devices ROM, PAL, PLA and VHDL |

| Unit I | DIGITAL LOGIC FAMILIES AND BOOLEAN ALGEBRA | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Digital logic families: RTL, DTL, TTL, ECL, MOS, CMOS circuits and their characteristics; Review of number system and codes, Boolean algebra: Postulates and theorem-De-Morgan's theorem- Duality Principle, Logic gates - Truth tables - min terms and max terms – sum of products and product of sums - and simplification of switching functions using Boolean algebra, K-maps and Quine McCluskey (Tabulation) method -NAND and NOR implementation.

| Unit II | COMBINATIONAL CIRCUITS – I | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Definition -Design procedure – Adders - Subtractors – Serial adder/ Subtractor - Parallel adder/ Subtractor- Carry look ahead adder- BCD adder- Magnitude Comparator.

| Unit III | COMBINATIONAL CIRCUITS – II | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Multiplexer- Demultiplexer- Encoder - Decoder – Parity Checker – Code Converters. Implementation of combinational logic using MUX, ROM, PAL and PLA- HDL for combinational Circuits.

| Unit IV | SYNCHRONOUS SEQUENTIAL CIRCUITS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Flip flops : SR, D, JK and T- conversion of flip-lops Classification of sequential circuits: Moore and Mealy models, Analysis and design of synchronous sequential circuits, Design of synchronous counters- state diagram- state reduction and state assignment.-Universal shift register – Shift counters – Ring counters.

| Unit V | ASYNCHRONOUS SEQUENTIAL CIRCUITS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Definition -fundamental mode and pulse mode circuits Analysis procedure of asynchronous circuits with /without using of SR latches- primitive state / flow table – Reduction of state and flow table - state assignment –Design Procedure of asynchronous circuits with /without using of SR latches-Problems in asynchronous sequential circuits: cycles -Races – Hazards.

**Total (45L+0T)=45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | M. Morris Mano, "Digital Design" ,Third Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2003 / Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2010. |
| 2. | S. Salivahanan and S. Arivazhagan, "Digital Circuits and Design**"**, Fourth Edition, Vikas Publishing House Pvt. Ltd, New Delhi, 2012. |


**Reference Books:**


| | |
|---|---|
| 1. | R.P.Jain, "Modern Digital Electronics", Fourth Edition, Tata McGraw–Hill Publishing company limited, New Delhi, 2013. |
| 2. | Charles H.Roth. **"**Fundamentals of Logic Design",Thomson Publication Company, 2010. |
| 3. | Thomas L. Floyd, **"**Digital Fundamentals", Pearson Education, Inc, New Delhi, 2010 |
| 4. | Donald P.Leach and Albert Paul Malvino, **"**Digital Principles and Applications", Fifth Edition, Tata McGraw Hill Publishing Company Limited, New Delhi, 2012. |
| 5. | John.M Yarbrough, Digital Logic Applications and Design, Thomson- Vikas Publishing house, New Delhi, 2011. (Unit III, IV) |


**E-References:**

| | |
|---|---|
| 1 | NPTEL courses on Digital Circuits and systems, IIT Madras. |

| Course Outcomes: | Bloom's Taxonomy Mapped |
|---|---|
| Upon completion of this course, the students will be able to: | |

| | | | |
|---|---|---|---|
| CO1 | : | Explain the various digital logic families**.** | L2:Understanding |
| CO2 | : | Simplify the switching function using Boolean function, K-map and Tabulation methods | L3:Applyng |
| CO3 | : | Design and Implement combinational logic circuits | L6:Creating |
| CO4 | : | Analysis and design of synchronous sequential logic circuits | L6:Creating |
| CO5 | : | Analysis and design of Asynchronous sequential logic circuits | L6:Creating |

| 22PTEE304 | POWER ELECTRONICS | | | | SEMESTER III | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electron Devices and Circuits | | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To study an overview of power semiconductor devices. |
| 2. | To obtain the knowledge of controlled rectifiers. |
| 3. | To acquire the principles of DC-DC converter. |
| 4. | To understand the principles of inverters and ac voltage controllers. |

| **UNIT I** | **POWER SEMICONDUCTOR DEVICES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Concept of power electronics- Structure, Operation, Static and Switching characteristics of power semiconductor devices: Power Diode, SCR, MOSFET, IGBT, IGCT –- Thyristor ratings and protection, Gate drive circuits for MOSFET and IGBT - TRIAC triggering concept- Switching and Conduction losses in a generic power semiconductor device – Thermal design.

| **UNIT II** | **PHASE CONTROLLED RECTIFIERS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Single phase and three phase fully controlled rectifiers – Power circuit, Operation, Waveform analysis and performance parameters - capacitor filter for low power rectifiers – LC filters – Concern for power quality– Effect of source and load inductance –Single phase and Three phase dual converters- Introduction to PWM rectifiers

| **UNIT III** | **DC TO DC CONVERTER** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Elementary chopper with an active switch and diode, concepts of duty ratio and average voltage– control strategy –Power Circuit and steady state analysis of Buck converter, Boost converter, Buck – boost converter and SEPIC converter- Design of inductor and capacitors for DC-DC converters.

| **UNIT IV** | **INVERTERS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Power circuit of single phase voltage source inverter, square wave operation of the inverter, bipolar and unipolar sinusoidal modulation, modulation index and output voltage, Power circuit of a three-phase voltage source inverter, operation, switch states, instantaneous output voltages, three-phase sinusoidal modulation -Space vector modulation – Current Source Inverter.

| **UNIT V** | **AC TO AC CONVERTERS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction and principle of operation of Single phase and Three phase AC voltage controllers – Multistage sequence control - Applications of AC Voltage Controllers–Introduction to Matrix converters.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | M.H.Rashid, 'Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI 4th Edition, New Delhi 2017. |
| 2. | P .S.Bimbra "Power Electronics" Khanna Publishers, New Delhi 2018. |

**Reference Books:**

| | |
|---|---|
| 1. | Ned Mohan, Tore. M. Undel and, William. P. Robbins, 'Power Electronics: Converters, Applicationsand Design', John Wiley and sons, 2007. |
| 2. | R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007. |
| 3. | M.D. Singh and K.B. Khanchandani, "Power Electronics," McGraw Hill India, 2013. |

**E-Reference**

| | |
|---|---|
| 1 | www.onlinecourses.nptel.ac.in/ |
| 2 | www.class-central.com |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's TaxonomyMapped** |
|---|---|---|---|
| CO1 | : | Choose suitable Power Semiconductor Devices for the application. | L3: Applying |
| CO2 | : | Know the operation of converters inverters and AC voltage controllers | L2: Understanding |
| CO3 | : | Analyze the performance of converters and inverters | L4: Analyzing |
| CO4 | : | Design and analyze converter and inverter circuits | L6: Creating |
| CO5 | : | Identify suitable control techniques for the converter | L1: Remembering |

| 22PTCY301 | ENVIRONMENTAL SCIENCE AND ENGINEERING | SEMESTER III | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Nil | **BS** | **3** | **0** | **0** | **3** |

**Course Objectives:**

To make the students conversant with the

| | |
|---|---|
| 1. | Principles of environmental resources. |
| 2. | Preservation of ecosystem and biodiversity. |
| 3. | Principles of environmental threats and pollution. |
| 4. | Principles of solid waste management. |
| 5. | Environmental issues and ethics. |

| UNIT I | ENVIRONMENTAL RESOURCES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Forest resources – importance, deforestation – water resources – hydrological cycle – food resources – effects of modern agriculture, fertilizers, pesticides – Land Resources- Land degradation-soil erosion- Mineral resources –types – mining - environmental effects of extracting and using mineral resources.

| UNIT II | ECOSYSTEM AND BIODIVERSITY | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Environment – biotic and abiotic components – Ecosystem – components –Energy Partitioning in Food Chains and Food Webs -tropic levels – energy flow in ecosystem, ecological pyramids – ecological succession, types – Biodiversity, types, values of biodiversity, hot spots of biodiversity, threat to biodiversity, endangered and endemic species, conservation of biodiversity – In-situ and Ex-situ conservation.

| UNIT III | ENVIRONMENTAL POLLUTION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Air pollution – classification of air pollutants - gaseous, particulates – sources, effects and control of gaseous pollutants, $SO_x$, $NO_x$, $H_2S$, CO and particulates – control methods – catalytic convertor, cyclone separator, electrostatic precipitator– Water pollution – heavy metal ions pollutants – organic pollutants, oxygen demanding wastes, aerobic and anaerobic decomposition, Dissolved oxygen (DO), BOD and COD - experimental determination of BOD only, treatment of domestic and industrial wastewater – Noise pollution –decibel scale - sources, effects and control measures.

| UNIT IV | ENVIRONENTAL THREATS AND SOLID WASTE MANAGEMENT | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Eutrophication, bio amplification, acid rain, greenhouse effect and global warming, ozone layer depletion, photo chemical smog – disaster management – origin, effects and management of earthquake and floods. Solid waste management – solid wastes, classification, origin, effects – treatment methods – composting, sanitary land filling – destructive methods – incineration, pyrolysis, 3R (reduce, reuse and recycling).

| UNIT V | SOCIAL ISSUES AND ENVIRONMENTAL ETHICS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

From unsustainable to sustainable development, objectives, and ways of achieving – urban problems related to energy an energy conservation – water conservation and management, rainwater harvesting – waste land reclamation. Environmental ethic – consumerism – human population, exponential and logistic growth, population explosion, population policy, family welfar programme – population control methods – HIV and AIDS.

**Total (45L+0T) =45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Elements of Environmental science and Engineering, P.Meenakshi, Prenitce — Hall of India, New Delhi, 2009. |
| 2. | A Textbook of Environmental Chemistry and Pollution Control: (With Energy, Ecology, Ethics and Society), Revise Edition, Dr. S.S. Dara, D.D. Mishra Published by S. Chand & Company Ltd, 20 14. |

**Reference Books:**

| | |
|---|---|
| 1. | IntroductiontoEnvironmentalEngineeringandScience,GilbertM.Masters;WendellP.ElaPublisher:Prentice-HallIndia,3rdEdition,2008. |
| 2. | Environmental Science, F;ldren D. Enger, Bredley F.Smith, WCD McGraw Hill 14"Edition 2015. |

**E-Reference**

| | |
|---|---|
| 1 | www.onlinecourses.nptel.ac.in/ |
| 2 | www.ePathshala.nic.in |

| **Course Outcomes:** | **Bloom's TaxonomyMapped** |
|---|---|
| Upon completion of this course, the students will be able to: | |

| | | | |
|---|---|---|---|
| CO1 | : | Play an important role in conservation of natural resources for future generation. | L6: Creating |
| CO2 | : | Paraphrase the importance of ecosystem and biodiversity. | L2: Understanding |
| CO3 | : | Analyze the impact of pollution and hazardous waste in a global and social context. | L4: Analyzing |
| CO4 | : | Understand contemporary issues that result in environmental degradation that would attempt to provide solutions to overcome the problems. | L2: Understanding |
| CO5 | : | Consider the issues of environment and human population in their professional undertakings. | L3: Applying |

| 22PTEE401 | CONTROL SYSTEMS | SEMESTER IV | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electrical Machine, Electrical Circuit Analysis | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the methods of representation of systems and getting their transfer function models. |
| 2. | To provide adequate knowledge in the time response of systems and steady state error analysis. |
| 3. | To give basic knowledge in obtaining the open loop and closed loop frequency response of systems. |
| 4. | To understand the concept of stability of control system and methods of stability analysis. |
| 5. | To study the three ways of designing compensators for a control system. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **SYSTEMS AND THEIR REPRESENTATION** | **9** | **0** | **0** | **9** |

Basic elements in control systems – Open and closed loop systems – Mathematical model and Electrical analogy of mechanical systems – Transfer function Representation– Synchro – AC and DC servo-motors – Block diagram reduction techniques – Signal flow graphs.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **TIME RESPONSE ANALYSIS** | **9** | **0** | **0** | **9** |

Standard test signals – Time response of first order and second order systems – Stability analysis: Steady-state errors and error constants – Types of control systems – Effect of adding poles and zeros to transfer functions – Response with P, PI, PD and PID controllers.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **FREQUENCY RESPONSE ANALYSIS** | **9** | **0** | **0** | **9** |

Correlation between time and frequency response: Second order systems – Polar plots – Bode plots – Computation of Gain Margin and Phase Margin – Frequency domain specifications – Constant M and N-circles – Nichols chart.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **STABILITY OF CONTROL SYSTEM** | **9** | **0** | **0** | **9** |

BIBO stability – Necessary conditions for stability – Routh-Hurwitz stability criterion – Root locus concepts – Rules for the construction of Root loci – Nyquist stability criterion – Assessment of relative stability using Nyquist criterion.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **COMPENSATOR DESIGN** | **9** | **0** | **0** | **9** |

Need for compensation – Types of compensators – Electric network realization and frequency characteristics of basi compensators: Lag, lead and lag-lead compensators –Cascade compensation in frequency domain.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | A. Anand Kumar, "Control Systems", PHI Learning Pvt. Ltd., New Delhi, 2nd Edition, 2015. |
| 2. | I.J. Nagrath& M. Gopal, "Control Systems Engineering", New Age International Publishers, Delhi, 5th Edition, 2015. |

**Reference Books:**

| | |
|---|---|
| 1. | K. Ogata, "Modern Control Engineering", Pearson Education, New Delhi, 2010. |
| 2. | M. Gopal, "Control Systems: Principles and Design", TMH, New Delhi, 4th Edition, 2012. |

**E-Reference**

| | |
|---|---|
| 1 | www.onlinecourses.nptel.ac.in/ |
| 2 | www.class-central.com |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | **Bloom's Taxonomy Mapped** |
|---|---|

| | | | |
|---|---|---|---|
| CO1 | : | Derive the transfer function models of any electrical and mechanical systems. | L3:Applying |
| CO2 | : | Analyze the time and frequency responses of the systems. | L4: Analyzing |
| CO3 | : | Analyze the stability of closed loop control systems. | L4: Analyzing |
| CO4 | : | Construct the root locus plot and analyze system stability. | L4: Analyzing |
| CO5 | : | Design the compensators using conventional techniques. | L6:Creating |

| 22PTEE402 | POWER GENERATION, TRANSMISSION AND DISTRIBUTION SYSTEM | SEMESTER IV |
|---|---|---|

| PREREQUISTIES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| ELECTRIC CIRCUIT ANALYSIS | PC | 3 | 0 | 0 | 3 |

**Course Objectives:**

| | |
|---|---|
| 1. | To impart knowledge on power generation plants and Substation. |
| 2. | To study the line parameters and analyze the performance of the transmission system. |
| 3. | To learn insulators, cables and grounding methodologies for power system. |

| UNIT I | POWER GENERATION SYSTEMS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Structure of electric power system-Terms, factors and significance of Load curve –Economics of Power Generation-Cost of Electrical Energy- Power generating Station: layout and operation of Thermal power plant, Hydroelectric power plant and Nuclear power plants –Comparison of power plants.

| UNIT II | TRANSMISSION LINE PARAMETERS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Line resistance- Inductance and capacitance calculations of single phase and three phase transmission lines with single and double circuits–Effect of earth on the capacitance of the transmission line– Skin and proximity effects-Inductive interference between power and communication lines.

| UNIT III | PERFORMANCE OF TRANSMISSION LINES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Representation of Lines-Performance of Short line, medium line and long transmission line; equivalent circuits, Phasor Diagrams, transmission efficiency and voltage regulation, ABCD constants-surge-impedance loading-Ferranti effect and corona effect.

| UNIT IV | OVERHEAD LINE INSULATORS AND CABLES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Insulators: Types, Potential distribution over a string of suspension insulators- improvement of string efficiency. Underground cables: Constructional features of LT and HT cables, capacitance of single core and 3- core cables, dielectric stress in a single core cable- grading of cables, thermal resistance of dielectric of a single core cable.

| UNIT V | SUBSTATION, GROUNDING SYSTEM AND DISTRIBUTION SYSTEM | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Substation: Lay out and operation-bus-bar arrangements in sub stations- Grounding: Need and Types, Neutral grounding and Resonant grounding- Transformer Earthling-Distribution system: Classification, Layout of AC and DC distribution, Connection Schemes of Distribution system

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | C.L. Wadhwa, 'Electrical Power Systems', New age International (P) Ltd., 2018. |
| 2. | S.N.Singh, "Electric Power Generation, Transmission and Distribution", Second Edition, PHI Pvt. Ltd., New Delhi, 2012. |

**Reference Books:**

| | |
|---|---|
| 1. | Ray, "Electrical Power systems: Concepts, Theory and Practice", PHI Pvt.Ltd., New Delhi,2012. |
| 2. | V.K. Mehta, Rohit Mehta, "Principles of Power System", S.Chand& Company Ltd., New Delhi, 2012 |

**E-Reference**

| | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/108/102/108102047/ |

| Course Outcomes: Upon completion of this course, the students will be able to: | | | Bloom's Taxonomy Level |
|---|---|---|---|
| CO1 | : | Explain the operation of generating stations and substations | L2-Understanding |
| CO2 | : | Model the transmission lines using system parameters | L3-Applying |
| CO3 | : | Analyze the performance of different types of transmission lines | L4-Analyzing |
| CO4 | : | Select an appropriate insulator and cable for transmission and distribution system | L4-Analyzing |
| CO5 | : | Describe the substation components and grounding techniques. | L1-Remembering |

| 22PTEE403 | PROTECTION AND SWITCHGEAR | SEMESTER IV | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power System | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

1. To acquire knowledge about the power system protection and switchgear components.
2. To understand the concepts of various protection schemes.
3. To study the functioning of static relays and numerical protection schemes.

| **UNIT I** | **PROTECTION AND RELAYS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Need for protective system – Protection system components – Zones of protection – Primary & Backup protection - Essential qualities of protection – Relay construction & operating principles: Electromechanical relays – Instantaneous relay – Inverse-time relay - Definite time lag relay - Over current relay – Reverse power relay – Distance relay – Differential relay – Translay scheme - Under frequency and over frequency relays - Universal relay torque equation – PSM, TSM.

| **UNIT II** | **CIRCUIT BREAKERS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Arc phenomenon – Principles of arc extinction – Methods of arc extinction – Important terms – Classification: Bulk oil and minimum oil circuit breaker – Air-blast circuit breakers: Types - Vacuum circuit breakers- $SF_6$ circuit breakers - Rating of circuit breakers – Problems of circuit interruption: RRRV – current chopping – capacitive current breaking – Resistance switching - Testing of circuit breakers – Selection of circuit breakers - HVDC circuit breakers.

| **UNIT III** | **EQUIPMENT PROTECTION SCHEMES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Feeder protection - Distance protection – Alternator protection - Short circuit protection of stator windings by percentage differential relays - Protection against turn to turn faults in stator winding - Field ground fault protection - Protection of stator windings by overvoltage relays - Protection against stator open circuits, loss of synchronism, loss of excitation, rotor overheating - Protection of transformers - Typical schemes.

| **UNIT IV** | **STATIC RELAYS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction - Advantages of static relays - Basic construction - Phase and amplitude comparators - Static directional relay - Directional overcurrent relay – Static differential relays and differential protective schemes.

| **UNIT V** | **NUMERICAL PROTECTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction – Block diagram – Sampling theorem – Fourier analysis of analogue signals – Least error squared technique – Digital filtering – Over current protection – Differential protection – Distance protection.

**Total (45L+0T)= 45 Periods**

**Text Books:**


1. Badri Ram and Vishwakarma, “Power System Protection and Switchgear”, Tata McGraw Hill, 2011.
2. Arun Ingole, “Switchgear and Protection”, Pearson Education India, 2017.


**Reference Books:**


1. Rao, T. S. M, “Power System Protection Static Relays with Microprocessor Applications”, Tata McGraw-Hill, 1998.
2. Paithankar, Y. G and Bhide, S. R, “Fundamentals of Power System Protection”, Prentice Hall, 2010.
3. Uppal, S.L, “Electrical Power", Khanna Publishers, New Delhi, 1986.
4. Ravindranath. B and Chander, N, “Power System Protection and Switchgear”, New Age International, 1996.


**E-References:**

1. NPTEL Course: Power System Protection - Prof. S.A. Soman, IIT-B.
2. NPTEL Course: Power System Protection – organized by IIT-B.
3. www.cdeep.iitb.ac.in. (Electrical Engineering)

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Illustrate the concepts and applications of protective relays. | L3: Applying |
| CO2 | : | Discuss about different types of circuit breakers | L2: Understanding |
| CO3 | : | Assess the protection schemes of various power components. | L1: Remembering |
| CO4 | : | Develop the knowledge on static relays. | L4: Analyzing |
| CO5 | : | Analyze the numerical protection schemes. | L4: Analyzing |

| 22PTEE404 | ELECTRICAL DRIVES AND CONTROL | | SEMESTER IV | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| DC Machines and Transformers , Synchronous and Induction Machines, Power Electronics | | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

1. To know about operation of the chopper fed dc drive, both qualitatively and quantitatively.
2. To understand the Operation and performance of AC motor drives.

| UNIT I | DC MOTOR CHARACTERISTICS & CHOPPER FED DC DRIVES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example load torque-speed characteristics, operating point, armature voltage control for varying motor speed. Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper.

| UNIT II | MULTI-QUADRANT & CLOSED-LOOP CONTROL OF DC DRIVE | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Review of Four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, current controller specification and design, speed controller specification and design.

| UNIT III | INDUCTION MOTOR | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve (i)applied voltage,(ii)applied frequency and (iii)applied voltage and frequency. Review of three-phase voltage source inverter, generation of three-phase PWM signals, constant V/f control of induction motor.

| UNIT IV | CONTROL OF SLIP RING INDUCTION MOTOR | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

| UNIT V | CONTROL OF SRM AND BLDC MOTOR DRIVES. | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

SRM construction - Principle of operation - SRM drive design factors-Torque controlled SRM- Block diagram of Instantaneous Torque control using current controllers and flux controllers. Construction and Principle of operation of BLDC Machine -Sensing and logic switching scheme,-Sinusoidal and trapezoidal type of Brushless dc motors – Block diagram of current controlled Brushless dc motor drive.

**Total (45L+0T)= 45 Periods**

**Text Books:**


1. G. K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, 1989.
2. R. Krishnan, “Electric Motor Drives: Modeling, Analysis and Control”, Prentice Hall,2010
3. Bose B K, "Modern Power Electronics and AC Drives", Pearson Education New Delhi, 2010.


**Reference Books:**


1. G. K. Dubey, “Fundamentals of Electrical Drives”, CRC Press, 2012.
2. W. Leonhard, “Control of Electric Drives”, Springer Science & Business Media, 2001.


**E-Reference**

1. https://www.iith.ac.in/~ketan/drives.htmL

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom’s Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the characteristics of dc motors and induction motors. | L2:Understanding |
| CO2 | : | Summarize the operation of chopper fed DC drives. | L4:Analyzing |
| CO3: | : | Understand the principles of speed-control of dc motors and induction motors. | L2:Understanding |
| CO4 | : | Identify suitablepower electronic converters used for dc motor and induction motor speed control. | L3:Applying |
| CO5 | : | Analyze the SRM and BLDC motor drive control | L4:Analyzing |

| 22PTEE405 | POWER ELECTRONICS AND DRIVES LABORATORY | SEMESTER IV |
|---|---|---|

| PREREQUISITES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Electrical Machines , Power Electronics | PC | 0 | 0 | 3 | 2 |

## Course Objectives:

To study, analyse the performance of different power electronic converter circuits and learn to simulate different power electronic converter circuits and analyze their performance.

## LIST OF EXPERIMENTS:

| | |
|---|---|
| 1. | Characteristics of power diode and SCR |
| 2. | Static and Switching Characteristics of Power MOSFET |
| 3. | Static and Switching Characteristics of Power IGBT |
| 4. | Single phase AC to DC fully controlled converter |
| 5. | Step down and step up chopper |
| 6. | IGBT based single-phase PWM inverter |
| 7. | IGBT based three-phase PWM inverter |
| 8. | TRIAC based single phase AC voltage controller |
| 9. | Speed control of separately excited chopper fed DC Drive. |
| 10. | V/f speed control method of Three phase Induction Motor. |
| 11. | Speed control of BLDC Motor. |
| 12. | Speed control of Switched Reluctance Motor |

**Total (0T+ 45P)= 45 Periods**

## Reference Books:


| | |
|---|---|
| 1. | M.H.Rashid, 'Power Electronics: Circuits, Devices and Applications', Pearson Education, PHI Third Edition, New Delhi, 2009. |
| 2. | P.S.Bimbra "Power Electronics" Khanna Publishers, New Delhi 2016. |
| 3. | Seung-Ki Sul, "Control of Electric Machine Drive Systems" , John Wiley & Sons, Ltd., 2011. |


## Course Outcomes:

| Upon completion of this course, the students will be able to: | | | Bloom's Taxonomy Mapped |
|---|---|---|---|
| CO1 | : | Analyze the characteristics of MOSFET, SCR and IGBT. | L1:Analyzing |
| CO2 | : | Demonstrate the performance of DC-DC Converters | L3:Applying |
| CO3 | : | Demonstrate the performance of DC-AC Converters | L3:Applying |
| CO4 | : | Analyze the performance characteristics of Power Converters for DC and AC Drive | L4:Analyzing |
| CO5 | : | Analyze the performance characteristics of Power Converters for Special Electrical Machine | L5:Evaluating |

| 22PTEE501 | MICROPROCESSOR AND MICROCONTROLLER | SEMESTER V |
|---|---|---|

| PREREQUISTIES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| C Programming | PC | 3 | 0 | 0 | 3 |

| **Course Objectives:** | | | | | |
|---|---|---|---|---|---|
| 1. | To study the architecture of μP8085 & μC 8051 | | | | |
| 2. | To study the Interrupt structure of 8085 & 8051. | | | | |
| 3. | To do simple applications development with programming 8085 & 8051. | | | | |
| **UNIT I** | **8085 8 BIT MICROPROCESSOR** | **9** | **0** | **0** | **9** |
| Fundamentals of microprocessors – Architecture of 8085 – Groups of Instructions - Addressing modes – Basic timing diagram – Organization and addressing of Memory and I/O systems –Interrupt structure – Stack and sub-routines - Simple 8085 based system design and programming. | | | | | |
| | | | | | |
| **UNIT II** | **8051 8 BIT MICROCONTROLLER** | **9** | **0** | **0** | **9** |
| Fundamentals of microcontrollers – Architecture of 8051 – Groups of Instructions - Addressing modes – Organization of Memory systems – I/O Ports – Timers/Counters – Serial Port - Interrupt structure – Simple programming concepts using Assemblers and Compliers. | | | | | |
| | | | | | |
| **UNIT III** | **INTERFACING WITH 8051 MICROCONTROLLER** | **9** | **0** | **0** | **9** |
| Need and requirements of interfacing – Interfacing – LED, 7 segment and LCD Displays – Tactile switches, Matrix keyboard – Parallel ADC – DAC – Interfacing of Current, Voltage, RTD and Hall Sensors. | | | | | |
| | | | | | |
| **UNIT IV** | **EXTERNAL COMMUNICATION INTERFACE** | **9** | **0** | **0** | **9** |
| Synchronous and Asynchronous Communication. RS232, RS 485, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee. | | | | | |
| | | | | | |
| **UNIT V** | **APPLICATIONS OF MICROCONTROLLERS** | **9** | **0** | **0** | **9** |
| Simple programming exercises- key board and display interface –Control of servo motor stepper motor control- Application to automation systems. | | | | | |
| | | | | | |
| **Total (45L+0T)= 45 Periods** | | | | | |
| | | | | | |
| **Text Books:** | | | | | |
| 1. | R.S. Gaonkar, 'Microprocessor Architecture Programming and Application', with 8085, Wiley Eastern Ltd., New Delhi, 2013. | | | | |
| 2. | K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004. | | | | |
| 3. | Muhammad Ali Mazidi & Janice GilliMazidi, R.D.Kinely 'The 8051 Micro Controller and Embedded Systems', PHI Pearson Education, 5th Indian reprint, 2003. | | | | |
| **Reference Books:** | | | | | |
| 1. | R. Kamal , "Embedded System", McGraw Hill Education, 2009. | | | | |
| 2. | D. V. Hall, "Microprocessors & Interfacing", McGraw Hill Higher Education, 1991. | | | | |
| **E-Reference** | | | | | |
| 1. | www.onlinecourses.nptel.ac.in/noc18_ee41 | | | | |
| 2. | www.class-central.com | | | | |
| 3. | www.mooc-list.com | | | | |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand any other types of modern microprocessor and microcontroller | L2:Understanding |

| | | | |
|---|---|---|---|
| CO2 | : | Understand the architecture of Microprocessor and Microcontroller | L1:Remembering |
| CO3 | : | Design and interface communications between digital systems | L3:Applying |
| CO4 | : | Apply the digital concepts to measure and control simple electrical systems | L2:Understanding |
| CO5 | : | Design a microcontroller based electrical control system. | L5:Evaluating |

| 22PTEE502 | POWER SYSTEM ANALYSIS AND STABILITY | | SEMESTER V | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electrical Machines | | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To model the power system under steady state operating condition |
| 2. | To apply efficient numerical methods to solve the power flow problem |
| 3. | To model and analyze the power systems under abnormal (or) fault conditions |
| 4. | To model and analyse the transient behaviour of power system when it is subjected to a fault. |

| **UNIT I** | **POWER SYSTEM OVERVIEW AND MODELLING** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Basic components of modern power system - Per-phase analysis: Generator model - Synchronous motor model - Three-phase transformer model - Three-winding transformer model - Line model- Short line model, Medium line model and Long line model - per unit quantities - Changing the base of per-unit quantities - representation of load impedance - Single line diagram - Impedance and reactance diagrams.

| **UNIT II** | **POWER FLOW ANALYSIS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Bus classification – Bus admittance matrix Formulation: Direct inspection method and Singular transformation method - Development of power flow model - solution of load flow equations: Gauss Seidel method - Newton Raphson method- Fast decoupled method – flowcharts – Comparison of the three power flow solution methods.

| **UNIT III** | **FAULT ANALYSIS - BALANCED FAULT** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Importance of short circuit studies-Assumptions in short circuit analysis – Balanced three phase fault – Short circuit capacity - Algorithm for formation of the Bus Impedance matrix- Systematic fault analysis using Bus Impedance matrix - Post fault bus voltages – Fault level - Current limiting reactors - Selection of circuit breakers.

| **UNIT IV** | **FAULT ANALYSIS - UNBALANCED FAULT** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Fundamentals of symmetrical components – Sequence impedances – Construction of sequence networks – Unsymmetrical faults on power system: Single line-ground fault, line-line fault – Double line-ground fault- Unbalanced Fault analysis using Thevenin's theorem and bus Z-bus computation of post fault currents in symmetrical component and phasor domains.

| **UNIT V** | **STABILITY STUDIES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Importance of stability studies – Classification of power system stability – Stability limits – Power angle equation- Inerti constant- Swing equation of single-machine connected to infinite bus – Solution of Swing equation by step-by-step method-II - Modified Euler's method – Runge-Kutta method – Equal area criterion – Critical clearing angle and time -Factors affectin transient stability – Techniques for transient stability improvement.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Hadi Saadat, "Power System Analysis", Tata McGraw Hill Publishers, New Delhi, 21st reprint 2010 |
| 2. | D.P.Kothari, and I.J.Nagrath, "Modern Power System Analysis", Tata McGraw Hill Education Private limited, New Delhi, Fourth Edition, 2011. |

**Reference Books:**

| | |
|---|---|
| 1. | John J. Grainger and W.D. Stevenson Jr., "Power System Analysis", McGraw Hill Inc., New Delhi, 2017. |
| 2. | B.R. Gupta, "Power System Analysis and Design", S.Chand& Co. Ltd., New Delhi, 2012 |
| 3. | C. L. Wadhwa, "Electrical Power Systems", New Age International Publishers, New Delhi, 2010. |

**E-Reference**

| | |
|---|---|
| 1 | https://onlinecourses.nptel.ac.in/, for power system analysis course, IIT Kharagpur |
| 2 | NPTEL courses on Power System Generation, Transmission and Distribution, IIT Delhi. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Develop the single line diagram for the power system. | L3:Applying |
| CO2 | : | Perform and analyze load flow computations using bus admittance matrix | L4: Analyzing |
| CO3 | : | Perform and analyze balanced fault using bus impedance matrix | L4: Analyzing |
| CO4 | : | Develop computational models for unsymmetrical fault analysis in power systems | L6:Creating |
| CO5 | : | Demonstrate the transient stability studies. | L3:Applying |

| 22PTEE503 | TOTAL QUALITY MANAGEMENT | | SEMESTER V | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Mathematics | **HS** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the statistical approach for quality control. |
| 2. | To Learn about the TQM principle. |
| 3. | To introduce the concept of statistical process control |
| 4. | To provide awareness on TQM standards |
| 5. | To create an awareness about the ISO and QS certification process and its need for the industries |

| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs - Analysis Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Principles of TQM, Leadership – Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.

| **UNIT II** | **TQM PRINCIPLES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen, Supplier Partnership – Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy, Performance Measure.

| **UNIT III** | **STATISTICAL PROCESS CONTROL (SPC)** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

The seven tools of quality, Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample, Normal Curve, Control Charts for variables and attributes, Process capability, Concept of six sigma, New seven Management tools.

| **UNIT IV** | **TQM TOOLS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA – Stages of FMEA.

| **UNIT V** | **QUALITY SYSTEMS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Dale H.Besterfiled, et al., "Total Quality Management", Pearson Education, Inc. 2003. (Indian reprint 2004). ISBN 81-297 0260-6. |

**Reference Books:**

| | |
|---|---|
| 1. | James R.Evans& William M.Lidsay, "The Management and Control of Quality", (5th Edition), South-Western (Thomso Learning), 2002 (ISBN 0-324-06680-5). |
| 2. | Feigenbaum.A.V. "Total Quality Management, McGraw Hill, 1991. |
| 3. | Oakland.J.S. "Total Quality Management Butterworth " Hcinemann Ltd., Oxford. 1989. |
| 4. | Narayana V. and Sreenivasan, N.S. "Quality Management – Concepts and Tasks", New Age International 1996. |
| 5. | Zeiri. "Total Quality Management for Engineers", Wood Head Publishers, 1991. |

**E-Reference**

| | |
|---|---|
| 1 | http://textofvideo.nptel.ac.in/video.php?courseId=110104080 |
| 2 | https://nptel.ac.in/courses/110104085/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the importance of quality, leadership and motivation in TQM | L2 Understanding |
| CO2 | : | Remember the problem of customers and continuous process improvement in supplier partnership, selection and rating | L1 Remembering |
| CO3 | : | Analyze the seven traditional tools, management tools and sigma concepts in TQM | L4 Analyzing |
| CO4 | : | Apply the TQM tools and know the performance measures, quality control in TQM | L3 Applying |
| CO5 | : | Evaluate the need for various quality control systems and quality auditing | L5 Evaluating |

| 22PTEE602 | MICROPROCESSOR AND MICROCONTROLLER LABORATORY | SEMESTER VI |
|---|---|---|

| PREREQUISITES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Analog and Digital Integrated Circuits | PC | 0 | 0 | 2 | 1 |

**Course Objectives:**

To provide training on programming of microprocessors and microcontrollers and understand the interface requirements, to provide training on interfacing of various peripheral devices and to provide training for the usage of ports in microprocessor and microcontroller.

**List of Experiments:**

1. Simple arithmetic operations: addition / subtraction / multiplication / division.
2. Programming with control instructions:
   a) Ascending / Descending order, Maximum / Minimum of numbers
   b) Programs using Rotate instructions
3. Hex / ASCII / BCD code conversions.
4. Interface Experiments: with 8085
   a) A/D Interfacing
   b) D/A Interfacing
5. Traffic light controller.
6. Keyboard Interfacing.
7. I/O Port / Serial communication
8. Programming Practices with Simulators/Emulators/open source.
9. Demonstration of basic instructions with 8051 Micro controller execution, including:
   a. Conditional jumps, looping
   b. Calling subroutines
10. Programming I/O Port 8051
    a. Study on interface with A/D & D/A
    b. Study on interface with DC & AC motor.

**Total (0T + 45P) = 45 Periods**

**Reference Books:**


| | |
|---|---|
| 1. | R. S. Gaonkar, "Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996 |
| 2. | K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning, 2004. |
| 3. | M. A.Mazidi, J. G. Mazidi, and R. D. McKinlay, "The 8051Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2007. |


**Course Outcomes:**

| Upon completion of this course, the students will be able to: | | | Bloom's Taxonomy Mapped |
|---|---|---|---|
| CO1 | : | Analyze linear and digital electronic circuits. | L4:Analyzing |
| CO2 | : | Apply computing platform and software for engineering problems. | L3:Applying |
| CO3 | : | Write programs for all mathematical operations. | L5:Evaluating |
| CO4 | : | Write programs for analog and digital interfacing devices. | L5:Evaluating |
| CO5 | : | Program the simulator and emulators | L4:Analyzing |

| 22PTEE701 | SMART GRID | SEMESTER VII | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To learn communication and automation technologies and high-performance computing for smart operation of power grid. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **SMART GRID ARCHITECTURE** | **9** | **0** | **0** | **9** |

Introduction-Conceptual model of Smart Grid, Smart Grid architecture and Components, Smart Grid Control, Smart Grid Characteristics , Smart Grid Enabling Technologies, Stages for Grid Modernization, Smart Grid Benefits and Challenges.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **COMMUNICATION AND INFORMATION SECURITY** | **9** | **0** | **0** | **9** |

Requirements of Smart Grid Communications, Communication infrastructure for the Smart Grid, communication technologies for Smart Grid, Information Layer of Smart Grid, SG Security Objectives, Cyber Security Requirements for Smart Grid.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **CONTROL AND AUTOMATION TECHNOLOGIES** | **9** | **0** | **0** | **9** |

Smart metering: Benefits, Architecture, Key components and operation, communications architecture for smart metering, Demand-side integration (DSI): Definitions and services provided by DSI, Substation automation equipment: architecture, components and functions, Intelligent electronic devices (IED), Relay IED, Bay controller.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **SMART TRANSMISSION AND DISTRIBUTION MANAGEMENT SYTSEMS** | **9** | **0** | **0** | **9** |

Structure of Energy management systems- Phasor Measurement Unit(PMU) - Wide-Area Measurement (WAM) for transmission Systems- Structure and main components of Distribution Management System- Supervisory Control and Data Acquisition (SCADA)- Customer information system.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **CLOUD COMPUTING AND DATA MANAGEMENT IN SMART GRID** | **9** | **0** | **0** | **9** |

Relationship between Smart Grid, cloud computing, and big data, Cloud Computing Characteristics in Improving Smart Grid, Cloud Computing Service Models, Cloud computing platform coupled with Smart Grid, Cloud Applications for Energy Management, Privacy Information Impacts on Smart Grid, Meter Data Management for Smart Grid.

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "SmartGrid Technology and Applications", Wiley, 2012 |
| 2. | Smart Grids Advanced Technologies and Solutions, Second Edition, Edited by Stuart Borlase, CRC, 2018. |


**Reference Books:**


| | |
|---|---|
| 1. | James Momoh "Smart Grid Fundamentals of Design and Analysis", Wiley, 2012. |


**E-Reference**

| | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/108/107/108107113/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Level** |
|---|---|---|---|
| CO1 | : | Describe the Smart Grid modernization process and its present developments. | L1-Remembering |
| CO2 | : | Select the suitable communication networks for smart grid applications. | L4-Analyzing |
| CO3 | : | Use a suitable smart device for Smart Grid operation. | L3-Applying |
| CO4 | : | Illustrate a smart transmission and distribution system using PMU, WAM and SCADA. | L3-Applying |
| CO5 | : | Explain the need of high end computing and big data analytics in smart grid. | L2-Understanding |

| 22PTEE702 | HIGH VOLTAGE ENGINEERING | | SEMESTER VII | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Measurements and Instrumentation, Power Generation, Transmission and Distribution system | | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To expose the various types of over voltage transients and their effect on power system. |
| 2. | To introduce the concept of insulation co-ordination technique. |
| 3. | To provide an overview of solid, liquid and gaseous dielectrics breakdown mechanism. |
| 4. | To show how to generate over voltages in the HV testing laboratory |
| 5. | To show how to measure of high voltage and current quantity in HV testing laboratory |
| 6. | To introduce testing procedure of HV power apparatus. |

| | | | | | |
|---|---|---|---|---|---|
| **Unit I** | **OVER VOLTAGES IN ELECTRICAL POWER SYSTEMS AND INSULATION CO-ORDINATION** | **9** | **0** | **0** | **9** |

Causes of over voltages and its effect on power system – Lightning, switching surges and temporary over voltages – Bewley lattice diagram-protection against over voltages; Principle of Insulation Coordination on High voltage and Extra high voltage power systems.

| | | | | | |
|---|---|---|---|---|---|
| **Unit II** | **ELECTRICAL BREAKDOWN IN GASES, LIQUIDS AND SOLIDS DIELECTRICS** | **9** | **0** | **0** | **9** |

Properties of Dielectric materials- Gaseous breakdown in uniform and non-uniform fields – corona discharges – Vacuum breakdown - conduction and breakdown in pure and commercial liquids dielectrics – breakdown mechanisms in solid and composite dielectrics- Application of insulating materials in electrical equipments.

| | | | | | |
|---|---|---|---|---|---|
| **Unit III** | **GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS** | **9** | **0** | **0** | **9** |

Generation of High DC voltages: Rectifiers, voltage multipliers and Vande Graff generator- Generation of High AC voltages: cascaded transformer, resonant transformer and tesla coil- Generation of High impulse voltages: single and multistage Marx circuits - Generation of switching voltages - Generation of impulse currents. Tripping and control of impulse generators.

| | | | | | |
|---|---|---|---|---|---|
| **Unit IV** | **MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS** | **9** | **0** | **0** | **9** |

Measurement of high DC, AC, impulse voltages – Measurement of high currents: Direct, Alternating and Impulse – digital techniques in impulse voltage and current measurements**.**

| | | | | | |
|---|---|---|---|---|---|
| **Unit V** | **HIGH VOLTAGE TESTING OF ELECTRICAL POWER APPARATUS** | **9** | **0** | **0** | **9** |

Overviews of International and Indian standards- laboratory test procedure: multi-level method, Up and Down method - HV Testing of Insulators, Bushings, Circuit Breakers, Power transformers, Surge Arresters, Power capacitors and Cables.

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | M.S. Naidu and V. Kamaraju, 'High Voltage Engineering', Tata McGraw Hill Publishing Company Ltd, New Delhi ,Fifth Edition, 2013. |


**Reference Books:**


| | |
|---|---|
| 1. | E. Kuffel W.S. Zaengl, and J.Kuffel , 'High Voltage Engineering Fundamentals', Newnes Publishers, Second Edition, Elsevier, New Delhi, 2005. |
| 2. | C.L. Wadhwa, 'High Voltage Engineering', New Age International (P) Ltd Publishers, Third Edition, 2010. |
| 3. | Rakosh Das Begamudre, 'Extra High Voltage AC Transmission Engineering', New Age International (P) Ltd Publishers, Third Edition, 2006. |


**E-references**

| | |
|---|---|
| 1 | www.onlinecourses.nptel.ac.in/noc18_ee41 |
| 2 | NPTEL courses on High Voltage Engineering, IIT Kanpur. |

| **Course Outcomes:** | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| Upon completion of this course, the students will be able to: | | | |
| CO1 | : | List the various types of over voltages and its effect on power system. | L1:Remembering |
| CO2 | : | Describe generation of various over voltages in HV testing laboratories. | L2:Understanding |
| CO3 | : | Use appropriate procedure for measurement of high voltage and high current DC, AC and impulse quantities. | L3:Applying |
| CO4 | : | Analyze high voltage breakdown phenomena in insulating materials. | L4:Analyzing |
| CO5 | : | Comprehend the test procedures as per the Indian standards. | L5:Evaluating |

| 22PTEE703 | PROJECT WORK | | SEMESTER VII | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITE:** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| | | **EEC** | **0** | **0** | **6** | **3** |

**COURSE OBJECTIVES:**

The student should be made to learn methodology to select a good project and able to work in a team leading to development of hardware/software product. Prepare a good technical report. Gain Motivation to present the ideas behind the project with clarity.

**GUIDELINES AND EVALUATION**

A Project topic must be selected either from research literature or the students themselves may propose suitable topics in consultation with their guides. The aim of the project work is to deepen Comprehension of principles by applying them to a new problem which may be the design /fabrication of any power component / circuit / sensor / Activator / Controller, a research investigation, a computer or management project or a design problem.

The students may be grouped into 2 to 4 and work under a project supervisor. The device/system/component(s) to be fabricated may be decided in consultation with the supervisor and if possible with an industry.

The progress of the project is evaluated for internal assessment based on a minimum of three reviews. The project review committee may be constituted by the Head of the Department. The student shall be instructed to meet the supervisor periodically and to attend the review committee meetings for evaluating the progress.

A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.

**Total (90P) = 90 Periods**

| **COURSE OUTCOMES:** On completion of the course the student will be able to | | **Bloom's Taxonomy Mapped** |
|---|---|---|
| CO1 | Ability to identify, formulate, design, interpret, analyze and provide solutions to complex engineering and societal issues by applying knowledge gained on basics of science and Engineering | L6:Creating |
| CO2 | Ability to choose, conduct and demonstrate a sound technical knowledge of their selected project topics in the field of power components, protection, high voltage, electronics, process automation, power electronics and drives, instrumentation and control by exploring suitable engineering and IT tools. | L6:Creating |
| CO3 | Ability to understand, formulate and propose new learning algorithms to solve engineering and societal problems of moderate complexity through multidisciplinary projects understanding commitment towards sustainable development. | L2:Understanding |
| CO4 | Ability to demonstrate, prepare reports, communicate and work in a team as a member/leader by adhering to ethical responsibilities | L6:Creating |
| CO5 | Ability to acknowledge the value of continuing education for oneself and to stay up with technology advancements. | L5:Evaluate |

| 22PTEEE11 | NETWORK ANALYSIS AND SYNTHESIS | SEMESTER V | | | |
|---|---|---|---|---|---|
| **PREREQUISITE** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electric circuit Analysis | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

1. To familiarize the different methods of analysis and synthesis of electrical circuits.

| UNIT I | S-DOMAIN ANALYSIS AND FREQUENCY DOMAIN ANALYSIS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

S - domain network – driving point and transfer impedances and their properties – transform network analysis– poles and zeros of network functions – time response from pole – zero plots. Immittance –loci of RLC networks – frequency response of RLC networks – frequency response from pole – zero – bode plots.

| UNIT II | NETWORK TOPOLOGY | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Network graphs, definitions, tree, co-tree,link, basic loop and basic cut sets – link currents; tie set schedules, tree branch voltages ; and cut – set schedules –incidence reduced incidence metrics – V shift and I shift – primitive impedance and admittance matrices – application to network solutions - duality and dual networks.

| UNIT III | TWO PORT NETWORKS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Characterization of two port networks in terms of Z , Y,H and T parameters – networks equivalents – relations between network parameters –interconnections two port networks- T and π representation- Analysis of T, Ladder ,Bridged – T and lattice networks – transfer function of terminated two port networks.

| UNIT IV | ELEMENTS OF NETWORK SYNTHESIS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Reliability of one port network – Hurwitz polynomials and properties – Positive Real functions and properties – frequency response of reactive one port – synthesis of one port network using Foster and Cauer methods - synthesis of RL, RC network using Foster and Cauer methods – synthesis of LC one port network.

| UNIT V | DESIGN OF FILTERS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Classification of Filters – pass band and stop band filters; classification and characteristic impedance – design of constant – K, M – derived and composite filters – qualitative treatment of active filters – Butterworth and Chebyshev filters. Attenuators; T type, π type, lattice, bridged T and L type attenuators.

**Total (45L+0T)= 45 Periods**

**Text Books:**


1. Franklin F. Kuo, 'Network Analysis and Synthesis', Wiley India Private Limited, Second Edition, 2006
2. Sudhakar. A., and Shyammohan S Palli , 'Circuits and Networks: Analysis and Synthesis' McGraw Hill Education, New Delhi, Fifth edition, 2017.


**Reference Books:**


1. A.Chakrabarti, 'Circuit Theory-Analysis and Synthesis', Dhanpat Rai & Co., New Delhi, Seventh revised Edition, 2018.
2. Van Valkenburg, M.E., 'Network Analysis', Prentice Hall of India Private Ltd., New Delhi, Third Edition, 2014.


**E- Reference:**

1. https:// archieve.nptel.ac.in/courses/108/102/108102042/

| | |
|---|---|

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Describe time response and frequency response of electrical circuits | L2: Understanding |
| CO2 | : | Apply graph theory to network solutions | L3: Applying |
| CO3 | : | Characterize two port networks | L4: Analyzing |
| CO4 | : | Choose appropriate method for network synthesis | L5: Evaluating |
| CO5 | : | Design of filters and attenuator networks. | L6: Creating |

| 22PTEEE12 | ADVANCED CONTROL SYSTEMS | | SEMESTER V | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Control system | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To gain knowledge in the analysis of non-linear system |
| 2. | To gain knowledge in the analysis of digital control of linear system. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **NON-LINEAR SYSTEM – DESCRIPTION & STABILITY** | **9** | **0** | **0** | **9** |

Linear vs non-linear – Examples – Incidental and Intentional – Mathematical description - Equilibria and linearization - Stability – Lyapunov function – Construction of Lyapunov function.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **PHASE PLANE AND DESCRIBING FUNCTION ANALYSIS** | **9** | **0** | **0** | **9** |

Construction of phase trajectory – Isocline method – Direct or numerical integration – Describing function analysis – Computation of amplitude and frequency of oscillation.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **Z - TRANSFORM AND DIGITAL CONTROL SYSTEM** | **9** | **0** | **0** | **9** |

Z transfer function – Block diagram – Signal flow graph – Discrete root locus – Bode plot.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **STATE-SPACE DESIGN OF DIGITAL CONTROL SYSTEM** | **9** | **0** | **0** | **9** |

State equation – Solutions – Realization – Controllability – Observability – Stability – Jury's test.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **MUTLI INPUT MULTI OUTPUT (MIMO) SYSTEM** | **9** | **0** | **0** | **9** |

Models of MIMO system – Matrix representation – Transfer function representation – Poles and Zeros – Decoupling – Introduction to multivariable Nyquist plot and singular values analysis – Model predictive control.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Benjamin C. Kuo, 'Digital Control Systems', Oxford University Press, 2010. |
| 2. | I.J. Nagrath and M. Gopal, 'Control Systems Engineering', New Age International Publishers, 2011. |

**Reference Books:**

| | |
|---|---|
| 1. | Raymond T. Stefani & Co., 'Design of feedback Control systems', Oxford University, 2010. |
| 2. | George J. Thaler, 'Automatic Control Systems', Jaico Publishers, 2011. |

**E-Reference**

| | |
|---|---|
| 1. | https://nptel.ac.in/courses/108103007 |
| 2. | https://www.google.co.in/books/edition/Advanced_Control_Systems/k7AVfjnoS7IC?hl=en&gbpv=1&dq=advanced+control+system&printsec=frontcover |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Use the conventional technique of non-linear system analysis. | L2: Understanding |
| CO2 | : | Solve the problems in digital control systems using Z transform. | L5: Evaluating |
| CO3 | : | Analyze discrete time systems using conventional techniques. | L3: Applying |
| CO4 | : | Analyze the digital control system using state-space formulation. | L3: Applying |
| CO5 | : | Know the formulation and analysis of MIMO systems. | L6: Creating |

| 22PTEEE13 | DISCRETE CONTROL SYSTEMS | | SEMESTER V | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Control Systems | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the digital signal processing. |
| 2. | To study the design of sampled data control systems in state space. |
| 3. | To impart knowledge on digital control algorithms and stability study. |

| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Review of frequency and time response analysis and specifications of continuous time systems - need for controllers - continuous time compensations - continues time PI, PD, PID controllers, Realization of basic compensators: Lag, Lead and Lag-Lead compensation schemes - problems.

| **UNIT II** | **SIGNAL PROCESSING IN DIGITAL CONTROL** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Need for digital control – Configuration of basic digital control scheme – Principles of signal conversion – Basic discrete-time signals – Time domain and frequency domain models for discrete-time systems - Aliasing – Reconstruction of analog signals – Practical aspects of the choice of sampling rate – Discretization based on bilinear transformation.

| **UNIT III** | **MODELING AND ANALYSIS OF SAMPLED DATA CONTROL SYSTEM** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Differential equation description – Z-transform method of description– Z-transform analysis of sampled data control systems –Jury's stability test – Routh stability criterion on the r-plane – State variable concepts: First companion – Second companion – Jordan canonical models – Discrete state variable models – Elementary principles.

| **UNIT IV** | **DESIGN OF DIGITAL CONTROL ALGORITHMS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction – z-plane specifications of control system design –Digital lead, lag and lag-lead compensator design using frequency response plots - Digital lead lag compensator design using Root locus plots – z-plane synthesis – Digital controllers for deadbeat performance - Examples.

| **UNIT V** | **PRACTICAL ASPECTS OF DIGITAL CONTROL ALGORITHMS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Development and implementation of digital PID control algorithms – Tunable PID controllers - Digital temperature control system: Control algorithm – Digital position control system: Digital measurement of shaft position/speed, control algorithm – Stepping motors and their controls: Torque-speed curves, Interfacing of stepper motors to microprocessors

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | M.Gopal, "Digital Control and Static Variable Methods", Tata McGraw Hill, New Delhi, 1997. |
| 2. | I.J.Nagrath&M.Gopal, "Control Systems Engineering", New Age International Publishers, New Delhi, 1989. |

**Reference Books:**

| | |
|---|---|
| 1. | B.C.Kuo, Digital Control Systems,Oxford University Press,2nd Edition,2007. |
| 2. | K. Ogata, Modern Control Engineering, Pearson Education, 2002. |
| 3. | Kenneth J. Ayala, "The 8051 Microcontroller- Architecture, Programming and Applications", Penram International, 2nd Edition, 1996. |

**E-References:**

| | |
|---|---|
| 1. | https://nptel.ac.in/courses/108103008/ |
| 2. | https://www.sciencedirect.com/topics/engineering/digital-control-system |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Outline sampling techniques to control systems. | L1: Remembering |
| CO2 | : | Design the various digital control algorithms. | L4: Analyzing |
| CO3 | : | Predict the performance of various types of digital controllers. | L4: Analyzing |
| CO4 | : | Identify the various types of digital compensators. | L2: Understanding |
| CO5 | : | Illustrate applications of digital control. | L3: Applying |

| 22PTEEE14 | BIOMEDICAL INSTRUMENTATION | SEMESTER V | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Measurements and Instrumentation | **PC** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To provide an adequate knowledge of the human physiology systems. |
| 2. | Biomedical applications of different transducers used. |
| 3. | To introduce the student to the various sensing and measurement devices of bio-medical electrical systems. |
| 4. | To provide awareness of electrical safety of medical equipment |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **HUMAN PHYSIOLOGICAL SYSTEMS AND BIO POTENTIAL ELECTRODES AND TRANSDUCERS** | **9** | **0** | **0** | **9** |

Cells and their structure – Nature of Cancer cells – Transport of ions through the cell membrane – resting and action potential – bio-electric potential – nerve tissues and organs – difference systems of human body. Physiology of Human body- Brain, heart, lungs-Cardiovascular system- Respiratory system- nervous system. Design of medical instruments components of biomedical instrument systems – electrodes - transducers.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **BIO SIGNAL ACQUISITION BIO POTENTIAL RECORDERS** | **9** | **0** | **0** | **9** |

Physiological signal amplifiers – isolation amplifiers – medical pre amplifier design – bridge amplifiers – line drive amplifiers – current amplifiers – chopper amplifiers – bio signal analysis – signal recovery and data acquisition – drift compensation in operational amplifiers – pattern recognition. Characteristics of recording system – Electrocardiography(ECG) – Electroencephalography(EEG) – Electromyography(EMG) – Electroretinography(ERG) & Electrooculography(EOG) – recorders for offline analysis.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **SPECIALIZED MEDICAL EQUIPMENT AND BIO-TELEMETRY** | **9** | **0** | **0** | **9** |

Blood cell counter – Electron microscope – radiation detectors – photo meters and colorimeters – digital thermometer – audio meters – X-ray tube – X-ray machine – Radiography and fluoroscopy – image intensifiers – angiography – applications of X-ray examination. Biotelemetry

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **PHYSIOLOGICAL ASSIST DEVICES AND OPERATION THEATRE EQUIPMENT** | **9** | **0** | **0** | **9** |

Pacemakers – Pacemaker batteries – artificial heart walls – Defibrillators – nerve and muscle stimulators – heart lung machine – kidney machine. Surgical diathermy – short wave diathermy – microwave diathermy – ultrasonic diathermy – therapeutic effect of heat – range and area of irritation of different diathermy techniques – Ventilators – Anesthesia machines – blood flow meters – Cardiac output measurements – Pulmonary function analyzers – Blood gas analyzers – oxymeters – elements of intensive care monitoring.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **SAFETY INSTUMENTATION AND ADVANCES IN BIOMEDICAL INSTRUMENTATION** | **9** | **0** | **0** | **9** |

Radiation safety instrumentation – physiological effects due to 50 Hz current passage – Micro shock and macro shock – electrical accidents in hospitals – Devices to protect against electrical hazards – hospital architecture. Computers in medicine – lasers in medicine – endoscope – Cryogenic surgery – Nuclear imaging techniques – computer tomography – thermography – ultrasonic imaging system – Magnetic resonance imaging – Positron emission tomography – digital subs traction angiography.

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | U. Satyanarayana, “Biochemistry” Fifth edition, Sri Padmavathi Publications Ltd., 2017. |
| 2. | N. A. Campbell, J. B. Reece, L. Urry, M. L. Cain and S. A. Wasserman, “Biology: A global approach”, Pearson Education Ltd, 2014. |
| 3. | Dr.M.Arumugam, ‘Bio-Medical Instrumentation’, Anuradha Agencies, 2012. |
| 4. | Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, ‘Bio-Medical Instrumentation and Measurements’, Second Edition Pearson Education, 2011 / PHI. |


**Reference Books:**

| | |
|---|---|
| 1. | R.S.Khandpur, 'Hand Book of Bio-Medical instrumentation', Tata McGraw Hill Publishing Co Ltd., 2012. |
| 2. | L.A. Geddes and L.E.Baker, 'Principles of Applied Bio-Medical Instrumentation', John Wiley &Sons, 2011. |
| 3. | C.Rajarao, 'Medical Instrumentation', John Wiley & Sons, 2013. |
| 4. | C.Rajarao and S.K. Guha, 'Principles of Medical Electronics and Bio-medical Instrumentation',Universities press (India) Ltd, Orient Longman ltd, 2012. |
| **E-Reference** | |
| 1 | www.onlinecourses.nptel.ac.in |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Remember the purpose & methods of measurement. | L1 Remembering |
| CO2 | : | Understand different display and recording devices for various applications. | L2 Understanding |
| CO3 | : | Evaluate electrical & non electrical physiological measurements and bio amplifier. | L5 Evaluating |
| CO4 | : | Apply physiological assist devices and operational theatre equipment. | L3 Applying |
| CO5 | : | Design biomedical equipment as it is a challenging interdisciplinary process | L6 Creating |

| 22PTEEE15 | COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS | | SEMESTER V | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power System Protection | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

To understand different techniques of digital relaying - their constructions, working principles, applications and limitations along with introduction to Wide Area Measurement System and network protection.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **INTRODUCTION TO COMPUTER RELAYING** | **9** | **0** | **0** | **9** |

Computer relay architecture - analog-to-digital converters - anti-aliasing filters - expected benefits of computer relaying

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **RELAYING PRACTICES** | **9** | **0** | **0** | **9** |

Introduction to protection systems, function of protection system, protection of transmission lines, overcurrent relays, directional relays, distance relays, pilot relaying, transformer protection, reactor protection, generator protection and bus protection

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **MATHEMATICAL BASIS FOR PROTECTIVE RELAYING ALGORITHMS** | **9** | **0** | **0** | **9** |

Fourier series, Walsh functions, Fourier transforms, probability and random process, Kalman filtering

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **SYSTEM RELAYING AND CONTROL** | **9** | **0** | **0** | **9** |

Phasor Measurement Unit - Measurement of frequency and phase – sampling clock synchronization – Application of phasor measurement to state estimation – Monitoring- Control applications

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **WIDE AREA MEASUREMENT SYSTEMS** | **9** | **0** | **0** | **9** |

Wide Area Measurement Systems (WAMS) architecture – WAMS based protection concepts : Adaptive dependability and security – Monitoring approach of apparaent impedances towards relay characteristics – WAMS based out-of step relaying – Supervision of backup zones – Intelligent load shedding – Intelligent islanding – System wide integration of SIPS – Load shedding and restoration

**Total (45L+0T) = 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Arun G. Phadke, James S. Thorp, Computer Relaying for Power Systems, Wiley, Second Edition,2009. |
| 2. | Allan Thomas Johns, S.K. Salman, Digital Protection for Power Systems, The Institution of Engineering and Technology, Second Edition, 1995. |

**Reference Books:**

| | |
|---|---|
| 1. | A.G. Phadke, J.S. Thorp, Synchronized Phasor Measurements and Their Applications, Springer |
| 2. | Walter A. Elmore, 'Protective Relaying: Theory and Applications, CRC Press |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand on protection system schemes, its co-ordination and settings for any general power network. | L2: Understanding |
| CO2 | : | Identify the digital relaying, its fundamentals, attributes and implementation. | L2: Understanding |
| CO3 | : | Analyze the concept synchro-phasor based power system relaying | L4: Analysing |
| CO4 | : | Assess the algorithms and its importance | L3: Applying |
| CO5 | : | Recall the power system monitoring using wide area measurement system | L1: Remembering |

| 22PTEEE16 | DIGITAL CONTROLLER IN POWER ELECTRONICS APPLICATION | SEMESTER V | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Control systems, Power Electronics | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the concepts of discrete time systems. |
| 2. | To analyze systems in z domain. |
| 3. | To design the digital controllers |

| UNIT I | INTRODUCTION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

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

| UNIT II | Z-PLANE ANALYSIS OF DISCRETE-TIME CONTROL SYSTEMS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Impulse sampling and data hold -Pulse transfer function - Realization of digital controllers- Mapping between s-plane and zplane - Stability analysis of closed loop systems in z-plane–Transient and steady state analyses.

| UNIT III | STATE SPACE APPROACH TO DISCRETE-TIME CONTROL SYSTEMS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

State space representation of continuous and digital control systems - Solution of continuous and discrete time state space equations -Pulse transfer function matrix - Discretization of continuous time state space equations.

| UNIT IV | DIGITAL CONTROLLER DESIGN METHODS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Cascade compensators using Root Locus- Design of PID controllers by using bilinear transformation- Digital controller design using bilinear transformation- Dead-beat response design- Deadbeat controller without and with prescribed manipulated variable-Choice of sample time for deadbeat controller-Realization of Digital controllers- Computer based simulation.

| UNIT V | DIGITAL CONTROLLERS IN POWER ELECTRONICS APPLICATIONS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Micro Controllers and Digital Signal Controllers for Converter Control Application, Interface Modules for Converter Control – A/D, Capture, Compare and PWM, Analog Comparators for instantaneous over current detection, interrupts, Discrete PI and PID equations, Algorithm for PI and PID implementation, Example Code for PWM generation.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | M. Gopal, "Digital Control and State Variable Methods", McGraw Hill Education, 4th Edition, 2014. |
| 2. | K.Ogata "Discrete- Time control systems", Pearson Education, India, 2nd Edition, 2015. |
| 3. | B.C.Kuo, "Digital Control System", Oxford University Press; 2ndEdition, 2012. |
| 4. | Karl J. Astrom & Tore Hagglun. "PID Controllers: Theory, Design and Tuning" International Society for Measurement and Control, 1995. |

**Reference Books:**

| | |
|---|---|
| 1. | G.F.Franklin, J.David Powell and M.Workman, Digital Control of Dynamic Systems, 3rd ed., Addison Wesley, 2000. |
| 2. | Constantine H. Houpis and Gary B. Lamont, Digital control systems: Theory, hardware, software, Mcgraw-Hill Book Company, 1985. |
| 3. | M. J. Robert "Fundamentals of Signals and Systems", McGraw Hill Education, 2007. |

**E-Reference**

| | |
|---|---|
| 1 | https://nptel.ac.in/courses/108103008 |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | To understand the digital control system | L2: Understanding |
| CO2 | : | Capable of determining the stability in z domain | L1: Applying |
| CO3 | : | To understand the state space analysis | L1: Remembering |
| CO4 | : | To design the various types of digital controllers | L3: Analysing |
| CO5 | : | To check the digital controllers in power electronics design | L5: Evaluating |

| 22PTEEE21 | HVDC TRANSMISSION SYSTEMS | | SEMESTER V | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITE** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution system, Power Electronics | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the concept, planning of DC power transmission and comparison with AC power transmission. |
| 2. | To analyze HVDC converters. |
| 3. | To study about the HVDC system control. |
| 4. | To analyze harmonics and design of filters. |
| 5. | To model and analysis the DC system under steady state. |

| | | | | | |
|---|---|---|---|---|---|
| **Unit I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |

DC Power transmission technology – Comparison of AC and DC transmission–Application of DC transmission –Description of DC transmission system– Planning for HVDC transmission–Modern trends in HVDC technology –DC breakers – Operating problems– HVDC transmission based on VSC –Types and applications of MTDC systems.

| | | | | | |
|---|---|---|---|---|---|
| **Unit II** | **ANALYSIS OF HVDC CONVERTERS** | **9** | **0** | **0** | **9** |

Line commutated converter-Analysis of Graetz circuit with and without overlap-Pulse number–Choice of converter configuration–Converter bridge characteristics–Analysis of 12 pulse converters –Analysis of VSC topologies and firing schemes

| | | | | | |
|---|---|---|---|---|---|
| **Unit III** | **CONVERTER AND HVDC SYSTEM CONTROL** | **9** | **0** | **0** | **9** |

Principles of DC link control–Converter control characteristics–System control hierarchy– Firing angle control–Current and extinction angle control–Starting and stopping of DC link–Power control –Higher level controllers –Control of VSC based HVDC link

| | | | | | |
|---|---|---|---|---|---|
| **Unit IV** | **REACTIVE POWER AND HARMONICS CONTROL** | **9** | **0** | **0** | **9** |

Reactive power requirements in steady state–Sources of reactive power–SVC and STATCOM–Generation of harmonics – Design of AC and DC filters –Active filters

| | | | | | |
|---|---|---|---|---|---|
| **Unit V** | **POWER FLOW ANALYSIS IN AC/DC SYSTEMS** | **9** | **0** | **0** | **9** |

Per unit system for DC quantities–DC system model –Inclusion of constraints –Power flow analysis–Case study.

**Total (45L + 0T) = 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Padiyar, K.R., "HVDC power transmission system", New Age International(P) Ltd., New Delhi, Second Edition, 2010 |
| 2. | Edward Wilson Kimbark, "Direct Current Transmission", Vol. I, Wiley Interscience, New York, London, Sydney,1971 |

**Reference Books:**

| | |
|---|---|
| 1. | Colin Adamson and Hingorani. N.G, "High Voltage Direct Current Power Transmission", Garraway Ltd, London, 1960. |
| 2. | Arrillaga, J., "High Voltage Direct Current Transmission ",Peter Pregrinus, London,1983. |

**E- Reference:**

| | |
|---|---|
| 1 | www.onlinecourses.nptel.ac.in/noc18_ee41 |

| **Course Outcomes:** | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| Upon completion of this course, the students will be able to: | | | |
| CO1 | : | Summarize basic principles and types of HVDC system. | L2:Understanding |
| CO2 | : | Analyze the converters used in HVDC system. | L4:Analyzing |
| CO3 | : | Familiarize with the HVDC system control. | L1:Remembering |
| CO4 | : | Analyze the reactive power control and design the filters for harmonics mitigation. | L6:Creating |
| CO5 | : | Examine the power flow analysis of HVDC system. | L3:Applying |

| 22PTEEE22 | EHVAC TRANSMISSION SYSTEMS | | | | | SEMESTER V |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System | | **PE** | **3** | **0** | **0** | **3** |
| **Course Objectives:** | | | | | | |
| 1. | To expose the fundamental concept of EHVAC transmission, electrostatic effects, corona effects and voltage controller for an EHVAC transmission system | | | | | |
| | | | | | | |
| **UNIT I** | **INTRODUCTION** | | **9** | **0** | **0** | **9** |
| Necessity of EHV AC transmission, benefits and challenges, power handling capacity and line losses, mechanical considerations, resistance of conductors, temperature rise of conductors and current-carrying capacity, properties of bundled conductors – numerical problems. | | | | | | |
| | | | | | | |
| **UNIT II** | **LINE AND GROUND REACTIVE PARAMETERS** | | **9** | **0** | **0** | **9** |
| Inductance of EHV line configurations, line capacitance calculation, sequence inductances and capacitances, line parameters for modes of propagation, resistance and inductance of ground return. | | | | | | |
| | | | | | | |
| **UNIT III** | **VOLTAGE GRADIENTS OF CONDUCTORS** | | **9** | **0** | **0** | **9** |
| . Electrostatics, field of sphere gap, field of line changes and properties, charge – potential relations for multi-conductors lines, surface voltage gradient on conductors, distribution of voltage gradient on sub-conductors of bundle, effect of high electro static field on Humans, animals and plants. | | | | | | |
| | | | | | | |
| **UNIT IV** | **CORONA EFFECTS** | | **9** | **0** | **0** | **9** |
| Power loss and corona loss, charge-voltage (q–V) diagram and corona loss, attenuation of travelling waves due to corona loss, audible noise: generation and characteristics, limits for audible, audible noise measurement and meters, formulae for audible noise and its use in design, relation between single-phase and three-phase AN levels example | | | | | | |
| | | | | | | |
| **UNIT V** | **POWER FREQUENCY VOLTAGE CONTROL** | | **9** | **0** | **0** | **9** |
| Power circle diagram and its use - voltage control using synchronous condensers - cascade connection of shunt and series compensation - sub synchronous resonance in series capacitor - compensated lines - static VAR compensating system | | | | | | |
| | | | | | | |
| **Total (45L + 0T) = 45 Periods** | | | | | | |
| | | | | | | |
| **Text Books:** | | | | | | |
| 1. | R. D. Begamudre, "EHVAC Transmission Engineering" New Age International(P)Ltd., Third Edition,2006. | | | | | |
| 2. | S. Rao,"HVAC and DC Transmission practice",Khanna Publishers, Delhi, Third Edition, 1990. | | | | | |
| **Reference Books:** | | | | | | |
| 1. | Shobhit Gupta and Deepak Gupta," EHV AC/DC Transmission",Engineering Books Publishers, 2014. | | | | | |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Summarize the trends in EHVAC Transmission and calculate Line inductance and capacitances of bundled conductors. | L2: Understanding |
| CO2 | : | Analyze the transmission line parameters. | L4: Analysing |
| CO3 | : | Recall the electrostatic effects and corona effects. | L1: Remembering |
| CO4 | : | Select the appropriate voltage control devices. | L4: Analysing |
| CO5 | : | Apply the compensation techiniques. | L3: Applying |

| 22PTEEE23 | FLEXIBLE AC TRANSMISSION SYSTEM | | | | | SEMESTER V |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Power Generation, Transmission and Distribution System, Power Electronics | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To introduce the Reactive Power Control Techniques. |
| 2. | To educate on Static VAR Compensators and Their Applications |
| 3. | To provide Knowledge on Thyristor Controlled Series Capacitors |
| 4. | To study about STATCOM Devices |
| 5. | To acquire Knowledge on FACTS Controllers |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |

Reactive Power Control in Electrical Power Transmission Lines -Uncompensated Transmission Line – Series Compensation – Basic Concepts of Static Var Compensator (SVC) – Thyristor Controlled Series Capacitor (TCSC) – Unified Power Flow Controller (UPFC).

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS** | **9** | **0** | **0** | **9** |

Voltage Control by SVC – Advantages of Slope in Dynamic Characteristics – Influence of SVC on System Voltage – Design of SVC Voltage Regulator –Modelling of SVC for Power Flow and Fast Transient Stability – Applications: Enhancement of Transient Stability – Steady State Power Transfer – Enhancement of Power System Damping.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS** | **9** | **0** | **0** | **9** |

Operation of the TCSC – Different Modes of Operation – Modelling of TCSC – Variable Reactance Model – Modelling for Power Flow and Stability Studies. Applications: Improvement of the System Stability Limit – Enhancement of System Damping

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS** | **9** | **0** | **0** | **9** |

Static Synchronous Compensator (STATCOM) – Principle of Operation – V-I Characteristics. Applications: Steady State Power Transfer-Enhancement of Transient Stability – Prevention of Voltage Instability. SSSC-Operation of SSSC and the Control of Power Flow –Modelling of SSSC In Load Flow and Transient Stability Studies.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **CO-ORDINATION OF FACTS CONTROLLERS** | **9** | **0** | **0** | **9** |

Controller Interactions – SVC – SVC Interaction – Co-Ordination of Multiple Controllers Using Linear Control Techniques – Control Coordination Using Genetic Algorithms.

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | R.Mohan Mathur, Rajiv K.Varma, "Thyristor – Based Facts Controllers For Electrical Transmission Systems", IEEE Press And John Wiley & Sons, Inc, 2002. |
| 2. | Narain G. Hingorani, "Understanding FACTS -Concepts and Technology of Flexible AC Transmission Systems", Standard Publishers Distributors, Delhi- 110 006, 2011. |
| 3. | K.R.Padiyar," FACTS Controllers in Power Transmission and Distribution", New Age International(P) Limited, Publishers, New Delhi, 2008. |


**Reference Books:**


| | |
|---|---|
| 1. | A.T.John, "Flexible A.C. Transmission Systems", Institution of Electrical and Electronic Engineers (IEEE), 1999. |
| 2. | V.K.Sood,"HVDC And FACTS Controllers – Applications of Static Converters in Power System", APRIL 2004 , Kluwer Academic Publishers, 2004. |
| 3. | Xiao – Ping Zang, Christian Rehtanz And Bikash Pal, "Flexible AC Transmission System: Modelling and Control" Springer, 2012. |


**E-References:**

| | |
|---|---|
| 1. | www.onlinecourses.nptel.ac.in |
| 2. | www.class-central.com |
| 3. | www.mooc-list.com |

| **Course Outcomes:** | **Bloom's Taxonomy Mapped** |
|---|---|
| Upon completion of this course, the students will be able to: | |

| | | | |
|---|---|---|---|
| CO1 | : | Analyze power system operation, stability, control and protection. | L4: Analyzing |
| CO2 | : | Develop analytical model of FACTS controller for power system application. | L4: Analyzing |
| CO3 | : | Apply load compensation techniques. | L3: Applying |
| CO4 | : | Evaluate the performance of steady state and transients of FACTS controllers. | L5: Evaluating |
| CO5 | : | Outline the features of coordination of FACTS controllers. | L1: Remembering |

| 22PTEEE24 | POWER SYSTEM OPERATION AND CONTROL | SEMESTER V | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System; Power System Analysis and Stability | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

1. To familiarize the significance of power system operation and control.
2. To understand the concepts of real power – frequency control, and reactive power – voltage control.
3. To acquire knowledge on economic power system operations, and computer aided control of power system.

| UNIT I | OVERVIEW OF POWER SYSTEM OPERATION AND CONTROL | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Power scenario in Indian grid – National and Regional load dispatching centers – requirements of good power system - necessity of voltage and frequency regulation. System load variation: System load characteristics, load curves -daily, weekly and annual, load-duration curve, load factor, diversity factor. Reserve requirements: Installed, spinning, cold and hot reserves. Basic concepts of economic dispatch, unit commitment, load shedding and islanding, deregulation, governor control, LFC, AVR, system voltage control and security control - Tariff: characteristics & types.

| UNIT II | REAL POWER - FREQUENCY CONTROL | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Fundamentals of speed governing mechanism and modeling: Speed-load characteristics – Load sharing between two synchronous machines in parallel; concept of control area, LFC control of a single-area system: Static and dynamic analysis of uncontrolled and controlled cases; Multi-area systems: Two-area system modeling: static analysis, uncontrolled case, tie-line with frequency bias control; state variable model- integration of economic dispatch control with LFC.

| UNIT III | REACTIVE POWER–VOLTAGE CONTROL | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Generation and absorption of reactive power - basics of reactive power control – Automatic Voltage Regulator (AVR) – brushless AC excitation system – block diagram representation of AVR loop - static and dynamic analysis – stability compensation – voltage drop in transmission line - methods of reactive power injection - tap changing transformer, SVC and STATCOM for voltage control.

| UNIT IV | ECONOMIC DISPATCH AND UNIT COMMITMENT | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Statement of economic dispatch problem - input and output characteristics of thermal plantIncremental cost curve, co-ordination equations with and without loss, solution by direct method and Lambda -iteration method (No derivation of loss coefficients)- Base point and participation factors method.

Statement of Unit Commitment problem- Constraints in Unit Commitment: spinning reserve- thermal unit constraints- hydro constraints- fuel constraints and other constraints; Unit Commitment solution methods: Priority-list methods, forward dynamic programming approach, numerical problems only in priority-list method using full-load average production cost.

| UNIT V | COMPUTER CONTROL OF POWER SYSTEMS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

EMS functions - Energy control centre functions: Monitoring, data acquisition and control, energy control centre levels - SCADA: system hardware configuration –master station-remote terminal units- and functions; Network topology determination- state estimation, security analysis and control - Various operating states: normal, alert, emergency, extremis and restorative; State transition diagram showing various state transitions and control strategies.

**Total (45 L +0 T)= 45 Periods**

**Text Books:**

1. Allen J. Wood and Bruce F.Wollenberg, "Power Generation, Operation and Control", Wiley India Ltd, New Delhi, Second Edition, Reprint 2016.
2. Olle. I. Elgerd, "Electric Energy Systems Theory – An Introduction", Tata McGraw Hill Publishing Company Ltd, New Delhi, 34th reprint 2010.
3. Kundur. P, "Power System Stability & Control", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 10th reprint 2010.

**Reference Books:**

1. Kothari, D.P., and Nagrath, I.J., "Modern Power System Analysis", Fourth, Tata McGraw Hill Education Pvt., Limited,

| | |
|---|---|
| . | New Delhi, 2011. |
| 2 | Grigsby, L.L.,"The Electric Power Engineering, Hand Book", CRC Press & IEEE Press, 2001 |
| 3 | Weedy, B.M. and Cory, B.J., "Electric Power systems", Wiley, 2012. |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | | **Bloom's Taxonomy Mapped** |
|---|---|---|
| CO1 | Recognize the fundamentals of power system operation and control. | L1: Understanding |
| CO2 | Interpret the control action to meet the real power demand variations. | L3: Applying |
| CO3 | Employ the reactive power injections for voltage profile improvement. | L3: Applying |
| CO4 | Formulate the economic scheduling problems in power system. | L4: Analysing |
| CO5 | Examine the need ofcomputer aided control for power system operations and control. | L4: Analysing |

| 22PTEEE25 | SUBSTATION ENGINEERING AND AUTOMATION | SEMESTER V | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power system protection, Electrical Measurements, Power system | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the importance of the substation design |
| 2. | To outline the different factor for effecting substation design |
| 3. | To classify the bus configurations |
| 4. | To know the design criteria for substation grounding |
| 5. | To understand the importance of substation automation |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |

Background, Need Determination, Budgeting, Financing, Traditional and innovative Substation Design, Site Selection and Acquisition, Design, Construction and Commissioning Process

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **HIGH VOLTAGE SWITCHING EQUIPMENT** | **9** | **0** | **0** | **9** |

Ambient conditions, Disconnect switches, Load Break switches, high speed grounding switches, power fuses, circuit switches, circuit breakers.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **TYPES OF SUBSTATIONS & BUS/SWITCHING CONFIGURATIONS** | **9** | **0** | **0** | **9** |

Transmission substation, distribution substation, collector substation, switching substations, gas insulated substations, air insulated substations, bus configurations: single bus, double bus, double break, main and transfer bus, double bus, single breaker, ring bus, break-and-a-half, Comparison of configurations.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **DESIGN OF SUBSTATION GROUNDING AND PROTECTION** | **9** | **0** | **0** | **9** |

Reasons for substation grounding system, accidental ground circuit, Design criteria-Actual Touch and step voltage, soil resistivity, grid resistance, grid current, use of the design equations, selection of conductors, grounding fence, other design considerations. Lightning stroke protection-lightning parameters, empirical design methods. Substation fire protection-Fire hazards, fire protection measures, fire protection selection criterion.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **SUBSTATION AUTOMATION AND COMMUNICATIONS** | **9** | **0** | **0** | **9** |

Introduction , components of substation automation system, automation applications, protocol fundamentals, supervisory control and data acquisition (SCADA) historical perspective, SCADA functional requirements, SCADA communication requirements, components of SCADA system, SCADA communication protocols, the structure of a SCADA communication protocol, security for substation communications, security methods, security assessment.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | John D. McDonald , Electrical Power Substation Engineering , CRC Press, 3 rd Edition, 2017 |

**Reference Books:**

| | |
|---|---|
| 1. | R. S. Dahiya, VinayAttri," Sub-Station Engineering Design & Computer Applications " S K Kataria and son Publications, 1 st Edition, 2013. |
| 2. | P. S. Satnam, P. V. Gupta, " Substation Design and Equipment " Dhanapat Rai Publications, 1 st Edition, 2013. |
| 3. | Turan Gonen, " Electric Power Distribution Engineering " CRC press, third edition, 2014. |

**E-Reference**

| | |
|---|---|
| 1 | https://www.transgrid.com.au/what-we-do/our-network/connections |
| 2 | https://new.abb.com/substations |
| 3 | https://ieeexplore.ieee.org/document/178016 |
| 4 | https://www.sciencedirect.com/topics/engineering/substations |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the commissioning of substation | L2: Understanding |
| CO2 | : | Know working principles of substation switching equipment | L2: Understanding |
| CO3 | : | Identify the different types of bus configurations | L1: Remembering |
| CO4 | : | Design substation grounding and protection | L6: Creating |
| CO5 | : | Analyse the substation communication (SCADA) | L4: Analysing |

| 22PTEEE26 | POWER SYSTEM AUTOMATION | | SEMESTER V | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System; Power System Analysis and Stability | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To acquire fundamental knowledge on power system instrumentation. |
| 2. | To familiarise on automations in electric power distribution systems. |
| 3. | To get conceptual aspects in modern tools for power system automation. |

| UNIT I | MEASUREMENTS AND SIGNAL TRANSMISSION TECHNIQUES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Object and philosophy of power system instrumentation to measure large currents, high voltages, Torque and Speed - Standard specifications - Data acquisition systems for Power System applications - Data Transmission and Telemetry - PLC equipment, RTU, IED - computer control of power system - Man Machine Interface.

| UNIT II | COMMUNICATION TECHNOLOGIES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Communication requirements; Two way capability – outages and faults; Public switched telephone network, Power line carrier communication – ripple control, cyclocontrol, carrier frequency (PLC, DLC, BPL), Radio communication (UHF point to point, UHF multi address system radio, VHF, PSN, Cellular radio), Fibre optics, Satellite communication. Standards: IEE802, IEC61850

| UNIT III | DISTRIBUTION SYSTEM INSTRUMENTATION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Definitions – automation switching control – management information systems (MIS) – remote terminal units – communication method for data transfer – consumer information service (CIS) – graphical information systems (GIS) - automatic meter reading (AMR) – Remote control load management.

| UNIT IV | DISTRIBUTION AUTOMATION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction to distribution automation: Customer automation- Feeder automation – Substation automation, Subsystems in distribution control centre – Distribution management systems-Outage management systems, Distribution management system framework-Advanced real time DMS applications- Advanced analytical DMS applications – DMS coordination with other systems.

| UNIT V | CONCEPTS FOR SMART SYSTEMS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Smart system solutions – Asset optimization, Demand optimization, distribution optimization, smart meter and communications, transmission optimization; Demand side management and demand response – DSM Planning-DSM techniques; Advanced metering infrastructure integration with distribution automation, distribution management system, and outage management system; Smart homes with home energy management systems.

**Total (45 L + 0 T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Pabla. A.S, “Electric Power Distribution”, Tata McGraw Hill, New Delhi, 2004. |
| 2. | Mini S Thomas, and John D McDonald, “Power System SCADA and Smart Grids”, Taylor and Francis, 2015. |
| 3. | Mahalanabis, Kothari and Ahson, “Computer Aided Power System Analysis and Control”, Tata McGraw Hill Publishers, 1991. |


**Reference Books:**


| | |
|---|---|
| 1. | Momoh A. Momoh, and James A. Momoh., “Electric Power Distribution, Automation, Protection, and Control”, CRC Press, 2007. |
| 2. | Gonen., “Electric Power Distribution System Engineering”, BSP Books, Pvt. Ltd, 2007. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the conceptual aspects in power system measurements and signal transmission techniques. | L2: Understanding |
| CO2 | : | Demonstrate various communication technologies for data transmission. | L3: Applying |
| CO3 | : | Acquire proficiency to distribution system instrumentation. | L3: Applying |
| CO4 | : | Demonstrate the automation in power distribution system. | L3: Applying |
| CO5 | : | Conceptualize the smart tools for automation. | L3: Applying |

| 22PTEEE27 | HIGH VOLTAGE INSULATION SYSTEMS | | | SEMESTER V | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| High voltage Engineering, Measurements and Instrumentation | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To expose the various types of insulating materials used for power system equipment |
| 2. | To introduce the concept of insulation design. |
| 3. | To provide an overview of insulation defects in power system equipment |
| 4. | To understand insulation condition monitoring techniques. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **INSULATING MATERIALS** | **9** | **0** | **0** | **9** |

Review of electrical insulating materials, characterization of insulation condition, models of deterioration and failure of practical insulating materials, electrical breakdown and operating stresses, development of insulation applications

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **ELECTRICAL INSULATION DESIGN CONCEPTS** | **9** | **0** | **0** | **9** |

Overview of insulation design requirements – electrical stress distribution in simple insulation system – electric stress control: Principles of stress control, Stress distribution in multiple dielectrics, Stress calculation.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **INSULATION DEFECTS IN HV POWER SYSTEM EQUIPMENTS** | **9** | **0** | **0** | **9** |

HV Insulators - HV bushings - HV power capacitors - HV surge arresters – HV circuit breakers, HV Cables - Gas Insulated system – HV Transformers - HV instrument transformers.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **BASIC METHODS FOR INSULATION ASSESSMENT** | **9** | **0** | **0** | **9** |

Generation and measurement of test high voltages - Non-destructive electrical measurements: Insulation Resistance, dielectric dissipation factor, partial discharges, dielectric response – Physical and chemical diagnostic methods.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **ONLINE INSULATION CONDITION MONITORING TECHNIQUES** | **9** | **0** | **0** | **9** |

Main problem with Offline condition monitoring - Noise-mitigation techniques - Non-electrical online condition monitoring - Online acoustic/electric PD location methods for transformers - Electrical online condition monitoring.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | R. E. James and Q. Su, "Condition Assessment of High Voltage Insulation in Power System Equipment", IET power and Energy Series Publisher, London, United Kingdom, 2008. |

**Reference Books:**

| | |
|---|---|
| 1. | Dieter Kind and Hermann Kärner (1985). High-Voltage Insulation Technology. Springer. |
| 2. | Ravindra Arora & Wolfgang Mosch, "High Voltage and Electrical Insulation Engineering", John Wiley& Sons Publishers, 2011. |
| 3. | E. Kuffel W.S. Zaengl, and J.Kuffel, 'High Voltage Engineering Fundamentals', Newness Publishers, Second Edition, Elsevier, New Delhi, 2005. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Know the various insulating materials. | L2: Understanding |
| CO2 | : | Understand the concepts of insulation design for power system equipment. | L2: Understanding |
| CO3 | : | Analyze insulation defects in high voltage power system equipment | L4: Analyzing |
| CO4 | : | Recite the basic methods for insulation assessment | L1: Remembering |
| CO5 | : | Apply online insulation condition monitoring techniques | L3: Applying |

| 22PTEEE31 | POWER SYSTEM TRANSIENTS | | | | SEMESTER VI | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System; Power System Analysis and Stability | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To impart knowledge on generation of switching transients and their control. |
| 2. | To familiarise on the mechanism of lighting strokes and the production of lighting surges. |
| 3. | To understand the propagation, reflection and refraction of travelling waves. |
| 4. | To acquire knowledge on voltage transients caused by faults, circuit breaker action, load rejection on integrated power system. |

| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Review and importance of the study of transients - causes for transients. RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems – role of the study of transients in system planning.

| **UNIT II** | **SWITCHING TRANSIENTS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit. Capacitance switching - effect of source regulation - capacitance switching with a restrike, with multiple restrikes. Illustration for multiple restriking transients - Ferro resonance.

| **UNIT III** | **LIGHTNING TRANSIENTS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design - protection using ground wires - tower footing resistance - Interaction between lightning and power system.

| **UNIT IV** | **TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves.

| **UNIT V** | **TRANSIENTS IN INTEGRATED POWER SYSTEM** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

The short line and kilometric fault - distribution of voltages in a power system - Line dropping and load rejection - voltage transients on closing and reclosing lines - over voltage induced by faults -switching surges on integrated system Qualitative application of EMTP for transient computation.

**Total (45 L + 0 T) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Allan Greenwood, "Electrical Transients in Power Systems", Wiley Inter Science, New York, 2nd Edition, 1991. |
| 2. | Pritindra Chowdhari, "Electromagnetic transients in Power System", John Wiley and Sons Inc., Second Edition, 2009. |
| 3. | Indulkar, C.S., Kothari, D.P., and Ramalingam, K., "Power System Transients – A Statistical Approach", PHI Learning Private Limited, Second Edition, 2010. |


**Reference Books:**


| | |
|---|---|
| 1. | Naidu, M.S., and Kamaraju, V., "High Voltage Engineering", McGraw Hill, Fifth Edition, 2013. |
| 2. | Begamudre, R.D., "Extra High Voltage AC Transmission Engineering", Wiley Eastern Limited, 1986. |
| 3. | Hase, Y., "Handbook of Power System Engineering", Wiley India, 2012. |
| 4. | Kirtley, J.L., "Electric Power Principles, Sources, Conversion, Distribution and Use", Wiley, 2012. |

| | |
|---|---|
| 5. | Akihiro Ametani, “Power System Transient theory and applications”, CRC press, 2013. |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | | **Bloom’s Taxonomy Mapped** |
|---|---|---|
| CO1 | Interpret the switching and lightning transients. | L4: Analysing |
| CO2 | Examine the generation of switching transients and their control. | L4: Analysing |
| CO3 | Analyse the mechanism of lightning strokes. | L4: Analysing |
| CO4 | Recognize the importance of propagation, reflection, and refraction of travelling waves. | L1: Understanding |
| CO5 | Review the concept of circuit breaker action, line dropping, and load rejection in an integrated power system. | L1: Understanding |

| 22PTEEE32 | POWER QUALITY | | SEMESTER VI | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITE** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution system, Power System Protection and Switchgear | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | Introduce the power quality terms and definitions |
| 2. | Understand the sources and issues of various power quality problems. |
| 3. | Gain in-depth knowledge of the mitigation/ suppression techniques of voltages sags, interruptions and harmonics. |
| 4. | Introduce the computer tools for transient's analysis. |
| 5. | Expose the various methods of power quality monitoring. |

| | | | | | |
|---|---|---|---|---|---|
| **Unit I** | **INTRODUCTION TO POWER QUALITY** | **9** | **0** | **0** | **9** |

Terms and definitions of Power quality, General classes of power quality problems: transients- long duration voltage variations- short duration voltage variations, voltage Imbalance, waveform distortion, voltage fluctuation, Power frequency variations-International standard of power quality-CBEMA and ITI curves.

| | | | | | |
|---|---|---|---|---|---|
| **Unit II** | **VOLTAGE SAGS AND LONG DURATION VOLTAGE VARIATIONS** | **9** | **0** | **0** | **9** |

Sources of sags and interruptions, estimating voltage sag performance, fundamental principles of voltage sag Protection – voltage sag mitigation solution at the End-User level- Evaluating the economics of different ride-through alternatives – Motor Starting sags.

**Long Duration voltage variations**: Principles of regulating the voltage – devices for voltage regulation-utility voltage regulator application- capacitor for voltage regulation- End user capacitor application - Flicker: sources and mitigation techniques.

| | | | | | |
|---|---|---|---|---|---|
| **Unit III** | **TRANSIENT OVERVOLTAGE** | **9** | **0** | **0** | **9** |

Sources of transient over voltage- Principles of overvoltage Protection- Devices for mitigation of over voltages – Utility capacitor-switching transients – Utility system lightning protection - Managing Ferro resonance- switching transients problems with loads - computer tools for transients analysis: PSCAD and EMTP.

| | | | | | |
|---|---|---|---|---|---|
| **Unit IV** | **HARMONICS** | **9** | **0** | **0** | **9** |

Fundamentals of Harmonics: Harmonic Distortion, voltage versus current distortion, Harmonics versus transients- harmonics phase sequences- triplen harmonics -harmonic indices, harmonic sources from commercial and industrial loads. Locating harmonic sources - power system response characteristics – Effects of Harmonics Distortion – Interharmonics - harmonic distortion evaluations, Principles and devices for controlling harmonic distortion, IEEE and IEC standards on harmonics.

| | | | | | |
|---|---|---|---|---|---|
| **Unit V** | **POWER QUALITY MONITORING** | **9** | **0** | **0** | **9** |

Monitoring considerations - power quality measurement equipment: disturbance analyser, spectrum and harmonics analysers, flicker meters, applications of Intelligent system for power quality monitoring.

**Total (45L+0T) = 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Roger. C. Dugan, Mark. F. McGranaghan, Surya Santoso, H.WayneBeaty, "Electrical Power Systems Quality", Tata McGraw Hill Publishing Company Ltd, New Delhi, Second Edition, 2009. |

**Reference Books:**

| | |
|---|---|
| 1. | C. Sankaran ,"Power quality", CRC Press, First Indian Edition, 2009. |
| 2. | G.T.Heydt, "Electric power quality", Stars in a Circle publishers, Second Edition, 1994. |
| 3. | Arindam Ghosh and Gerald Ledwich, "Power Quality Enhancement Using Custom Power Devices", Springer-Verlag Publishers, New York Inc., Second Edition.2002. |

**E-Reference:**

| | |
|---|---|
| 1 | www.onlinecourses.nptel.ac.in |

| | |
|---|---|
| 2 | www.class-central.com |
| 3 | www.mooc-list.com |

| **Course Outcomes:** | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| Upon completion of this course, the students will be able to: | | | |
| CO1 | : | Understand the definitions and characterization of various power quality issues. | L1:Remembering |
| CO2 | : | Discuss the sources of sag & long duration voltage variations and its control methods | L2:Understanding |
| CO3 | : | Summarize the sources of transient overvoltage and principle of control methods | L2:Understanding |
| CO4 | : | Analyse harmonics problem and apply filters to suppress harmonics in distribution system | L4:Analyzing |
| CO5 | : | Demonstrate the operation and application of power quality measuring equipment. | L3:Applying |

| 22PTEEE33 | DISTRIBUTED GENERATION AND MICROGRID | | SEMESTER VI | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To impart knowledge on distributed generation technologies. |
| 2. | To familiarise on impact on grid integration. |
| 3. | To understand the microgrid operation and control. |

| UNIT I | INTRODUCTION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

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

| UNIT II | DISTRIBUTED GENERATIONS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

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

| UNIT III | IMPACT OF GRID INTEGRATION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

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

| UNIT IV | BASICS OF A MICROGRID | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

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

| UNIT V | CONTROL AND OPERATION OF MICROGRID | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

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

**Total (45 L + 0 T) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Lee Willis, H., Walter G. Scott , "Distributed Power Generation – Planning and Evaluation", Marcel Decker Press, 2000. |
| 2. | Godoy Simoes, M., Felix A. Farret, "Renewable Energy Systems – Design and Analysis with Induction Generators", CRC Press, 2004. |
| 3. | Robert Lasseter, and Paolo Piagi, "Micro-grid: A Conceptual Solution", PESC, June 2004. |


**Reference Books:**


| | |
|---|---|
| 1. | John Twidell and Tony Weir, "Renewable Energy Resources" Tyalor and Francis Publications, 2005. |
| 2. | Dorin Neacsu, "Power Switching Converters: Medium and High Power", CRC Press, Taylor & Francis, 2006. |
| 3. | Amirnaser Yezdani, and Reza Iravani, "Voltage Source Converters in Power Systems: Modeling, Control and Applications", IEEE John Wiley Publications, 2009. |
| 4. | Katiraei, F., and Iravani, M.R., "Transients of a Micro-Grid System with Multiple Distributed Energy Resources", International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005. |
| 5. | Ye, Z., Walling, R., Miller, N., Du, P., and Nelson, K., "Facility Microgrids", General Electric Global Research Center, Niskayuna, New York, Subcontract report, May 2005. |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | **Bloom's Taxonomy Mapped** |
|---|---|

| | | |
|---|---|---|
| CO1 | Identify various forms of energy sources. | L2: Understanding |
| CO2 | Recognize various DG technologies. | L2: Understanding |
| CO3 | Analyse the impact on grid while integrating DGs. | L4: Analysing |
| CO4 | Demonstrate the concepts of microgrids. | L3: Applying |
| CO5 | Categorize various microgrid control schemes. | L4: Analysing |

| 22PTEEE34 | RESTRUCTURED POWER SYSTEM | | SEMESTER VI | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System; Power System Analysis and Stability | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To impart knowledge on power system restructuring. |
| 2. | To familiarise on electricity market models. |
| 3. | To understand various network operations / analyses including transmission system operations, optimal power flow, and automatic generation control. |

| UNIT I | POWER SYSTEM RESTRUCTURING | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction –Deregulation - Need for deregulation – Power system restructure models - Electricity Market Participants – GENCOS- DISCOS- TO- ISO- PX- SC - trading arrangements - Operational Planning Activities (OPA) of Electricity Market Participants - Causes of restructuring- types and effects of restructuring – restructure models

| UNIT II | ELECTRICAL UTILITY | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Electrical utility restructuring Power System Operation in competitive environment –Electricity Market Models (PoolCo-bilateral- hybrid)- Components of restructured system - Power Sector restructuring and influence on environment - Functions and responsibilities of PX- ISO- RTO and ITP - Electric Utility Market – Market Models - wholesale electricity market characteristic – Electricity Market types (energy- ancillary services- transmission- forward- real time) – Market power evaluation and mitigation

| UNIT III | EVALUATION OF TRANSMISSION SYSTEM | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Electricity pricing and Transmission pricing in a restructured market - Congestion management in a deregulated market – Available Transfer Capabilities (ATC) of transmission system – Application of Monte Carlo Simulation in ATC calculation – ATC calculation with sensitivity analysis method - Tagging Electricity Transaction – Tagging process – Implementation-Curtailment and cancellation of transaction - Availability Based Tariff

| UNIT IV | OPTIMUM POWER FLOW (OPF) ANALYSIS IN MARKET ENVIRONMENT | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction – Approaches to OPF – Application of OPF analysis in Electricity and Power Markets with Electricity Market Participants – Power Flow Tracing – current decomposition axioms- Mathematical model of loss allocation- usage sharing problem on transmission facilities - Methodology of graph theory - Economic issues- Mechanism and transmission issues in the new market environment.

| UNIT V | AGC IN RESTRUCTURED POWER SYSTEM | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction – Traditional Vs Restructured Scenario –AGC in New market environment - Block diagram and State Space representation of a two-area interconnected power system in deregulated environment – Load-Frequency Control (LFC) dynamics and Bilateral Contacts – Modelling- DISCO Participation Matrix (DPM)- Generation Participation Matrix (GPM).

**Total (45 L + 0 T) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Loi Lei Lai, “Power System Restructuring and deregulation”- John Wiley & Sons,2001. |
| 2. | Md. Shahidehpour, and Muwaffag Almoush, “Restructured Electric Power System – Operation- Trading and Volatility”, Marcel Dekker Inc, New York, 2001. |
| 3. | Arthur. R. Bergen, and Vijay Vittal, “Power System Analysis,” Prentice Hall, New Jersey, 2000. |


**Reference Books:**


| | |
|---|---|
| 1. | Xi Fan, Wang, and Yonghua Song, Malcolm Irving, “Modern Power System Analysis”, Springer, 2008. |
| 2. | Das, D., “Electrical Power Systems”, New Age International (P) Ltd, New Delhi, 2008. |
| 3. | Iiic, M., Galiana, F., and Fink, L., “Power Systems Restructuring” Norwell M A Kluwer, 1998. |

| | |
|---|---|
| 4. | Philipson. L., and Willis H. Le, "Understanding Electric Utilities and de-regulation", Marcel Dekker Inc Publishers, New York, 2006. |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Recognize components in restructured power system. | L2: Understanding |
| CO2 | : | Interpret various models in electricity market. | L3: Applying |
| CO3 | : | Examine the congestion management and ATC in transmission system. | L4: Analysing |
| CO4 | : | Formulate the power flow problem in restructured power system. | L4: Analysing |
| CO5 | : | Develop automatic generation control in restructured power system. | L4: Analysing |

| 22PTEEE35 | POWER SYSTEM PLANNING AND RELIABILITY | SEMESTER VI |
|---|---|---|

| PREREQUISTIES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Power Systems | PE | 3 | 0 | 0 | 3 |

**Course Objectives:**

1. Understand the concepts of power system planning
2. Analyze power system reliability
3. Understand generation, transmission and distribution planning and reliability

| UNIT I | INTRODUCTION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction, Objectives & Factors affecting to System Planning , Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning.

| UNIT II | RELIABILITY | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Reliability, Failure, Concepts of Probability, Evaluation Techniques (i) Markov Process (ii) Recursive Technique, Stochastic Prediction of Frequency and Duration of Long & Short Interruption, Adequacy of Reliability, Reliability Cost.

| UNIT III | GENERATION PLANNING AND RELIABILITY | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Generation Sources, Integrated Resource Planning, Generation System Model, Loss of Load (Calculation and Approaches),Outage Rate, Capacity Expansion, Scheduled Outage, Loss of Energy, Evaluation Methods, Interconnected System, Factors Affecting Interconnection under Emergency Assistance.

| UNIT IV | TRANSMISSION PLANNING AND RELIABILITY | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction, Objectives of Transmission Planning, Network Reconfiguration, System and Load Point Indices, Data required for Composite System Reliability.

| UNIT V | DISTRIBUTION PLANNING AND RELIABILITY | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Radial Networks, Network Reconfiguration, Evaluation Techniques, Interruption Indices, Effects of Lateral Distribution Protection, Effects of Disconnects, Effects of Protection Failure, Effects of Transferring Loads, Distribution Reliability Indices, Parallel & Meshed Networks, Bus Bar Failure, Scheduled Maintenance, Temporary and Transient Failure, Breaker Failure.

**Total (45L+0T)= 45 Periods**

**Text Books:**


1. R.L. Sullivan “Power System Planning”, Tata McGraw Hill Publishing Company Ltd.
2. Roy Billinton & Ronald N. Allan “Reliability Evaluation of Power System”, Springer Publication
3. T. W. Berrie “Electricity Economics & Planning”, Peter Peregrinus Ltd., London.


**Reference Books:**


1. Ali Chowdhury, Don Koval, “Power Distribution System Reliability: Practical Methods and Applications”, Wiley-IEEE Press, 2009.
2. Roy Billinton, R.N. Allan, “Reliability Evaluation of Power Systems”, Springer, 1996.


**E-Reference**

1. https://archive.nptel.ac.in/courses/117/103/117103149/

| Course Outcomes: Upon completion of this course, the students will be able to: | | | Bloom’s Taxonomy Mapped |
|---|---|---|---|
| CO1 | : | Understand the power system planning | L2: Understanding |
| CO2 | : | Determine the reliability of power system | L1: Applying |
| CO3 | : | Understand the generation planning and reliability of power system | L1: Remembering |
| CO4 | : | Understand the transmission planning and reliability of power system | L2: Understanding |
| CO5 | : | Uunderstand the distribution planning and reliability of power system | L1: Remembering |

| 22PTEEE36 | POWER PLANT ENGINEERING | | SEMESTER VI | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Systems | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

The objective of this course is to familiarize with operation of various power plants

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **THERMAL POWER PLANT** | **9** | **0** | **0** | **9** |

Thermal Stations- layout- main components- boiler- economizer- air preheater- super heater- reheater- condenser- feed heater- cooling powers- FD and ID fans- Coal handling plant-water treatment plant- Ash handling plant- Types of boilers and theirs characteristics- Steam turbines- and their characteristics- governing system for thermal stations

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **HYDRO POWER PLANT** | **9** | **0** | **0** | **9** |

Hydro Electric Stations- Selection of site- layout- classification of hydro plants- general arrangement and operation of a hydro-plant- governing system for hydel plant- types of turbines-pumped storage plants.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **NUCLEAR POWER PLANT** | **9** | **0** | **0** | **9** |

Nuclear power plants - Principles of nuclear energy - Working of Nuclear Reactors : Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANada Deuterium- Uranium reactor (CANDU), Breeder, Gas Cooled and Liquid Metal Cooled Reactors - location - advantages and disadvantages of nuclear power plants - Reactor control

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **POWER FROM RENEWABLE ENERGY** | **9** | **0** | **0** | **9** |

Principle, Construction and working of Solar Thermal, Solar Photo Voltaic (SPV), Wind, Tidal, Geo Thermal, Biogas and Fuel Cell power systems.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **POWER PLANT ECONOMICS AND ENVIRONMENTAL HAZARDS** | **9** | **0** | **0** | **9** |

Economics of power generation -Capital & Operating Cost of different power plants. Environmental aspect of power generation- Comparison of site selection criteria, relative merits & demerits of different plants - Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants- safety measures for Nuclear Power plants.

**Total (45L) = 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Nag. P.K., Power Plant Engineering, 2nd ed., Tata McGraw-Hill, 2002 |
| 2. | Domkundwar, S., Power Plant Engineering, Dhanpat Rai & Sons, 1988 |
| 3. | El-Wakil, M.M., "Power plant Technology", McGraw-Hill Book Co, 2002 |

**Reference Books:**

| | |
|---|---|
| 1. | Deshpande.M.V, "Elements of Electrical Power station Design", Pitman, New Delhi,Tata McGraw Hill, 2008. |
| 2. | Soni Gupta, Bhatnagar and Chakrabarti, "A text book on Power Systems Engineering", Dhanpat Rai and Sons, New Delhi, 1997. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Recall the construction and principle of working for different power plants. | L1: Remembering |
| CO2 | : | Identify the site requirements and component requirements. | L2: Understanding |
| CO3 | : | Analyze the concept governors and their control of power plant. | L4: Analysing |
| CO4 | : | Assess the power plant and its suitability for the environment. | L3: Applying |
| CO5 | : | Interpret the economics involved in design of power plant. | L2: Understanding |

| 22PTEEE41 | SPECIAL ELECTRICAL MACHINES | SEMESTER VI | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electrical Machines | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

1. To learn the fundamental concepts of special electrical machines.
2. To select proper special machines based on applications.

| UNIT I | SYNCHRONOUS RELUCTANCE MOTORS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Constructional features – Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram - Characteristics – Vernier motor.

| UNIT II | PERMANENT MAGNET BRUSHLESS D.C. MOTORS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Power controllers – Motor characteristics and control.

| UNIT III | PERMANENT MAGNET SYNCHRONOUS MOTORS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Principle of operation – EMF and torque equations – Reactance – Phasor diagram – Power controllers - Converter - Volt-ampere requirements – Torque speed characteristics - Microprocessor based control.

| UNIT IV | SWITCHED RELUCTANCE MOTORS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Constructional features – Principle of operation – Torque prediction – Power controllers – Non-linear analysis – Microprocessor based control - Characteristics – Computer control.

| UNIT V | STEPPING MOTORS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi stack configurations – Theory of torque predictions – Linear and non-linear analysis – Characteristics – Drive circuits

**Total (45L+0T)= 45 Periods**

**Text Books:**

1. T.J.E. Miller, "Brushless Permanent Magnet and Reluctance Motor Drives", Clarendon Press, Oxford, 1989.
2. P.P. Acarnley, "Stepping Motors – A Guide to Motor Theory and Practice", Peter Perengrinus, London, 1982.

**Reference Books:**

1. R. Krishnan, "Switched reluctance motor drives", CRC Press, 2001.
2. R. Krishnan , "Permanent Magnet Synchronous and Brushless DC Motor Drives", CRC Press, 2010

**E-References:**

1. www.onlinecourses.nptel.ac.in
2. www.class-central.com
3. www.mooc-list.com

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Explain the principles behind the different special machines. | L2: Understanding |
| CO2 | : | Apply the electromagnetic concepts for development of EMF and Torque in machines. | L3: Applying |
| CO3 | : | Select the control structure in terms of hardware to control the special machines. | L4: Analyzing |
| CO4 | : | Analyze appropriate control techniques for efficient control of special machines. | L4: Analyzing |
| CO5 | : | Develop strategy and methods to implement suitable application-based projects. | L2: Understanding |

| 22PTEEE42 | INDUSTRIAL ELECTRICAL SYSTEMS | | | | SEMESTER VI | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Distribution System, Measurements and Instrumentation. | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To expose the electrical components, safety equipments , residential and commercial installations, illumination systems and automation in Electrical Systems |

| UNIT I | ELECTRICAL SYSTEM COMPONENTS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

LT system wiring components, select ion of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, RCCB inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices

| UNIT II | COMMERCIAL ELECTRICAL SYSTEMS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Types of commercial wiring systems, general rules and guidelines for installation, load calculations, selection and sizing of components , rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation,.

| UNIT III | ILLUMINATION SYSTEMS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

. Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

| UNIT IV | PROTECTION AND COMPERNSATION MEASURES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

| UNIT V | ELECTRICAL SYSTEM AUTOMATION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.

**Total (45L+0T) = 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | S.L. Uppal and G.C. Garg, “Electrical Wiring, Estimating & Costing”, Khanna publishers, 2008.<br>K. B. Raina, “Electrical Design, Estimating & Costing”, New age International, 2007. |
| 2. | S. Singh and R. D. Singh, “Electrical estimating and costing”, Dhanpat Rai and Co., 1997. |
| 3. | H. Joshi, “Residential Commercial and Industrial Systems”, McGraw Hill Education, 2008. |

**Reference Books:**

| | |
|---|---|
| 1. | Partab , Art and Science of Utilization of Electrical Energy. |
| 2. | Open Shaw Taylor, "Utilization of Electrical Energy", Oriented Longmans Limited, (Revised in SI Units), 1971. |
| 3. | C. L Wadhwa , Generation ,Distribution and Utilization of Electrical Energy |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Associate the various components of industrial electrical system | L2: Understanding |
| CO2 | : | Apply appropriate criteria for selection and sizing of the different electrical systems. | L3: Applying |
| CO3 | : | Recall the various terms and factors for illuminations systems | L1:Remebering |
| CO4 | : | Analyse the essential safety, protection and compensation measures. | L4:Analysing |
| CO5 | : | Select the appropriate electrical system for automation. | L4:Analysing |

| 22PTEEE43 | MODERN ELECTRICAL DRIVES | SEMESTER VI | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electrical Drives and control. | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

1. To know about the overview of Electrical drives.
2. To know about the Vector control strategies for DC motor drives.
3. To understand the concepts of various DSP based control.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **DC MOTOR DRIVES:** | **9** | **0** | **0** | **9** |

Modeling of DC motors, State space modeling, block diagram & Transfer function, Single phase, three phases fully controlled and half controlled DC drives. Dual converter control of DC drives Closed loop control of separately excited dc motor drive. Supply harmonics and ripple in motor current chopper controlled DC motor drives.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **INDUCTION MOTOR DRIVES** | **9** | **0** | **0** | **9** |

Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control (DTC)

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **SYNCHRONOUS MOTOR DRIVES** | **9** | **0** | **0** | **9** |

Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **PERMANENT MAGNET MOTOR AND SWITCHED RELUCTANCE MOTOR DRIVES** | **9** | **0** | **0** | **9** |

Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives. Various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **DSP BASED MOTION CONTROL** | **9** | **0** | **0** | **9** |

Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.

**Total (45L+0T)= 45 Periods**

**Text Books:**

1. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.
2. P. C. Krause, O. Wasynczuk and S. D. Sudhoff, "Analysis of Electric Machinery and Drive Systems", John Wiley & Sons, 2013.

**Reference Books:**

1. H. A. Taliyat and S. G. Campbell, " DSP based Electromechanical Motion Control" , CRC press, 2003
2. R. Krishnan, "Permanent Magnet Synchronous and Brushless DC motor Drives", CRC Press, 2009.
3. https://nptel.ac.in/courses/

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Apply Power converters for DC drives. | L1: Remembering |
| CO2 | : | Understand the basics of Permanent magnet motor and Switched reluctance motor drives. | L2: Understanding |
| CO3 | : | Learn the concepts of Synchronous motor drives. | L5: Evaluating |
| CO4 | : | Gain knowledge of Induction motor drives. | L4: Analyzing |
| CO5 | : | Explain DSP based motion control. | L3: Applying |

| 22PTEEE44 | ANALYSIS OF ELECTRICAL MACHINES | SEMESTER VI | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| DC Machines , Synchronous and Induction Machines | **PE** | **2** | **0** | **2** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To model & simulate all types of DC machines |
| 2. | To develop reference frame equations for various elements like R, L and C |
| 3. | To model an induction (three phase and 'n' phase) and synchronous machine |
| 4. | To drive reference frame equations for induction and synchronous machine |
| 5. | To study the need and working of multiphase induction and synchronous machine |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **MODELING OF BRUSHED-DC ELECTRIC MACHINERY** | **6** | **0** | **3** | **9** |

Fundamentals of Operation – Introduction – Governing equations and modeling of Brushed DC-Motor – Shunt, Series and Compound – State model derivation – Construction of Model of a DC Machine using state equations- Shunt, Series and Compound.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **REFERENCE FRAME THEORY** | **6** | **0** | **3** | **9** |

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame .

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **INDUCTION MACHINES** | **6** | **0** | **3** | **9** |

Three phase induction machine - equivalent circuit– free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – Simulation under no load and load conditions- Machine variable form, arbitrary reference variable form.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **SYNCHRONOUS MACHINES** | **6** | **0** | **3** | **9** |

Three phase synchronous machine - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations).

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **MULTIPHASE (MORE THAN THREE-PHASE) MACHINES CONCEPTS** | **6** | **0** | **3** | **9** |

Preliminary Remarks - Necessity of Multiphase Machines - Evolution of Multiphase Machines- Advantages of Multiphase Machines - Working Principle - Multiphase Induction Machine, Multiphase Synchronous Machine -Modeling of 'n' phase machine. Applications of Multiphase Machines

**LAB COMPONENT**

| | |
|---|---|
| 1 | Modeling of DC machines. |
| 2 | Simulation under no-load and loaded conditions for a PMDC motor |
| 3 | Simulation of smooth starting for DC motor. |
| 4 | Simulation under no-load and load conditions of a three phase induction machine in machine variable form and arbitrary reference variable form |
| 5 | Simulation under no-load and load conditions of a three phase synchronous machine in machine variable form and arbitrary reference variable form. |

**Total (30L+0T+15P)= 45 Periods**

**Test Books:**


| | |
|---|---|
| 1. | Stephen D. Umans, "Fitzgerald & Kingsley's Electric Machinery", Tata McGraw Hill, 7th Edition, 2020. |
| 2. | Bogdan M. Wilamowski, J. David Irwin, The Industrial Electronics Handbook, Second Edition, Power Electronics and Motor Drives, CRC Press, 2011, 1st Edition. |
| 3. | Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek, "Analysis of Electric Machinery and Drive Systems", 3rd Edition, Wiley-IEEE Press, 2013.. |

| | |
|---|---|
| 4. | Chee Mun Ong, Dynamic Simulation of Electric Machinery using MATLAB, Prentice Hall, 1997, 1st Edition |
| 5. | Atif Iqbal,Shaikh Moinoddin, Bhimireddy Prathap Reddy, Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Wiley,2021,1st Edition |
| **Reference Books** | |
| 1. | R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Pearson Education, 1st Imprint, 2015, 1st Edition. |
| 2. | R.Ramanujam, Modeling and Analysis of Electrical Machines, I.k.International Publishing House Pvt.Ltd,2018. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Find the modeling for a brushed DC-Motor (Shunt, Series, Compound and separately excised motor) and to simulate DC motors using state models | L1: Remembering |
| CO2 | : | Apply reference frame theory for, resistive and reactive elements (three phase) | L2: Understanding |
| CO3 | : | Compute the equivalent circuit and torque of three phase induction motor and synchronous motor in machine variable arbitrary reference frame variable | L5: Evaluating |
| CO4 | : | Demonstrate the working of multiphase induction and synchronous machine. | L3: Applying |
| CO5 | : | Compute the model of three phase and multiphase induction and synchronous machine. | L6: Creating |

| 22PTEEE45 | MULTILEVEL POWER CONVERTERS | SEMESTER VI | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power electronics | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To introduce the fundamentals of multilevel voltage source inverters and multilevel current source inverters with its modulation control |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **DIODE-CLAMPED MULTILEVEL INVERTERS** | **9** | **0** | **0** | **9** |

Three-Level Inverter - Converter Configuration and Switching State, Space Vector Modulation - Stationary Space Vectors, Dwell Time Calculation and Switching Sequence Design, Neutral-Point Voltage Control 164
Discontinuous Space Vector Modulation, SVM Based on Two-Level Algorithm, High-Level Diode-Clamped Inverters - Four- and Five-Level Diode-Clamped Inverters

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **MULTILEVEL VOLTAGE SOURCE INVERTERS** | **9** | **0** | **0** | **9** |

Introduction, NPC/H-Bridge Inverter, Inverter Topology and Modulation Scheme, Waveforms and Harmonic Content, Multilevel Flying-Capacitor Inverters, Inverter Configuration, Modulation Schemes

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **CASCADED MULTILEVEL INVERTERS** | **9** | **0** | **0** | **9** |

H-Bridge Inverter, Bipolar Pulse-Width Modulation and Unipolar Pulse-Width Modulation, CHB Inverter with Equal DC Voltages, H-Bridges with Unequal DC Voltages, Carrier Based PWM Schemes, Phase-Shifted Multicarrier Modulation, Level-Shifted Multicarrier Modulation, Comparison Between Phase- and Level-Shifted PWM Schemes

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **MODULAR MULTILEVEL INVERTER** | **9** | **0** | **0** | **9** |

Five level Modular Multilevel Inverter- Power circuit , operation and applications, DC Voltage balance control, Carrier Based PWM for Modular Multilevel Inverter

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **PWM TECHNIQUES** | **9** | **0** | **0** | **9** |

Trapezoidal Modulation, Selective Harmonic Elimination, Space Vector Modulation-Switching States, Space Vectors, Dwell Time Calculation, Switching Sequence, Harmonic Content

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Bin Wu, Mehdi Narimani, 'High-Power Converters and AC Drives, 2nd Edition, Wiley-IEEE Press, 2017 |

**Reference Books:**

| | |
|---|---|
| 1. | N. Mohan, T. M. Undeland, et al., Power Electronics—Converters, Applications and Design, 3rd edition, John Wiley & Sons, New York, 2003 |

**E-Reference**

| | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/108/102/108102157/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the configurations for multilevel voltage source inverters. | L1: Remembering |
| CO2 | : | Describe the working principle of multilevel current source inverters | L2: Understanding |
| CO3 | : | Draw the topology structure of different types of multilevel inverters | L3: Applying |
| CO4 | : | Understand the principle of space vector modulation for multilevel inverters | L1: Remembering |
| CO5 | : | Select an appropriate modulation scheme for multilevel inverters | L4: Analyzing |

| 22PTEEE46 | MODELING AND CONTROL OF POWER CONVERTERS | | SEMESTER VI | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Electronics and Control Systems | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To learn the basics of control system simulation. |
| 2. | To do symbolic calculation and study the principles of sliding mode control and the way of apply smc for buck converter. |
| 3. | To learn the concept of power factor correction. |
| 4. | To design simulate smc for buck converter and power factor correction circuit with controller. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **SIMULATION BASICS IN CONTROL SYSTEMS** | **9** | **0** | **0** | **9** |

Transfer Function-How to build transfer function, identify Poles, zeros, draw time response plots, bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions, RHP Pole and RHP Zero Functions), state space modelling-transfer function from state space model.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **SYMBOLIC CALCULATIONS** | **9** | **0** | **0** | **9** |

Symbolic Variables - Symbolic Vector Variables, Commands for Handling Polynomial Expressions - Extracting Parts of a Polynomial -. Factorization and Roots of Polynomials, Symbolic Matrix Algebra - Operations with Symbolic Matrices - Other Symbolic Matrix Operations.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **SLIDING MODE CONTROL BASICS** | **9** | **0** | **0** | **9** |

Introduction- Introduction to Sliding-Mode Control- Basics of Sliding-Mode Theory- Application of Sliding-Mode Control to DC-DC Converters—Principle-Sliding mode control of buck converter.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **POWER FACTOR CORRECTION CIRCUITS** | **9** | **0** | **0** | **9** |

Introduction, Operating Principle of Single-Phase PFCs, Control of boost converter based PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **CONTROLLER DESIGN FOR PFC CIRCUITS** | **9** | **0** | **0** | **9** |

Power factor correction circuit using other SMPS topologies: Cuk and SEPIC converter - PFC circuits employing bridgeless topologies.

**Total (45L+0T) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Feedback Control problems using MATLAB and the Control system tool box By Dean Frederick and Joe Chow, 2000, 1st Edition, Cengage Learning. |
| 2. | Ned Mohan,"Power Electronics: A First Course", Johnwiley, 2013, 1st Edition. |
| 3. | Marian K. Kazimierczuk and AgasthyaAyachit,"Laboratory Manual for Pulse-Width Modulated DC-DC Power Converters", Wiley 2016, 1st Edition. |
| 4. | Power Electronics handbook, Industrial Electronics series, S.K.Varenina, CRC press, 2002, 1st Edition. |


**Reference Books:**


| | |
|---|---|
| 1. | Sliding mode control for Switching Power Converters:, Techniques and Implementation, Slew-Chong Tan, Yuk Ming Lai Chi-Kong Tse, 1st Edition, CRC Press. |
| 2. | Andre Kislovski, "Dynamic Analysis of Switching-Mode DC/DC Converters", Springer 1991. |
| 3. | MATLAB Symbolic Algebra and Calculus Tools, Lopez Cesar, Apress, 2014. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | To calculate transfer function for constant, differential, integral, First order and Second order factors. | L2: Understanding |
| CO2 | : | To illustrate the effect of poles and zero's in the 's' plane. | L1: Remembering |
| CO3 | : | To select Symbolic equations for solving problems related with Matrices, Polynomial and vectors. | L5: Evaluating |
| CO4 | : | To compute the control expression for DC – DC buck converter using sliding mode control theory | L3: Applying |
| CO5 | : | To determine the controller expression for power factor correction circuits and to simulate sliding mode control of buck converter and power factor correction circuit. | L5: Evaluating |

| 22PTEEE47 | GRID CONVERTERS FOR RENEWABLE ENERGY APPLICATIONS | | SEMESTER VI | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power electronics | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To introduce the inverter structures and grid integration methods for solar and wind energy systems. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **PHOTOVOLTAIC INVERTER STRUCTURES** | **9** | **0** | **0** | **9** |

Power circuit, operation modes and Solar PV integration with H5 Inverter, HERIC Inverter, REFU Inverter, Neutral Point Clamped (NPC) Half-Bridge Inverter, Conergy NPC Inverter, Three-Phase PV Inverter, Control Structures

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **GRID SYNCHRONIZATION IN SINGLE-PHASE POWER CONVERTERS** | **9** | **0** | **0** | **9** |

Grid Synchronization Techniques for Single-Phase Systems, Grid Synchronization Using the Fourier Analysis, Grid Synchronization Using a Phase-Locked Loop, PLLs Based on In-Quadrature Signal Generation, PLL Based on the Hilbert Transform , PLL Based on the Inverse Park Transform, PLLs Based on Adaptive Filtering

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **GRID CONVERTER STRUCTURES FOR WIND TURBINE SYSTEMS** | **9** | **0** | **0** | **9** |

Wind Turbine System Power Configurations, Grid Power Converter Topologies: Single-Cell (Voltage Source Converter or Current Source Converter), Multicell (Interleaved or Cascaded), Wind Turbine System Control: Generator-Side Control, Wind Turbine System Control Grid Control

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **GRID SYNCHRONIZATION IN THREE-PHASE POWER CONVERTERS** | **9** | **0** | **0** | **9** |

Synchronous Reference Frame PLL under Unbalanced and Distorted Grid Conditions, Decoupled Double Synchronous Reference Frame PLL (DDSRF-PLL): Double Synchronous Reference Frame, Decoupling Network and Analysis of the DDSRF, Double Second-Order Generalized Integrator FLL (DSOGI-FLL), Structure of the DSOGI, Relationship between the DSOGI and the DDSRF

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **GRID CONVERTER CONTROL FOR WIND TURBINE SYSTEMS** | **9** | **0** | **0** | **9** |

Voltage Oriented Control and Direct Power Control: Synchronous Frame VOC: PQ Open-Loop Control, Synchronous Frame VOC: PQ Closed-Loop Control, Stationary Frame VOC: PQ Open-Loop Control, Stationary Frame VOC: PQ Closed-Loop Control, Virtual-Flux-Based Control, Direct Power Control, Stand-alone, Micro-grid, Droop Control and Grid Supporting: Grid-Connected/Stand-Alone Operation without Load Sharing, Micro-Grid Operation with Controlled Storage, Droop Control

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Remus Teodorescu, Marco Liserre, Pedro Rodríguez, 'Grid Converters for Photovoltaic and Wind Power Systems, Wiley-IEEE Press, 2017 |

**Reference Books:**

| | |
|---|---|
| 1. | Chetan Singh Solanki, " Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2011. |

**E-Reference**

| | |
|---|---|
| 1 | https://onlinecourses.nptel.ac.in/noc22_ee71 |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the configurations for inverter structures for solar photovoltaic system | L1: Remembering |
| CO2 | : | Use grid synchronization technique for single phase converters | L3: Applying |
| CO3 | : | Draw the topology structure of three phase converter for wind energy conversion system | L3: Applying |
| CO4 | : | Understand the principle of grid converter control for wind energy conversion system | L1-Remembering |
| CO5 | : | Select an grid synchronization scheme for three phase converters | L4-Analyzing |

| 22PTEEE48 | CONTROL AND INTEGRATION OF RENEWABLE ENERGY SOURCES | SEMESTER VI |
|---|---|---|

| PREREQUISITES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Nil | PE | 3 | 0 | 0 | 3 |

**Course Objectives:**

1. To understand electric power Generation, Transmission and Distribution
2. To study Power System Operation and Control

| UNIT I | INTRODUCTION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Electric grid, Utility ideal features, Supply guarantee, power quality, Stability and cost; Importance & Effects of Renewable Energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns.

| UNIT II | DYNAMIC ENERGY CONVERSION TECHNOLOGIES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction, types of conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies

| UNIT III | STATIC ENERGY CONVERSION TECHNOLOGIES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction, types of conventional and nonconventional static generation technologies; Principle of operation and analysis of fuel cell, photovoltaic systems and wind generation technologies; MPPT techniques and its classifications, principle of operation and partial shading effects; Storage Technologies - batteries, fly wheels, super capacitors and ultra-capacitors.

| UNIT IV | CONTROL ISSUES AND CHALLENGES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Linear and nonlinear controllers, predictive controllers and adaptive controllers, Load frequency and Voltage Control, PLL, Modulation Techniques, Control of Diesel, PV, wind and fuel cell based generators, Dimensioning of filters, Fault-ride through Capabilities.

| UNIT V | INTEGRATION OF ENERGY CONVERSION TECHNOLOGIES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction & importance, sizing, Optimized integrated systems, Interfacing requirements, Distributed versus Centralized Control, Grid connected Photovoltaic systems –classifications, operation, merits & demerits; Islanding Operations, stability and protection issues, load sharing, operation & control of hybrid energy systems, Solar Photovoltaic applications. IEEE & IEC Codes and standards for renewable energy grid integrations

**Total (45L+0T) = 45 Periods**

**Text Books:**


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


**Reference Books:**


1. Solar Photovoltaic: Fundamentals, technologies & Applications, Chetan Singh Solanki, PHI Publishers, 2019, 3rd Edition.
2. Solar PV Power: Design, Manufacturing and Applications from Sand to Systems, Rabindra Kumar Satpathy, Venkateswarlu Parmuru, Academic Press, 2020.
3. Control of Power Inverters in Renewable Energy and Smart Grid Integration, Quing-Chang Zhong, IEEE-John Wiley and Sons Ltd. Publishers, 2013,1st Edition.
4. Power Conversion and Control of Wind Energy Systems, Bin Wu, Yongqiang Lang, NavidZargari, IEEE- John Wiley and Sons Ltd. Publishers,2011,1st Edition.
5. Report on “Large Scale Grid Integration of Renewable Energy Sources - Way Forward” Central Electricity

| | |
|---|---|
| | Authority, GoI, 2013. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand different renewable energy sources and storage devices. | L2: Understanding |
| CO2 | : | Model and simulate renewable energy sources. | L5: Evaluating |
| CO3 | : | Apply various MPPT techniques for wind and solar energy generation | L3: Applying |
| CO4 | : | Analyze and simulate control strategies for grid connected and off-grid systems | L4: Analyzing |
| CO5 | : | Develop converters to comply with grid standards to obtain grid integration | L6: Creating |

| 22PTEEE51 | DIGITAL SIGNAL PROCESSING | | SEMESTER VI | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Fourier Series and Transforms | | **PE** | **2** | **1** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | Understand the concepts of continuous time and discrete time systems. |
| 2. | Analyze systems in complex frequency domain. |
| 3. | Understand digital filters. |

| **UNIT I** | **INTRODUCTION TO SIGNALS AND SYSTEMS** | **6** | **3** | **0** | **9** |
|---|---|---|---|---|---|

Signals and systems- Signal properties: periodicity, absolute integrability, deterministic and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, Classification of signals – Continuous time (CT) and Discrete Time (DT) signals, Periodic & Aperiodic signals, Deterministic & Random signals, Energy & Power signals. System properties: linearity, additivity and homogeneity, shift-invariance, causality, stability, realizability, Examples.

| **UNIT II** | **DISCRETE TIME SYSTEM ANALYSIS** | **6** | **3** | **0** | **9** |
|---|---|---|---|---|---|

Z-transform and its properties, inverse z-transforms; difference equation – Solution by z transform, application to discrete systems - Stability analysis, frequency response –Convolution – Discrete TimeFouriertransform , magnitude and phase representation.

| **UNIT III** | **DISCRETE FOURIER TRANSFORM & COMPUTATION** | **6** | **3** | **0** | **9** |
|---|---|---|---|---|---|

Discrete Fourier Transform- properties, magnitude and phase representation - Computation of DFT using FFT algorithm – DIT &DIF using radix 2 FFT – Butterfly structure.

| **UNIT IV** | **DESIGN OF DIGITAL FILTERS** | **6** | **3** | **0** | **9** |
|---|---|---|---|---|---|

FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics. Analog filter design – Butterworth and Chebyshev approximations; IIR Filters, digital design using impulse invariant and bilinear transformation - mWarping, pre warping.

| **UNIT V** | **DIGITAL SIGNAL PROCESSORS** | **6** | **3** | **0** | **9** |
|---|---|---|---|---|---|

Introduction – Architecture – Features – Addressing Formats – Functional modes - Introduction to Commercial DSP Processors.

**Total (30L+15T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | J.G. Proakis and D.G. Manolakis, 'Digital Signal Processing Principles, Algorithms and Applications', Pearson Education, New Delhi, 2007 |
| 2. | S.K. Mitra, 'Digital Signal Processing – A Computer Based Approach', McGraw Hill Edu, 2013. |
| 3. | B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2009. |
| 4. | A. V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing", Prentice Hall,2009. |

**Reference Books:**

| | |
|---|---|
| 1. | Sen M.kuo, woonseng…s.gan, "Digital Signal Processors, Architecture, Implementations & Applications, Pearson,2013. |

**E-Reference**

| | |
|---|---|
| 1. | https://books.google.co.in/books/isbn=8131710009 |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | To be able to determine if a given system is linear/causal/stable | L2:Understanding |
| CO2 | : | Capable of determining the frequency components present in a deterministic signal | L4: Analyzing |
| CO3 | : | Capable of characterizing LTI systems in the time domain and frequency domain | L1:Remembering |
| CO4 | : | To be able to design digital filters | L3:Applying |
| CO5 | : | Capable of understanding the digital signal processors | L2:Understanding |

| 22PTEEE52 | EMBEDDED SYSTEM DESIGN | SEMESTER VI |
|---|---|---|

| PREREQUISITES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Microprocessor & Microcontroller, C programming | PE | 3 | 0 | 0 | 3 |

**Course Objectives:**

| | |
|---|---|
| 1. | To acquaint the students the building blocks of embedded system, selection of various components for building an embedded system. |
| 2. | To understand different communication protocols used in embedded system |
| 3. | To study the different programming techniques used in embedded system software engineering |
| 4. | To understand the concepts of operating systems that are exclusively used in embedded systems. |

| | | | | | |
|---|---|---|---|---|---|
| **Unit I** | **INTRODUCTION TO EMBEDDED SYSTEM** | **9** | **0** | **0** | **9** |

Introduction to functional building blocks of embedded systems – Embedded Hardware Core - Bus Structure - Block Diagram of Embedded System - a Microprocessor-Based System – a Microcontroller-Based System – DSP - Register, memory devices, ports, timer, interrupt controllers.

| | | | | | |
|---|---|---|---|---|---|
| **Unit II** | **PROCESSOR AND MEMORY ORGANIZATION** | **9** | **0** | **0** | **9** |

Structural units in a processor; selection of processor & memory devices; shared memory; DMA; interfacing processor, memory and I/O units; memory management – Cache mapping techniques, dynamic allocation - Fragmentation.

| | | | | | |
|---|---|---|---|---|---|
| **Unit III** | **DEVICES AND BUSES** | **9** | **0** | **0** | **9** |

Timers, Counters, serial communication using I2C, CAN, USB buses- parallel communication using ISA, PCI, PCI/X buses; interfacing with devices/ports, device drivers in a system – Serial port & parallel port.

| | | | | | |
|---|---|---|---|---|---|
| **Unit IV** | **EMBEDDED PROGRAMMING** | **9** | **0** | **0** | **9** |

Structure of Embedded C Program, C Program build process, Type, Storage Class and Scope of Variables, Building a C Program, Bitwise operations, Pointer variables and memory addresses, Functions and structures, Pointers to functions and structures, Interrupt functions in C program

| | | | | | |
|---|---|---|---|---|---|
| **Unit V** | **REAL TIME OPERATING SYSTEM RTOS** | **9** | **0** | **0** | **9** |

Introduction to basic concepts of RTOS, Context switching, pre-emptive & non-pre-emptive multitasking, semaphores - Scheduling – Thread states, pending threads, context switching, round robin scheduling, priority based scheduling, assigning priorities, deadlock, watch dog timers. –Interrupt handling, task scheduling; embedded system design issues in system development process – Action plan, use of target system, emulator, use of software tools

**Total (45L+0T) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Daniel W. Lewis 'Fundamentals of Embedded Software', Prentice Hall of India, 2004. |
| 2. | James K. Peckol - Embedded System - A Contemporary Design Tool, John Wiley, 2nd Edition, 2019 |
| 3. | Steve Heath, 'Embedded System Design', II edition, Elsevier, 2003. |
| 4. | David E. Simon, 'An Embedded Software Primer', Pearson Education, 2004. |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the basic concepts of Embedded Systems. | L2: Understanding |
| CO2 | : | Appreciate the general organization of Embedded Systems | L1: Remembering |
| CO3 | : | Understand various devices required for an Embedded System Design | L2: Understanding |
| CO4 | : | Understand the implementation of Programming techniques for Embedded System | L3: Applying |
| CO5 | : | Know the various blocks of RTOS and its implementation in Design | L5: Evaluating |

| 22PTEEE53 | ARTIFICIAL INTELLIGENCE AND COMPUTER VISION | SEMESTER VI | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Soft computing | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1 | To understand the various characteristics of Intelligent agents |
| 2 | To learn the different search strategies in AI |
| 3 | To learn to represent knowledge in solving AI problems |
| 4 | To understand the different ways of designing software agents |
| 5 | To know about the various applications of AI |
| 6 | To provide introduction to computer vision |

| | | | | | |
|---|---|---|---|---|---|
| **Unit I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |

Introduction-Definition – Future of Artificial Intelligence – Characteristics of Intelligent Agents – Typical Intelligent Agents – Problem Solving Approach to Typical AI problems.

| | | | | | |
|---|---|---|---|---|---|
| **Unit II** | **PROBLEM SOLVING METHODS** | **9** | **0** | **0** | **9** |

Problem solving Methods – Search Strategies – Uninformed – Informed – Heuristics – Local Search Algorithms and Optimization Problems – Searching with Partial Observations – Constraint Satisfaction Problems – Constraint Propagation – Backtracking Search – Game Playing – Optimal Decisions in Games – Alpha – Beta Pruning – Stochastic Games

| | | | | | |
|---|---|---|---|---|---|
| **Unit III** | **KNOWLEDGE REPRESENTATION** | **9** | **0** | **0** | **9** |

First Order Predicate Logic – Prolog Programming – Unification – Forward Chaining – Backward Chaining – Resolution – Knowledge Representation – Ontological Engineering – Categories and Objects – Events – Mental Events and Mental Objects – Reasoning Systems for Categories – Reasoning with Default Information

| | | | | | |
|---|---|---|---|---|---|
| **Unit IV** | **SOFTWARE AGENTS AND AI APPLICATIONS** | **9** | **0** | **0** | **9** |

Architecture for Intelligent Agents – Agent communication – Negotiation and Bargaining – Argumentation among Agents – Trust and Reputation in Multi-agent systems.

AI applications: Language Models – Information Retrieval – Information Extraction – Natural Language Processing – Machine Translation – Speech Recognition – Robot – Hardware –Perception – Planning – Moving.

| | | | | | |
|---|---|---|---|---|---|
| **Unit V** | **COMPUTER VISION** | **9** | **0** | **0** | **9** |

**Digital Image Processing:** Image formation –image filtering- Edge detection- principal component analysis-corner detection – SIFT –Large scale image search application

**Geometric techniques in computer vision:** Image transformations – Camera projections- camera calibration – Depth from stereo – two view structure from motion- object tracking

**Machine learning for computer vision:** introduction to machine learning-Image classification – object detection – semantic segmentation

**Total (45L+0T)=45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | S. Russel and P. Norvig, "Artificial Intelligence: A Modern Approach", Prentice Hall, Third Edition, 2009. |
| 2. | I. Bratko, "Prolog: Programming for Artificial Intelligence" , Fourth Edition, Addison-Wesley Education Publishers Inc., 2011. |
| 3 | David A. Forsyth and Jean Ponce, "Computer Vision: A Modern Approach", Pearson Publications, Second Edition, 2012. |
| 4 | Richard Hartley and Andrew Zisserman, "Multiple View Geometry in Computer Vision", Cambridge University Press , Second Vision, 2004. |

| **Reference Books:** | |
|---|---|
| 1 | M. Tim Jones," Artificial Intelligence: A systems Approach (Computer science)", Jones and Bartlett Publishers Inc., First Edition, 2008. |
| 2 | Nils J.Nilsson," The Quest for Artificial Intelligence", Cambridge University Press, 2009. |
| 3 | William F. Clocksin and Christopher S. Mellish, "Programming in Prolog: Using ISO standard", Fifth Edition, Springer , 2003. |
| 4 | Gerhard Weiss, " Multi Agent systems", Second Edition, MIT Press, 2013. |
| 5 | David L. Poole and Alan K.Mackworth, "Artificial Intelligence: Foundations of Computational Agents", Cambridge University Press 2010. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Choose appropriate search algorithms for any AI problem | L5: Evaluating |
| CO2 | : | Represent a problem using first order and predicate logic | L2: Understanding |
| CO3 | : | Provide the apt agent strategy to solve a given problem | L4: Analyzing |
| CO4 | : | Design software agents to solve a problem and applications for NLP that use Artificial Intelligence. | L6: Creating |
| CO5 | : | Use AI techniques in computer vision | L3: Applying |

| 22PTEEE54 | SOFT COMPUTING | | | | SEMESTER VI | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Mathematics, 'C' Programming | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To provide Basics of artificial neural network. |
| 2. | To provide adequate knowledge of genetic algorithms and its application to economic dispatch and unit commitment problems |
| 3. | To expose the students to the features of hybrid control systems |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **ARTIFICIAL NEURAL NETWORK** | **9** | **0** | **0** | **9** |

Review of fundamentals – Biological neuron, artificial neuron, activation function, single layer perceptron – Limitation – Multi layer perceptron – Back Propagation Algorithm (BPA) – Recurrent Neural Network (RNN) – Adaptive Resonance Theory (ART) based network – Radial basis function network – online learning algorithms, BP through time – RTRL algorithms – Reinforcement learning.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **NEURAL NETWORKS FOR MODELLING AND CONTROL** | **9** | **0** | **0** | **9** |

Modelling of non-linear systems using ANN – Generation of training data – Optimal architecture– Model validation – Control of non-linear systems using ANN – Direct and indirect neuro control schemes – Adaptive neuro controller – Familiarization with neural network toolbox.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **FUZZY SET THEORY** | **9** | **0** | **0** | **9** |

Fuzzy set theory – Fuzzy sets – Operation on fuzzy sets – Scalar cardinality, fuzzy cardinality, union and intersection, complement (Yager and Sugeno), equilibrium points, aggregation, projection, composition, cylindrical extension, fuzzy relation – Fuzzy membership functions.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **FUZZY LOGIC FOR MODELLING AND CONTROL** | **9** | **0** | **0** | **9** |

Modelling of non-linear systems using fuzzy models – TSK model – Fuzzy logic controller – Fuzzification – Knowledge base – Decision making logic – Defuzzification – Adaptive fuzzy systems – Familiarization with fuzzy logic toolbox.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **HYBRID CONTROL SCHEMES** | **9** | **0** | **0** | **9** |

Fuzzification and rule base using ANN – Neuro fuzzy systems – ANFIS – Fuzzy neuron– GA – Optimization of membership function and rule base using Genetic Algorithm – Introduction to other evolutionary optimization techniques, support vector machine– Case study – Familiarization with ANFIS toolbox.

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | LauranceFausett, Englewood cliffs, N.J., 'Fundamentals of Neural Networks',Pearson Education, 1992 |
| 2. | S.N.Sivanandam and S.N.Deepa,' Principles of Soft computing, Wiley India Edition, 2nd Edition, 2013 |
| 3. | Timothy J. Ross, 'Fuzzy Logic with Engineering Applications', Tata McGraw Hill, 1997. |


**Reference Books:**


| | |
|---|---|
| 1. | Simon Haykin, 'Neural Networks', Pearson Education, 2003. |
| 2. | Hagan, Demuth, Beale, " Neural Network Design", Cengage Learning, 2012. |
| 3. | N.P.Padhy, " Artificial Intelligence and Intelligent Systems", Oxford, 2013. |
| 4. | Millon W.T., Sutton R.S. and Webrose P.J., "Neural Networks for Control", MIT press, 1992 |
| 5. | Goldberg, "Genetic Algorithm in Search, Optimization and Machine learning", Addison Wesley Publishing Company Inc. 1989 |


**E-Reference**

| | |
|---|---|
| 1 | www.onlinecourses.nptel.ac.in |
| 2 | www.class-central.com |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Ability to understand and apply basic Artificial neural network. | L2 Understanding |
| CO2 | : | To understand and apply modelling and control of neural network. | L3 Applying |
| CO3 | : | To remember modelling and control of fuzzy control systems. | L1 Remembering |
| CO4 | : | Evaluate hybrid control schemes. | L5 Evaluating |
| CO5 | : | Design a fuzzy controller. | L6 Creating |

| 22PTEEE55 | INTERNET OF THINGS FOR ELECTRICAL SYSTEM | SEMESTER VI | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Microprocessors and microcontrollers | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To illustrate the concept of Internet of Things (IoT). |
| 2. | To familiarize with implementations of IoT for electrical engineering applications. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |

Internet of Things - Definition- IoT conceptual framework-IoT architecture and Features, Major Components of IoT System, IoT software components for device hardware, Development Tools for IoT

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **IOT DEVICES** | **9** | **0** | **0** | **9** |

Sensors: Sensing the Real World, Analog Sensors and Digital Sensors, Sensors for Temperature, Humidity, Distance, Light, Acceleration, Vibrations and Shocks, Orientation and Direction Compass, Magnetic Sensors/Magnetometer, Sound, Sensing the Things: Reading Barcodes, QR Code, Motion Sensors for Moving Objects, Environmental Monitoring Sensor, GPS, Actuator: Piezoelectric vibrators and sounders, Speakers, Solenoids, Servomotor, Relay switch

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **IOT COMMUNICATION SYSTEM** | **9** | **0** | **0** | **9** |

M2M Communication for IoT, M2M Architecture, M2M Software and Development Tools, Modified OSI Model for the IoT/M2M Systems, Near-Field Communication, RFID, Bluetooth BR/EDR and Bluetooth Low Energy, ZigBee, Wi-Fi, GPRS/GSM Cellular Networks-Mobile Internet, Differences between NFC, BT LE, ZigBee and WLAN protocols

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **IOT DATA PROCESSING AND ANALYSIS** | **9** | **0** | **0** | **9** |

Data Acquiring and Storage: Data Generation, Data Acquisition, Data Validation, Data Categorization, Data Store, Data Centre Management, Server Management, Database Management System, Query Processing, SQL, NOSQL, Online Transactions and Processing, Business Intelligence, Complex Applications Integration, Online analytical processing, Analytics using Big Data in IoT/M2M, Knowledge-Management Reference Architecture

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **IOT APPLICATIONS** | **9** | **0** | **0** | **9** |

Industrial IoT, Automotive IoT: Connected Cars Technology, Vehicle-to-Infrastructure Technology, Predictive and Preventive Maintenances, RFID IoT Systems: RFID IoT Network Architecture and Components of an RFID System, Wireless Sensor Network IoT Applications

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Pethuru Raj & Anupama C Mohan, The Internet of Things – Enabling Technologies, Platforms, and Use Cases, CRC Press, 2017. |

**Reference Books:**

| | |
|---|---|
| 1. | Raj Kamal, Internet of Things Architecture and Design Principles, McGraw Hill Education (India) Private Limited, 2017 |

**E-Reference**

| | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/106/105/106105166/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Recall the structure and components of IOT system. | L1: Remembering |
| CO2 | : | Select an appropriate device to interface IOT system with physical world | L4: Analyzing |
| CO3 | : | Apply suitable communication technologies for IOT system | L3: Applying |
| CO4 | : | Classify the data processing schemes for IoT application | L4: Analyzing |
| CO5 | : | Use IOT platform for real time engineering solutions | L3: Applying |

| 22PTEEE56 | COMPUTER ARCHITECTURE | SEMESTER VI | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Fundamentals of computers | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

1. To learn the fundamental concepts of computer architecture.
2. To learn the working of different arithmetic operations.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |

Functional units, Basic Operational Concepts, Bus Structure, Memory Locations and Addresses, Memory Operations, Instruction and Instruction Sequencing, Addressing modes.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **ARITHMETIC UNIT** | **9** | **0** | **0** | **9** |

Addition and Subtraction of Signed Numbers, Design of Fast Adders, Multiplication of Positive Numbers, Booth Algorithm, Fast Multiplication, Integer Division, Floating point number operations.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **PROCESSOR UNIT AND PIPELINING** | **9** | **0** | **0** | **9** |

Fundamental Concepts, Execution of Instruction, Multi Bus Organization, Hardwired control, Micro programmed control, Basic Concepts of pipelining, Data Hazards, Instruction Hazards, Data path & Control Considerations.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **MEMORY SYSTEMS** | **9** | **0** | **0** | **9** |

Basic Concepts, Semiconductor RAM, ROM, Cache memory, Improving Cache Performance, Virtual memory, Memory Management requirements, Secondary Storage Device.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **INPUT AND OUTPUT ORGANIZATION** | **9** | **0** | **0** | **9** |

Accessing I/O devices, Programmed I/O, Interrupts, Direct Memory Access, Interface circuits, Standard I/O Interfaces (PCI, SCSI, USB).

**Total (45L+0T)= 45 Periods**

**Text Books:**

1. Carl Hamacher V.,Zvonko G.Vranesic, Safwat G. Zaky, " Computer organization ", Tata McGraw Hill, 5th Edition, 2008.
2. Hayes, "Computer Architecture and Organization ", 3rd edition,Tata McGraw Hill, 2006

**Reference Books:**

1. Patterson and Hennessey, "Computer Organization and Design ". The Hardware/Software interface, Harcourt Asia Morgan Kaufmann, 3rd Edition, 2007
2. Heuring V.P., Jordan H.F., " Computer System Design and Architecture ", 6th edition ,Addison Wesley, 2008

**E-References:**

1. www.onlinecourses.nptel.ac.in
2. www.class-central.com
3. www.mooc-list.com

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Explain the working principle and implementation of computer hardware components and its various functional units | L2: Understanding |
| CO2 | : | Apply the operations of arithmetic unit to perform specific task | L3: Applying |
| CO3 | : | Analyze the different types of control and the concept of pipelining | L4: Analyzing |
| CO4 | : | Illustrate various memory components including Cache memory and Virtual memory | L4: Analyzing |
| CO5 | : | Explain the different ways of communication with I/O devices and standard I/O interfaces | L2: Understanding |

| 22PTEEE57 | ROBOTICS AND AUTOMATION | | SEMESTER VI | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Signals and Systems | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| | To understand the basic concepts associated with the design, functioning, applications and social aspects of robots |
| | To study about the electrical drive systems and sensors used in robotics for various applications. |
| | To learn about analyzing robot kinematics, dynamics through different methodologies and study various design aspects of robot arm manipulator and end-effector |
| | To learn about various motion planning techniques and the associated control architecture. |
| | To understand the implications of AI and other trending concepts of robotics. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **BUILDING BLOCKS OF A ROBOT** | **9** | **0** | **0** | **9** |

Robot kinematics - Geometric approach for 2R, 3R manipulators, homogenous transformation using D-H representation, kinematics of WMR, Lagrangian formulation for 2R robot dynamics.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **KINEMATICS AND DYNAMICS** | **9** | **0** | **0** | **9** |

Robot kinematics - Geometric approach for 2R, 3R manipulators, homogenous transformation using D-H representation, kinematics of WMR, Lagrangian formulation for 2R robot dynamics.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **DESIGN OF ROBOTS & END-EFFECTORS** | **9** | **0** | **0** | **9** |

. Mechanical design aspects of a 2R manipulator, WMR; End-effector - common types – selection of the right end effector, End effector control, Maintenance, Uses and Benefits.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **NAVIGATION, PATH PLANNING AND CONTROL ARCHITECTURE** | **9** | **0** | **0** | **9** |

Mapping & Navigation – SLAM, Path planning for serial manipulators; types of control architectures - Cartesian control, Force control and hybrid position/force control, Behaviour based control, application of Neural network, fuzzy logic, optimization algorithms for navigation problems, programming methodologies of a robot.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **RECENTSEARCH TRENDS IN ROBOTICS** | **9** | **0** | **0** | **9** |

Application of Machine learning - AI, Expert systems; Tele-robotics and Virtual Reality, Micro &Nanorobots, Unmanned vehicles, Cognitive robotics, Evolutionary robotics, Humanoids.

**Total (45L+0) = 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Saeed. B. Niku, Introduction to Robotics, Analysis, system, Applications, Pearson educations, 2002. |
| 2. | Roland Siegwart, Illah Reza Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press, 2011. |

**Reference Books:**

| | |
|---|---|
| 1. | Richard David Klafter, Thomas A. Chmielewski, Michael Negin, Robotic engineering: an integrated approach, Prentice Hall, 1989 |
| 2. | Craig, J. J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, 1989. |
| 3. | K.S. Fu, R.C. Gonzalez and C.S.G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill, 1987. |
| 4. | Wesley E Snyder R, Industrial Robots, Computer Interfacing and Control, Prentice Hall International Edition, 1988 |
| 5. | Robin Murphy, Introduction to AI Robotics, MIT Press, 2000. |

**Course Outcomes:**

| Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the basic building blocks of Robot | L2:Understanding |
| CO2 | : | Understand the Design concepts in robotics | L2:Understanding |

| | | | |
|---|---|---|---|
| CO3 | : | Analyze the AI trends in robotics | L4:Analysing |
| CO4 | : | Apply the algorithms in control architecture. | L3:Applying |
| CO5 | : | Analyze the mathematical solutions for the robot dynamics. | L4:Analysing |

| 22PTEEE61 | UTILIZATION OF ELECTRICAL ENERGY | SEMESTER VII | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power System and Electrical Machines | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the generation of electrical power by conventional and non-conventional methods. |
| 2. | To impart knowledge on principle and design of illumination systems. |
| 3. | To analyze the performance and different methods of electric heating and electric welding. |
| 4. | To impart knowledge on electric traction systems and their performance. |
| 5. | To understand electric drives for various industrial applications. |

| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Generation of electrical power by conventional & non-conventional methods – a brief review of tidal power, wind power, geothermal power, solar energy, hydro station, steam and nuclear power plants. Economics of generation – definitions – load duration curve – number and size of generator units – Cost of electrical energy – tariff – need for electrical energy conservation –methods.

| **UNIT II** | **ILLUMINATION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction-nature of radiation – definition – laws of illumination – luminous efficacy-photometry – lighting calculations – design of illumination systems for residential, commercial, street lighting and sports ground– types of lamps –incandescent lamp- mercury vapour –fluorescent lamp-energy efficiency lamps – types of lighting schemes – requirements of good lighting

| **UNIT III** | **HEATING AND WELDING** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction- classification of methods of heating – requirements of a good heating material – design of heating element – temperature control of resistance furnace – electric arc furnace –induction heating – dielectric heating – electric welding – resistance welding – electric arc welding-electrical properties of arc-applications of electric arc welding.

| **UNIT IV** | **ELECTRIC TRACTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction – requirements of an ideal traction system – supply systems – train movement -mechanism of train movement – traction motors and control –speed control of three phase induction motor- multiple unit control – braking – recent trends in electric traction.

| **UNIT V** | **DRIVES AND THEIR INDUSTRIAL APPLICATIONS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Electric drive –advantages of electric drive-individual drive and group drive –factors affecting selection of motor – types of loads – steady state –transient characteristics –size of motor– load equalization – industrial applications – modern methods of speed control of D.C drives-dynamic braking using thyristors-regenerative braking using thyristors.

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | C.L. Wadhwa, “Generation, Distribution and Utilization of Electrical Energy”, New Age International Pvt.Ltd, 2003. |
| 2. | Eric Openshaw Taylor, “Utilisation of Electric Energy”, English Universities Press Limited, 1937 |
| 3. | J.B. Gupta, “Utilization of Electric Power and Electric Traction”, S.K.Kataria and Sons, 2002. |


**Reference Books:**


| | |
|---|---|
| 1. | G.C.Garg, S.K.Gridhar&S.M.Dhir, “A Course in Utilization of Electrical Energy”, Khanna Publishers, Delhi, 2003. |
| 2. | H. Partab, “Art and Science of Utilization of Electrical Energy”, Dhanpat Rai and Co, New Delhi, 2004. |


**E-References:**

| | |
|---|---|
| 1. | www.onlinecourses.nptel.ac.in |
| 2. | www.class-central.com |
| 3. | www.mooc-list.com |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Memorize the concept of conventional and non-conventional methods of power generation and economic aspects. | L1: Remembering |
| CO2 | : | Interpret the concept behind illumination and design a suitable illumination system for a specific application. | L3: Applying |
| CO3 | : | Design and choose an appropriate heating method for specific application and gain knowledge about electric welding system. | L4: Analyzing |
| CO4 | : | Explain the concepts and recent trends of traction system. | L4: Analyzing |
| CO5 | : | Discuss the concepts of electric drives and their characteristics. | L2: Understanding |

| 22PTEEE62 | ELECTRICAL ENERGY CONSERVATION AND AUDITING | SEMESTER VII | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To get knowledge about basics of energy and energy scenario of India. |
| 2. | To familiarise the energy conservation methods. |
| 3. | To acquire knowledge on energy auditing, energy efficiency and modern energy efficient devices. |

| **UNIT I** | **ENERGY SCENARIO** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Commercial and non-commercial energy -Primary energy resources - Commercial energy production - Final energy consumption - Energy needs of growing economy - Long term energy scenario - Energy pricing - Energy sector reforms - Energy and environment - Energy security - Energy conservation and its importance - Restructuring of the energy supply sector - Energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

| **UNIT II** | **BASICS OF ENERGY** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Electricity tariff - Load management and maximum demand control - Thermal Basics-fuels - Thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

| **UNIT III** | **ENERGY MANAGEMENT AND AUDIT** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Definition - Energy audit – Need and types of energy audit. Energy management (audit) approach understanding energy costs - Bench marking - Energy performance - Matching energy use to requirement - Maximizing system efficiencies - Optimizing the input energy requirements, fuel and energy substitution - Energy audit instruments. Material and energy balance: Facility as an energy system - Methods for preparing process flow, material and energy balance diagrams.

| **UNIT IV** | **ENERGY EFFICIENCY** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Electrical system: Electricity billing - Electrical load management and maximum demand control -Power factor improvement and its benefit - Selection and location of capacitors - Performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types - Losses in induction motors - Motor efficiency - Factors affecting motor performance - Rewinding and motor replacement issues - Energy saving opportunities with energy efficient motors.

| **UNIT V** | **ENERGY EFFICIENT TECHNOLOGIES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Maximum demand controllers - Automatic power factor controllers - Energy efficient motors –Soft starters with energy saver - Variable speed drives - Energy efficient transformers - Electronic ballast - Occupancy sensors - Energy efficient lighting controls - Energy saving potential of each technology.

**Total (45 L+ 0 T) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Sonal Desai, “Handbook of Energy Audit”, McGraw Hill, 2015. |
| 2, | Tripathy, S. C, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991. |
| 3. | Hossam A Gabbar, “Energy Conservation in Infrastructure Systems”, Wiley-IEEE Press, New Jersey, 2018 |


**Reference Books:**


| | |
|---|---|
| 1. | General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, New Delhi, 2015. |
| 2, | Energy Efficiency in Electrical Utilities, Bureau of Energy Efficiency, New Delhi, 2015. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | **Bloom's Taxonomy Mapped** |
|---|---|---|
| CO1 | Identify the present energy scenario and future energy strategy. | L1: Understanding |
| CO2 | Recognize the various forms of energy. | L1: Understanding |
| CO3 | Interpret energy management methods and energy auditing. | L3: Applying |
| CO4 | Familiar in energy efficiency of electrical systems. | L4: Analysing |
| CO5 | Familiar with the advanced energy efficient technologies. | L4: Analysing |

| 22PTEEE63 | ELECTRICAL WIRING, ESTIMATION AND COSTING | | SEMESTER VII | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Basic Electrical Engineering | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To describe the fundamental electrical tools required for electrical wiring and estimate the costing of electrical wiring for residential, industrial, overhead, underground and substations. |

| **UNIT I** | **ELECTRICAL WIRING & GENERAL PRINCIPLES OF ESTIMATION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Guidelines for electrical wiring – Schematic diagram of electrical wiring system, sizes of wires, stranded wires, types of wires, wire splicing and termination, difference between neutral and earth wire, General idea about I.E rule - Indian Electricity Act.

General principles of estimation - Electrical Schedule of rates, catalogues, Survey and source selection, Recording of estimates Quantity and cost of material required. Purchase system, Purchase enquiry and selection of appropriate purchase mode, Comparative statement, Purchase orders, Payment of bills

| **UNIT II** | **RESIDENTIAL INSTALLATION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Guidelines for electrical wiring installations of residential and positioning of equipment, Circuit design in lightning and power circuits , Method of drawing single line diagram, Selection of type of wiring and rating , Load calculations, Selection of rating of main switch, distribution board, cable selection, earthing, selection of switchgear, Sequence to be followed for preparing estimate, Preparation of detailed estimates and costing for residential instatllations.

| **UNIT III** | **COMMERCIAL INSTALLATION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

. Fundamental considerations for planning of electrical wiring installation for commercial buildings, Design considerations , Load calculations and selection of size of service connection, Deciding the size of cables, busbar and busbar chambers, Selection of rating of main switch, distribution board, Earthing, cable selection, ,Selection of rating of main switch, distribution board, cable selection, earthing, selection of switchgear, Sequence to be followed for preparing estimate, Preparation of detailed estimates and costing for commercial instatllations.

| **UNIT IV** | **OVERHEAD AND UNDERGROUND DISTRIBUTIONSYSTEM** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Overhead distribution system and underground distribution system : materials and accessories required for the overhead distribution system, estimate for 440V/3-phase/ 4 wires or 3 wires overhead distribution system, types of service connections, method of installation of service connection(1-phase and 3-phase), I.E. rules pertaining to overhead lines and service connection.

| **UNIT V** | **SUBSTATION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Classification of substation, selection and location of site for substation, main electrical connections, graphical symbols for various types of apparatus and circuit elements on substation, main connection diagram, key diagram of typical sub stations, equipment for substation and switchgear installations, substation auxiliaries supply, substation earthing.

**Total (45L+0T) = 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Raina K. B. and Bhattacharya S.K. " Electrical Design, estimating & Costing", New Age International (p) Limited, New Delhi,2007. |
| 2. | Gupta J.B. , "Electrical Installation Estimating & Costing", S. K. Kataria& Sons, New Delhi,2015. |
| 3. | Uppal S.L. "Electrical Estimating & Costing", New Age International (p) Limited, New Delhi ,2008 |

**Reference Books:**

| | |
|---|---|
| 1. | SurjithSingh,"Electrical Estimating and Costing", Danpat Rai &Co. |
| 2. | CEA Regulations 2010 |
| 3. | I.E rules for wiring and supply act manuals. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Recall the guidelines for electrical wiring installations. | L1: Remebering |

| | | | |
|---|---|---|---|
| CO2 | : | Apply appropriate select criteria and sizing of the electrical wiring for different systems. | L3: Applying |
| CO3 | : | Analyse the load calculations and provide appropriate earthing provision.. | L4: Analysing |
| CO4 | : | Prepare a detailed estimate and costing. | Synthesis |
| CO5 | : | Differentiate the various electrical installation. | L2: Understanding |

| 22PTEEE64 | RENEWABLE ENERGY SOURCES | | SEMESTER VII | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Basic Electrical and Electronics Engineering | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

To impart knowledge on the different renewable energy sources and technologies.

| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

World Energy Use – Reserves of Energy Resources – Environmental Aspects of Energy Utilisation – Renewable Energy Scenario in Tamil Nadu, India and around the World – Potentials – Achievements / Applications – Economics of Renewable Energy Systems.

| **UNIT II** | **SOLAR ENERGY** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Solar Radiation – Measurements of Solar Radiation – Flat Plate and Concentrating Collectors – Solar Direct Thermal Applications – Solar Thermal Power Generation – Fundamentals of Solar Photo Voltaic Conversion – Solar Cells – Solar PV Power Generation – Solar PV Applications.

| **UNIT III** | **WIND ENERGY** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Wind Data and Energy Estimation – Types of Wind Energy Systems – Performance – Site Selection – Details of Wind Turbine Generator – Safety and Environmental Aspects.

| **UNIT IV** | **BIO – ENERGY** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Biomass Direct Combustion – Biomass Gasifiers – Biogas Plants – Digesters – Ethanol Production – Bio Diesel – Cogeneration – Biomass Applications.

| **UNIT V** | **OTHER RENEWABLE ENERGY SOURCES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Tidal Energy – Wave Energy – Open and Closed Ocean Thermal Energy Conversion(OTEC) Cycles – Small Hydro-Geothermal Energy – Hydrogen and Storage – Fuel Cell Systems – Hybrid Systems.

**Total (45L) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Rai. G.D., "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2011. |
| 2. | Twidell, J.W. & Weir, A., "Renewable Energy Sources", EFN Spon Ltd., UK, 2006. |
| 3. | Godfrey Boyle, "Renewable Energy, Power for A Sustainable Future", Oxford University Press, U.K., 1996. |


**Reference Books:**


| | |
|---|---|
| 1. | Chetan Singh Solanki, Solar Photovoltaics, "Fundamentals, Technologies and Applications", PHI Learning Private Limited, New Delhi, 2009. |
| 2. | Tiwari. G.N., Solar Energy – "Fundamentals Design, Modelling & Applications", Narosa Publishing House, New Delhi, 2002. |
| 3. | Freris. L.L., "Wind Energy Conversion Systems", Prentice Hall, UK, 1990. |
| 4. | Johnson Gary, L. "Wind Energy Systems", Prentice Hall, New York, 1985 |
| 5. | David M. Mousdale – "Introduction to Biofuels", CRC Press, Taylor & Francis Group, USA 2010 |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Recall the available renewable Energy Sources | L1:Remembering |
| CO2 | : | Compare the types of generators. | L2:Understanding |
| CO3 | : | Apply different types of mechanism for energy conversion. | L3:Applying |
| CO4 | : | Analyze the benefits and challenges in harnessing renewable Energy. | L4:Analysing |
| CO5 | : | Recognize and apply appropriate renewable energy sources. | L2:Understanding |

| 22PTEEE65 | ENERGY MANAGEMENT SYSTEM AND SCADA | | | | | SEMESTER VII |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Generation, Transmission and Distribution System; Power System Analysis and Stability | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the energy management and energy auditing process. |
| 2. | To understand energy rate structures, energy systems maintenance and energy efficiency |
| 3. | To acquire knowledge on SCADA applications to power system. |

| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Need for energy management - energy basics- designing and starting an energy management program – energy accounting - energy monitoring, targeting and reporting. energy audit process. Important concepts in an economic analysis - Economic models-Time value of money- Utility rate structures- cost of electricity-Loss evaluation Load management: Demand control techniques-Utility monitoring and control system- HVAC and energy management-Economic Justification.

| **UNIT II** | **ENERGY BILLS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Electric rate structures: Utility costs-regulatory agencies-customer classes and rate schedules-residential rate schedules-general service rate schedules-large industrial rate schedules-cogeneration and buy-back rates. Rate schedules for natural gas, fuel oil, coal, steam and chilled water, water and waste water. Monthly energy bill analysis.

| **UNIT III** | **ENERGY MANAGEMENT** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Energy systems maintenance: continuous Improvement maintenance program, planning, estimate present energy related maintenance costs - Determine the present condition of the major energy-related systems. Motors and adjustable speed drives – Cogeneration system.

| **UNIT IV** | **SCADA SYSTEM COMPONENTS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Evolution of SCADA, SCADA definitions, SCADA Functional requirements and Components, SCADA Hierarchical concept, SCADA architecture, General features, SCADA Applications, Benefits. Remote Terminal Unit (RTU), Interface units, Human-Machine Interface Units (HMI), Display Monitors/Data Logger Systems, Intelligent Electronic Devices (IED), Communication Network, SCADA Server, SCADA Control systems and Control panels.

| **UNITV** | **SCADA APPLICATIONS IN POWER SYSTEM** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Applications in Generation, Transmission and Distribution sector, Substation SCADA system Functional description, System specification, System selection such as Substation configuration, IEC61850 ring configuration, SAS cubicle concepts, gateway interoperability list, signal naming concept. System Installation, Testing and Commissioning.

**Total (45 L + 0 T) = 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | EastopT.D& Croft D.R, "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, ISBN-0-582-03184, 1990. |
| 2. | Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, "Guide to Energy Management", Seventh Edition, The Fairmont Press, Inc., 2011 |

**Reference Books:**

| | |
|---|---|
| 1. | Albert Thumann, Terry Niehus, William J. Younger, "Handbook of Energy Audits", Ninth Edition, The Fairmont Press, Inc., 2012. |
| 2 | Wayne C. Turner, "Energy Management Handbook", Fourth Edition, The Fairmont Press, Inc., 2001. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | **Bloom's Taxonomy Mapped** |
|---|---|

| | | |
|---|---|---|
| CO1 | Recognize the basics of energy management and energy audit. | L2: Understanding |
| CO2 | Classify energy rate structures. | L2: Understanding |
| CO3 | Illustrate energy systems maintenance and energy efficient systems. | L3: Applying |
| CO4 | Demonstrate SCADA components. | L3: Applying |
| CO5 | Use SCADA to power system applications. | L3: Applying |

| 22PTEEE66 | DIGITAL POWER SYSTEM PROTECTION | SEMESTER VII | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Digital Signal Processing | PE | **3** | **0** | **0** | **3** |

**Course Objectives:**

To understand the basic concepts of numerical relaying principles, the mathematical methods involved and its implementation for equipment protection.

| | | | | | |
|---|---|---|---|---|---|
| **Unit I** | **ELEMENTS OF DIGITAL PROTECTION AND ARCHITECTURE OF NUMERICAL RELAY** | **9** | **0** | **0** | **9** |

Components of Digital Relay – Signal Conditioning Sub systems – Conversion Sub-systems - The DSP Signal Processing Chain – ADC – Types - Quantization error – Sampling – Anti Aliasing Filter – Digital Relay sub-system - Functional Block Diagram of Numerical Relay

| | | | | | |
|---|---|---|---|---|---|
| **Unit II** | **SINUSOIDAL WAVE BASED ALGORITHM, FOURIER AND WALSH BASED TECHNIQUES** | **9** | **0** | **0** | **9** |

Sample and first-derivative method - First and Second-derivative method - Two sample technique - Three sample technique - Full cycle, fractional cycle, Fourier transform and Walsh based algorithms

| | | | | | |
|---|---|---|---|---|---|
| **Unit III** | **LEAST SQUARE AND DIFFERENTIAL EQUATION BASED TECHNIQUES** | **9** | **0** | **0** | **9** |

Integral LSQ fit - Power series LSQ fit - multi-variable series LSQ technique - Differential equation protection - Basic Principles - Simultaneous DE Techniques

| | | | | | |
|---|---|---|---|---|---|
| **Unit IV** | **DIGITAL DIFFERENTIAL PROTECTION OF TRANSFORMERS** | **9** | **0** | **0** | **9** |

Principles of Transformer protection - FIR based algorithms - LSQ curve fitting algorithms - Fourier based algorithms - Flus restrained current differential relay - Basic hardware requirements.

| | | | | | |
|---|---|---|---|---|---|
| **Unit V** | **DIGITAL LINE DIFFERENTIAL PROTECTION** | **9** | **0** | **0** | **9** |

Introduction - Current based differential schemes - Principles - Frequency modulation - Modal current - protection scheme - Composite voltage and current based scheme

**Total (45+0)= 45Periods**

**Text Books:**


| | |
|---|---|
| 1. | Johns and Salman, "Digital Protection for Power Systems", Peter Peregrinus Ltd. UK |
| 2. | SR. Bhide, "Digital Power System Protection", PHI Pvt. Ltd. Delhi 2014 |
| 3. | Power System Protection. Vol.4: Digital Protection and Signalling, Institution of Engineering and Technology, 1994 |
| 4. | Vladimir Gurevich, "Digital Protective Realays - Problems and Solutions", CRC Press, 2011 |


| **Course Outcomes:** | | **Bloom's Taxonomy Mapped** |
|---|---|---|
| CO1 | Understand the basic concepts of digital protection and numerical relay. | L2:Understanding |
| CO2 | Appreciate various mathematical techniques in digital protection | L1:Remembering |
| CO3 | Understand how mathematical techniques are applied for digital protection | L2:Understanding |
| CO4 | Understand the implementation of techniques for Transformer and Line protection | L2:Understanding |
| CO5 | Able to select appropriate hardware required for the digital protection. | L3:Applying |

| 22PTEEE67 | TRACTION ENGINEERING | | SEMESTER VII | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Power Electronics, Electrical Machines | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To learn the fundamentals of electric traction, power substation, distribution system and overhead contact system design, construction and operation |
| 2. | To learn the traction mechanics, power supply systems and role of battery banks and maintenance |
| 3. | To learn the traction motor drives and control |
| 4. | To learn about traction power supply and protection |
| 5. | To learn about railway signalling |

| **UNIT I** | **INTRODUCTION TO ELECTRIC TRACTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.

| **UNIT II** | **TRACTION MECHANICS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Requirements of Ideal Traction Systems, the Indian Scenario of Electric traction, Present day State of art Electric traction as a Viable Transport Strategy, Advantages of Electric Traction over other systems of traction, Ideal choice of traction system, Power supply systems for Electric Traction, DC systems, Single phase ac system and three phase ac systems, Kando systems, Latest Developments in 3phase with special reference to locomotives, EMUs and Metro stock, Role of Battery banks in Traction, types and maintenance.

| **UNIT III** | **TRACTION MOTOR AND DRIVES** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Type of traction motor best suited for traction duties, Available motor characteristics and their suitability for traction duties, speed control methods, Braking methods, special Emphasis and techniques of regenerative braking, Optimization of design and construction features for improved power to weight ratio, Power Factor and Harmonics, Tractive Effort and Drive Ratings, Important Features of Traction Drives, conventional DC and AC Traction drives, Semiconductor/IGBT based Converter Controlled Drives, DC Traction using Chopper Controlled Drives, AC Traction employing Poly-phase motors, Traction control of DC locomotives and EMU's, Traction control system of AC locomotives, Control gear, PWM control of induction motors, Power & amp; Auxiliary circuit equipment (Other than traction motors), Linear Induction motors, introduction to Maglev Technology.

| **UNIT IV** | **POWER SUPPLY AND PROTECTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Traction substation, spacing and location of Traction substations, Major equipment at traction substation, selection and sizing of major equipment like transformer and Switchgear, Types of protection provided for Transformer and overhead lines, surge protection, maximum demand and load sharing between substations, sectionalizing paralleling post and feeder posts, Booster transformers, Return Conductor, 2X25KV AC system, controlling/monitoring, Railway SCADA systems, Train lighting and Air-conditioning.

Design requirement of catenary wire, contact wire, Dropper, Height, span length, Automatic weight tensioning, section insulator, overlap, Different techniques of current collection (overhead and underground systems), neutral section, overhead crossing of power lines, Protection

| **UNIT V** | **RAILWAY SIGNALING** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Block Section Concept, AC/DC Track Circuits, Interlocking Principle, Train speed and signaling, Solid state Interlocking, Automatic Warning Systems, CAB signaling, Signaling level crossing. Permissible limit of EMI and EMC, Permissible capacitively-coupled current, Coupling between circuits, conductive coupling, Electrostatic induction.

**Total (45L+0T) = 45 Periods**

**Reference Books:**


1. E. A. Binney, "Electric Traction Engineering: An Introduction", Cleaver-Hume Press, 1955, 1 Oct 2007

| | |
|---|---|
| 2. | Douglas W. Hinde, M. Hinde, "Electric Traction Systems and Equipment", Elsevier Science & Technology, 1968 |
| 3. | Samuel Sheldon, Erich Hausmann, "Electric Traction and Transmission Engineering", Van Nostrand, 1911 |
| 4. | Frederick William Carter, "Railway Electric Traction", E. Arnold & Company, 1922 |
| 5. | Edward Parris Burch, "Electric traction for railway trains; a book for students, electrical and mechanical engineers, superintendents of motive power and others", New York, McGraw-Hill Book Company |
| 6. | Edward Trevert, "Electric Railway Engineering", Lynn, Mass. : Bubier Pub. Co. |
| 7. | Burch Edward Parris, "Electric Traction for Railway Trains; a Book for Students, Electrical and Mechanical Engineers, Superintendents of Motive Power and Others", Arkose Press, ISBN: 9781345582376, 9781345582376 |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | To understand the basics of traction and supply systems. | L2: Understanding |
| CO2 | : | To understand the traction mechanics and ideal choice of supply systems. | L4: Analyzing |
| CO3 | : | To describe the concepts of traction motors and applying the solid state drive control. | L3: Applying |
| CO4 | : | To design the protection system for the traction power supply system | L5: Evaluating |
| CO5 | : | To understand the concepts of railway signaling | L2: Understanding |

| 22PTEEE71 | ELECTRIC VEHICLES AND CONTROL | | SEMESTER VII | | | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electrical drives and control | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To provide knowledge on electric vehicle architecture and its configurations |
| 2. | To impart knowledge on vehicle control, use of energy storage systems and energy management in Electric Vehicle |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **ELECTRIC VEHICLES** | **9** | **0** | **0** | **9** |

Configurations of Electric Vehicles (EV), Performance of Electric Vehicles, Tractive Effort in Normal Driving and Energy Consumption, Hybrid Electric Vehicles (HEV): Classification, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **PLUG-IN HYBRID ELECTRICVEHICLES (PHEV) AND FUEL CELL ELECTRIC VEHICLES** | **9** | **0** | **0** | **9** |

Functions and Benefits of PHEV, Components of PHEVs, Operating Principles of Plug-in Hybrid Vehicle, Control Strategy of PHEV, Fuel Cell: Operation and Types, Fuel Cell Electric Vehicle: Configuration and Control Strategy

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **ELECTRIC PROPULSION SYSTEMS** | **9** | **0** | **0** | **9** |

Typical electric propulsion system, Classification of electric motor drives for EV and HEV, Multiquadrant Control of Chopper-Fed DC Motor Drives, Vector Control of Induction Motor drives, Permanent Magnetic Brush-Less DC Motor Drives, Switched Reluctance Motor Drives for Electric Vehicles

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **ENERGY STORAGE SYSTEM** | **9** | **0** | **0** | **9** |

Status of Battery Systems for Automotive Applications, Battery Technologies: Nickel–Metal Hydride (Ni–MH) Battery, Lithium–Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors: Features, operation and performance, Ultrahigh-Speed Flywheels, Hybridization of Energy Storages

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **ENERGY MANAGEMENT SYSTEM** | **9** | **0** | **0** | **9** |

Energy Management System(EMS) in Electric Vehicle, Rule-based control strategy: Deterministic rule-based control, Fuzzy logic-based control, and Neural network-based control. Optimization based control strategy: Dynamic Programming, Metaheuristic optimization methods and Model predictive control, Semi-active type Hybrid Energy Storage System-based EMS, Fully-active type Hybrid Energy Storage System-based EMS

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, Taylor & Francis Group, Second Edition ,2011. |
| 2. | Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, AliEmadi,, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles" CRC Press, 2016 |


**Reference Books:**


| | |
|---|---|
| 1. | Ali Emadi, Mehrdad Ehsani, John M.Miller ,"Vehicular Electric Power Systems", Ali Emadi, Mehrdad Ehsani, John M.Miller, Special Indian Edition, Marcel dekker, Inc 2010 |


**E-Reference**

| | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/108/106/108106170/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Recall the fundamentals of electric vehicle and its mechanics | L1: Remembering |
| CO2 | : | Explain the architecture of different forms of hybrid electric vehicles. | L2: Understanding |
| CO3 | : | Illustrate the four-quadrant operation of DC drive, induction motor drive and SRM drive for Electric Vehicles. | L4: Analyzing |
| CO4 | : | Select an appropriate energy storage system for Electric vehicle | L4: Analyzing |
| CO5 | : | Use the suitable energy management control strategy for hybrid electric vehicle | L3: Applying |

| 22PTEEE72 | ELECTRIC VEHICLE ARCHITECTURE | SEMESTER VII | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electric Drives, Energy management, Electric Vehicles | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To provide knowledge about electric vehicle architecture and power train components. |
| 2. | To know the concepts of dynamics of electrical vehicles |
| 3. | To impart knowledge on vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs) |
| 4. | To understand the concept of energy storage systems |
| 5. | To provide knowledge about different energy sources and energy management in HEVs. |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **HYBRID ELECTRIC VEHICLE ARCHITECTURE AND POWER TRAIN COMPONENTS** | **9** | **0** | **0** | **9** |

History of evolution of Electric Vehicles - Comparison of Electric Vehicles with Internal Combustion Engines - Architecture of Electric Vehicles (EV) and Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components and sizing, Gears, Clutches, Transmission and Brakes.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **MECHANICS OF HYBRID ELECTRIC VEHICLES** | **9** | **0** | **0** | **9** |

Fundamentals of vehicle mechanics - tractive force, power and energy requirements for standard drive cycles of HEV's - motor torque and power rating and battery capacity.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **CONTROL OF DC AND AC MOTOR DRIVES** | **9** | **0** | **0** | **9** |

Speed control for constant torque, constant HP operation of all electric motors - DC/DC chopper based four quadrant operation of DC motor drives, inverter based V/f Operation (motoring and braking) of induction motor drives, vector control operation of Induction motor and PMSM, Brushless DC motor drives, Switched reluctance motor (SRM) drives

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **ENERGY STORAGE SYSTEMS** | **9** | **0** | **0** | **9** |

Battery: Principle of operation, types, models, estimation of parameters, battery modeling, SOC of battery, Traction Batteries and their capacity for standard drive cycles, Vehicle to Grid operation of EV's. Alternate sources: Fuel cells, Ultra capacitors, Fly wheels.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **HEV CONTROL STRATEGY AND ENERGY MANAGEMENT** | **9** | **0** | **0** | **9** |

HEV supervisory control - Selection of modes - power spilt mode - parallel mode - engine brake mode - regeneration mode series parallel mode - energy management of HEV's.

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Iqbal Husain, ‘Electric and Hybrid Electric Vehicles’, CRC Press, 2011. |
| 2. | Wei Liu, ‘Hybrid Electric Vehicle System Modeling and Control’, Second Edition, WILEY, 2017. |


**Reference Books:**


| | |
|---|---|
| 1. | James Larminie and John Lowry, ‘Electric Vehicle Technology Explained’, Second Edition, 2012. |
| 2. | Goodarzi, Gordon A., Hayes, John G, Electric power train: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles, Wiley 2018 |
| 3. | De Doncker, Rik, Pulle, Duco W.J., Veltman, Andre, Advanced Electrical Drives, First Edition, CRC Press, Taylor and Francis Group, 2011. |
| 4. | Mehradad Eshani, Yimin Gao, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory and Design, Second Edition, CRC Press, Taylor and Francis Group, 2010. |
| | RiK De Doncker, Advanced Electric Drives – Analysis , Modeling ,Control, Springer publications |

| E-Reference | |
|---|---|
| 1 | https://nptel.ac.in/courses/108/106/108106170/ |
| 2 | https://nptel.ac.in/courses/108/102/108102121/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Learn the electric vehicle architecture and power train components. | L1: Remembering |
| CO2 | : | Acquired the concepts of dynamics of electrical vehicles | L2: Understanding |
| CO3 | : | Apply the vehicle control for standard drive cycles of hybrid electrical vehicles (HEVs). | L3: Applying |
| CO4 | : | Ability to design and select energy storage systems. | L6: Creating |
| CO5 | : | Evaluate different energy sources and energy management in HEVs. | L5: Evaluating |

| 22PTEEE73 | DESIGN OF MOTORS AND POWER CONVERTERS FOR ELECTRIC VEHICLE | SEMESTER VII |
|---|---|---|

| PREREQUISTIES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Power Electronics, Special Electrical Machines | PE | 3 | 0 | 0 | 3 |

**Course Objectives:**

| | |
|---|---|
| 1. | To study the characteristics of motors used Electric Vehicle |
| 2. | To understand the design of dc drives used in Electric Vehicle |
| 3. | To analyse the ac drives used in Electric Vehicle |
| 4. | To understand the role of converters used in Electric Vehicle |

| UNIT I | EV MOTORS CHARACTERISTICS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Requirement of EV motors, Review of Conventional Vehicle: Introduction to Hybrid Electric Vehicles: Types of EVs, Hybrid Electric Drive-train, Tractive effort in normal driving, Comparison of EV motors,
Basics of DC Motor, Torque speed characteristics, DC Motor dynamics, Field Weakening Control, Four quadrant operation

| UNIT II | DESIGN OF DC DRIVES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Single quadrant variable speed chopper fed DC drives, Four quadrant variable speed chopper fed DC Drives, Single phase/ three phase converter, Dual converter fed DC Drive, current loop control, Armature current reversal, Field current control, Different controllers and firing circuits.

| UNIT III | INVERTER FED AC DRIVES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Analysis of different AC motor with single phase and three phase inverters Operations in different modes and configurations., Problems and strategies.

| UNIT IV | PERMANENT MAGNET AC MOTORS AND CONTROL | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

BLDC dynamic modelling, torque equations, BLDC control methods, machine sizing, current, voltage and speed limits, extending constant power speed range, current control methods- Application of hall current sensor in PM AC motors.

| UNIT V | PWM AND INVERTER | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Sinusoidal PWM, Injection of third order harmonics, Space Vector Modulation, Dead time & compensation Encoders, Resolvers, R/D Converters.

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | B.K. Bose, "Power Electronics and Motor Drives", Elsevier 2015. |

**Reference Books:**

| | |
|---|---|
| 1. | H. Buyse and I.J. Robert, "Electrical machines and converters: Modeling and simulation", North Holland, digitized 2007. |
| 2. | R. Krishnan, " Electric Motor Drives Modeling Analysis and Control", Prentice -Hall of India2001. |
| 3. | P.S. Bhimra," Generalized Theory of Electrical Machines", Khanna Publisher. |

**E-Reference**

| | |
|---|---|
| 1 | https://nptel.ac.in/courses/108104140 |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Describe the characteristics of the motors use in EV. | L1: Remembering |
| CO2 | : | Analyze dynamics of DC motor and different controllers used in their control | L4: Analysing |
| CO3 | : | Explain the speed control and PWM techniques used in the control of ac motor | L2: Understanding |
| CO4 | : | Analyze the operation and control of permanent magnet ac motors. | L4: Analyzing |
| CO5 | : | Analyze sensors used for control of 3-phase ac motors. | L4: Analysing |

| 22PTEEE74 | DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM | SEMESTER VII | | | |
|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electric vehicle | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To introduce the fundamentals of charging architectures, converter topologies and control schemes for electric vehicle charging system |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **CHARGING ARCHITECTURES FOR ELECTRIC VEHICLES** | **9** | **0** | **0** | **9** |

Classification of EV charging architectures, Onboard Chargers, Level 1: Dedicated Converter (Slow Charging), Level 2: Integrated Converter (Semi-fast Charging), Off-Board Chargers, Level 3: Dedicated Off-Board DC Chargers (Fast Charging), Common AC Bus Architecture, Common DC Bus Architecture

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **CONVERTER TOPOLOGIES FOR CHARGING STATION** | **9** | **0** | **0** | **9** |

Vienna Rectifier, Multipulse Rectifier with DC Active Power Filter, Non-isolated Multichannel Interleaved Buck Converter, Phase-Shifted ZVS Full-Bridge Converter, Grid-connected cascaded H-bridge converter, Grid-connected Modular Multilevel Converter based integrated charger for split integrated battery pack, Neutral-Point Clamped Converter

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **CONTROL SCHEMES AND CHARGING STANDARDS** | **9** | **0** | **0** | **9** |

Control Schemes for Charging Converters, Single-Phase AC–DC Converter Control, Three-Phase AC–DC Converter Control, voltage-oriented control (VOC) and direct power control (DPC), Electric Vehicle / Plug in Hybrid Electric Vehicle charging Standards

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **BATTERY TECHNOLOGIES FOR TRANSPORTATION APPLICATIONS** | **9** | **0** | **0** | **9** |

Nickel-Cadmium (Ni-Cd) Battery, Nickel-Metal Hydride (Ni-MH), Lithium-Ion (Li-Ion), Flow Batteries, Battery Charging Methods, Battery management system

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **LATEST DEVELOPMENTS IN EV CHARGING** | **9** | **0** | **0** | **9** |

Inductive Charging, Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H), EV charging safety configuration and considerations, Grid-Tied Residential charging Systems, Grid-Tied Public charging Systems, EV cable communication protocols, Charging cable standards

**Total (45L+0T)= 45 Periods**

**Text Books:**

| | |
|---|---|
| 1. | Sulabh Sachan, P. Sanjeevikumar, Sanchari Deb, Smart Charging Solutions for Hybrid and Electric Vehicles, Wiley-Scrivener Publishing LLC, 2022 |

**Reference Books:**

| | |
|---|---|
| 1. | Mary Murphy " Electric and Hybrid Vehicles: Principles, Design and Technology ", Larsen and Keller Education, 2019 |

**E-Reference**

| | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/108/103/108103009/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand the configurations for chargers for electric vehicle | L1: Remembering |
| CO2 | : | Select a converter topology for electric vehicle charging station | L3: Applying |
| CO3 | : | Use an appropriate control scheme for charging converter | L3: Applying |
| CO4 | : | Understand the principle of batteries used for EV charging station | L1: Remembering |
| CO5 | : | Explain the latest developments in Electric vehicle charging technologies | L2: Understanding |

| 22PTEEE75 | TESTING OF ELECTRIC VEHICLES | | SEMESTER VII | | | |
|---|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electrical Machines and Power Electronics | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To know various standardization procedures |
| 2. | To learn the testing procedures for EV & HEV components |
| 3. | To know the functional safety and EMC |
| 4. | To realize the effect of EMC in EVs |
| 5. | To study the effect of EMI in motor drives and in DC-DC converter system |

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **EV STANDARDIZATION** | **9** | **0** | **0** | **9** |

Introduction - Current status of standardization of electric vehicles, electric Vehicles and Standardization - Standardization Bodies Active in the Field – Standardization activities in countries like Japan. The International Electro Technical Commission - Standardization of Vehicle Components.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **TESTING OF ELECTRIC MOTORS AND CONTROLLERS FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES** | **9** | **0** | **0** | **9** |

Test Procedure Using M-G Set, electric motor, controller, application of Test Procedure, Analysis of Test Items for the Type Test - Motor Test and Controller Test (Controller Only). - Test Procedure Using Eddy Current Type Engine Dynamometer, Test Strategy, Test Procedure, Discussion on Test Procedure. Test Procedure Using AC Dynamometer.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **FUNDAMENTALS OF FUNCTIONAL SAFETY AND EMC** | **9** | **0** | **0** | **9** |

Functional safety life cycle - Fault tree analysis - Hazard and risk assessment – software development - Process models - Development assessments - Configuration management - Reliability - Reliability block diagrams and redundancy - Functional safety and EMC - Functional safety and quality - Standards - Functional safety of autonomous vehicles.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **EMC IN ELECTRIC VEHICLES** | **9** | **0** | **0** | **9** |

Introduction - EMC Problems of EVs, EMC Problems of Motor Drive, EMC Problems of DC-DC Converter System, EMC Problems of Wireless Charging System, EMC Problem of Vehicle Controller, EMC Problems of Battery Management System, Vehicle EMC Requirements.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **EMI IN MOTOR DRIVE AND DC-DC CONVERTER SYSTEM** | **9** | **0** | **0** | **9** |

Overview -EMI Mechanism of Motor Drive System, Conducted Emission Test of Motor Drive System, IGBT EMI Source, EMI Coupling Path, EMI Modelling of Motor Drive System. EMI in DC-DC Converter, EMI Source, The Conducted Emission High-Frequency, Equivalent Circuit of DC-DC Converter System, EMI Coupling Path

**Total (45L+0T) = 45 Periods**

**Reference Books:**


| | |
|---|---|
| 1. | Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005, 1st Edition. |
| 2. | Electromagnetic Compatibility of Electric Vehicle, Li Zhai, Springer 2021, 1st Edition. |
| 3. | EMC and Functional Safety of Automotive Electronics, Kai Borgeest, IET 2018, 1st Edition. |
| 4. | EMI/EMC Computational Modeling Handbook, Druce Archam beault, colin branch, Omar M.Ramachi ,Springer 2012, 2nd Edition. |
| 5. | Automotive EMC, Mark Steffika, Springer 2013, 1st Edition. |
| 6. | Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative, Beate Müller, Gereon Meyer, Springer 2015, 1st Edition. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | To describe the status and other details of standardization of EVs | L1: Remembering |
| CO2 | : | To illustrate the testing protocols for EVs and HEV components | L2: Understanding |
| CO3 | : | To analyze the safety cycle and need for functions safety for EV | L4: Analyzing |
| CO4 | : | To analyze the problems related with EMC for EV components. | L4: Analyzing |
| CO5 | : | To evaluate the EMI in motor drive and DC-DC converter system. | L5: Evaluating |

| 22PTEEE76 | INTELLIGENT CONTROL OF ELECTRIC VEHICLES | SEMESTER VII |
|---|---|---|

| PREREQUISITES | CATEGORY | L | T | P | C |
|---|---|---|---|---|---|
| Power Electronics and Electric Vehicle | PE | 3 | 0 | 0 | 3 |

**Course Objectives:**

| | |
|---|---|
| 1. | To design and drive the mathematical model of a BLDC motor and its characteristics |
| 2. | To learn the different control schemes for BLDC motor |
| 3. | To study the basics of fuzzy logic |
| 4. | To study the FPGA & VHDL basics |
| 5. | To implement fuzzy logic control of BLDC motor in real time |

| UNIT I | MATHEMATICAL MODEL AND CHARACTERISTICS ANALYSIS OF THE BLDC MOTOR | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Mathematical Model, Differential Equations, Transfer Functions, State-Space Equations. Characteristics Analysis, Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients

| UNIT II | SPEED CONTROL FOR ELECTRIC DRIVES | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction -PID Control Principle, Anti windup Controller, Intelligent Controller. Vector Control. Control applied to BLDC motor

| UNIT III | FUZZY LOGIC | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Membership functions: features, fuzzification, methods of membership value assignments Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals - fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems, overview of fuzzy expert system-fuzzy decision making

| UNIT IV | FPGA AND VHDL BASICS | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Introduction – FPGA Architecture-Advantages-Review of FPGA family processors- Spartan 3, Spartan 6 and Spartan 7. VHDL Basics- Fundamentals-Instruction set-data type-conditional statements- programs like arithmetic, sorting, PWM generation, Speed detection

| UNIT V | REAL TIME IMPLEMENTATION | 9 | 0 | 0 | 9 |
|---|---|---|---|---|---|

Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of 48 V BLDC motor using FPGA.

**Total (45L+0T) = 45 Periods**

**Reference Books:**


| | |
|---|---|
| 1. | Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, G. Abas Goodarzi, Wiley 1st Edition 2018. |
| 2. | VHDL Primer, A (3rd Edition), Jayaram Bhasker, Prentice Hall, 1st Edition 2015. |
| 3. | Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Third Edition" CRC Press, Taylor & Francis Group, 2021, 1st Edition. |
| 4. | Chang-liang, Permanent Magnet Brushless DC Motor Drives and Controls, Xia Wiley 2012, 1st Edition. |
| 5. | M.N. Cirstea, A. Dinu, J.G. Khor,M. McCormick, Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes publications, 1st Edition, 2002. |
| 6. | Wei Liu, Hybrid Electric Vehicle System Modeling and Control, Wiley 2017, 2nd Edition |
| 7. | Electric and Plug-in Hybrid Vehicle Networks Optimization and Control, Emanuele Crisostomi • Robert Shorten, Sonja Stüdli • Fabian Wirth, CRC Press, 1st Edition. 2018. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | To design the mathematical model of a BLDC motor and to discuss about its characteristics | L2: Understanding |
| CO2 | : | To demonstrate the PID control, anti-windup controller, Intelligent Controller and Vector Control. Control applied to BLDC motor. | L5: Evaluating |
| CO3 | : | To illustrate the basics of fuzzy logic system | L1: Remembering |
| CO4 | : | To describe the basics of VHDL & FPGA applied to control of EVs. | L2: Understanding |
| CO5 | : | To design and implement of fuzzy logic control scheme for BLDC motor using FPGA in real time | L6: Creating |

| 22PTEEE77 | HYBRID ELECTRIC VEHICLES | | | | SEMESTER VII | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electric Drives, Electric Vehicles | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

1. This course introduces the fundamental concepts, principles and analysis of hybrid and electric vehicles.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT I** | **HISTORY OF HYBRID ELECTRIC VEHICLES** | **9** | **0** | **0** | **9** |

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, Capabilities, Automation system computer facilities.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT II** | **HYBRID ELECTRIC VEHICLES - INTRODUCTION** | **9** | **0** | **0** | **9** |

Micro hybrid vehicles, mild hybrid vehicles, full hybrid vehicles, Parallel Hybrid vehicles, series Hybrid Vehicles, Series-Parallel Hybrid vehicles, plug-in hybrid vehicles, power flow diagrams for various operating modes. Plug-in Hybrid Vehicles: Operating principle, architectures: series-parallel-series-parallel, challenges related to grid connection. Range-extended Electric Vehicles: Classification and configurations, Fuel Cell Electric Vehicles, Solar electric Vehicles, Electric Bi-cycles and their propulsion systems, Vehicle-to- grid, vehicle- to-home concepts, Concept of Hybrid Electric Vehicles.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **ELECTRIC PROPULSION UNIT** | **9** | **0** | **0** | **9** |

Electric components used in electric vehicles, Configuration and control of DC Motor drives, Induction Motor drives, Permanent Magnet Motor drives, Switch Reluctance Motor drives, Drive system efficiency.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **ELECTRIC DRIVE-TRAINS** | **9** | **0** | **0** | **9** |

Basic concept of electric traction, introduction to various electric drivetrain topologies, power flow control in electric drive-train topologies, fuel efficiency analysis

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **EV MODELLING AND SIMULATION** | **9** | **0** | **0** | **9** |

Modelling of BEV-Forward looking Model-Driver Perspective, Backward Looking Model-Drive Cycle Perspective, Modelling of Driver, Modelling of Brake Control Unit, Modelling of Vehicle Control Strategy, Modelling of Vehicle Chassis Sizing of Components- Steady State Energy Balance Equation, Powertrain Dimensioning-Peak vs Continuous performance, Type of Drive cycles, Types of Control Strategy, Analysis-Performance, Range, Consumption Prediction

**Total (45L+0T)= 45 Periods**

**Text Books:**


1. Goodarzi, Gordon A., Hayes, John G, Electric power train: energy systems, power electronics & drives for hybrid, electric & fuel cell vehicles, Wiley 2018
2. Wei Liu, Introduction of Hybrid Vehicle system Modelling and Control, Wiley student edition 2013.
3. Mehradad Eshani, Yimin Gao, Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory and Design, Second Edition, CRC Press, Taylor and Francis Group, 2010.
4. James Larminie John Lowry, Electric Vehicle Technology Explained, Second Edition, Wiley, 2012.
5. Ali Emadi, Mehrdad Ehsani, John M. Miller, 'Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles', CRC Press, 2003.
6. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press, 2003, 2ndEdition.


**Reference Books:**


1. RiK De Doncker, Advanced Electric Drives – Analysis , Modeling ,Control, Springer publications
2. De Doncker, Rik, Pulle, Duco W.J., Veltman, Andre, Advanced Electrical Drives, First Edition, CRC

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|---|---|
| | Press, Taylor and Francis Group, 2011. |
| 3. | Ned Mohan, Power Electronics Convertor, Applications, and Design, Third Edition, Wiley, 2002. |
| 4. | Electric and Hybrid Vehicles Design Fundamentals, Iqbal Husain, Second Edition, CRC Press, Taylor and Francis Group, 2011. |
| 5. | Sandeep Dhameja, 'Electric Vehicle Battery Systems', Newnes, 2002. |
| 6. | Chris Mi, M. Abul Masrur, David Wenzhong Gao, 'Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives', Wiley, 2011. |
| **E-Reference** | |
| 1 | https://nptel.ac.in/courses/108/106/108106170/ |
| 2 | https://nptel.ac.in/courses/108/102/108102121/ |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Plan the selection of electrical machines for hybrid and electric vehicles. | L3: Applying |
| CO2 | : | Analyze the drive-train topologies and advanced propulsion techniques | L4: Analyzing |
| CO3 | : | Understand the concepts of electric vehicles, hybrid electric vehicles and their impact on environment | L2: Understanding |
| CO4 | : | Evaluate modelling and simulation of EV | L5: Evaluating |
| CO5 | : | Demonstrate the power system of various vehicular system. | L6: Creating |

| 22PTEEE78 | BATTERY MANAGEMENT SYSTEMS | | | | SEMESTER VII | |
|---|---|---|---|---|---|---|
| **PREREQUISTIES** | | **CATEGORY** | **L** | **T** | **P** | **C** |
| Basics of Electrical Engineering, Electric Circuit theory, Chemistry and Physics | | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

To understand different techniques of digital relaying - their constructions, working principles, applications and limitations along with introduction to Wide Area Measurement System and network protection.

| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction to Battery Management System(BMS), Cells & Batteries, Nominal voltage and capacity, C rate, Energy and power, Cells connected in series, Cells connected in parallel, Electrochemical and lithium-ion cells, Rechargeable cell, Charging and Discharging Process, Overcharge and Undercharge, Modes of Charging

| **UNIT II** | **BATTERY-MANAGEMENT-SYSTEM REQUIREMENTS.** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Introduction and BMS functionality, Battery pack topology, BMS Functionality, Voltage Sensing, Temperature Sensing, Current Sensing, BMS Functionality, High-voltage contactor control, Isolation sensing, Thermal control, Protection, Communication Interface, Range estimation, State-of charge estimation.

| **UNIT III** | **BATTERY STATE OF CHARGE AND STATE OF HEALTH ESTIMATION** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Preliminary definitions. - Battery state of charge estimation (SOC)- voltage-based methods to estimate SOC , Model-based state estimation - Battery State of Health Estimation (SOH) - Lithium-ion aging: Negative electrode, Lithium ion aging: Positive electrode

| **UNIT IV** | **MODELLING AND SIMULATION.** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Equivalent-circuit models (ECMs), Physics-based models (PBMs), Empirical modelling approach, Physics-based modelling approach, Simulating an electric vehicle, Vehicle range calculations, Simulating constant power and voltage, Simulating battery packs.

| **UNIT V** | **DESIGN OF BMS** | **9** | **0** | **0** | **9** |
|---|---|---|---|---|---|

Design of battery BMS: Design principles of battery BMS, Effect of distance, load, and force on battery life and BMS, energy balancing with multi-battery system

**Total (45L) = 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Plett, Gregory L. Battery management systems, Volume I: Battery modeling. Artech House, 2015. |
| 2. | Plett, G., Battery Management Systems: Volume II, Equivalent-Circuit Methods, Artech House, 2015 |
| 3 | Bergveld, H.J., Kruijt, W.S., Notten, P.H.L "Battery Management Systems -Design by Modelling" Philips Research Book Series 2002. |


**Reference Books:**


| | |
|---|---|
| 1. | Davide Andrea," Battery Management Systems for Large Lithium-ion Battery Packs" Artech House, 2010 |
| 2. | Pop, Valer, et al. Battery management systems: Accurate state-of-charge indication for battery-powered applications. Vol. 9. Springer Science & Business Media, 2008. |


| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Recall the role of battery management system | L1: Remembering |
| CO2 | : | Identify the requirements of Battery Management System w.r.t application | L2: Understanding |
| CO3 | : | Analyze the concept associated with battery charging / discharging process | L4: Analysing |
| CO4 | : | Assess the various parameters of battery and battery pack | L3: Applying |
| CO5 | : | Design the battery pack model. | L4: Analysing |

| 22PTEEE79 | ENERGY STORAGE SYSTEMS AND APPLICATIONS | SEMESTER VII | | | |
|---|---|---|---|---|---|
| **PREREQUISITES** | **CATEGORY** | **L** | **T** | **P** | **C** |
| Electrical Engineering | **PE** | **3** | **0** | **0** | **3** |

**Course Objectives:**

| | |
|---|---|
| 1. | To understand the various types of energy storage technologies. |
| 2. | To analyze thermal storage system. |
| 3. | To analyze different battery storage technologies. |
| 4. | To model the Lithium-ion batteries. |
| 5. | To study the various applications of energy storage systems. |

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|---|---|---|---|---|---|
| **UNIT I** | **INTRODUCTION** | **9** | **0** | **0** | **9** |

Necessity of energy storage – Types of energy storage – Comparison of energy storage technologies – Demand functions of energy storage technology in power system, application outlook and challenges of energy storage technology in power system.

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|---|---|---|---|---|---|
| **UNIT II** | **THERMAL STORAGE SYSTEM** | **9** | **0** | **0** | **9** |

Thermal storage – Types – Modeling of thermal storage units – Simple water and rock bed storage system – Pressurized water storage system – Modeling of phase change storage system – Simple units, packed bed storage units – Modeling using porous medium approach – Use of TRNSYS.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT III** | **ELECTRICAL ENERGY STORAGE** | **9** | **0** | **0** | **9** |

Fundamental concept of batteries – Measuring battery performance, charging and discharging, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide, Li-ion batteries – Mathematical modeling of Lead Acid batteries – Flow batteries.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT IV** | **LITHIUM-ION BATTERY MODELING** | **9** | **0** | **0** | **9** |

Analysis on charge and discharge temperature characteristics of Lithium-ion batteries – Electrothermal coupling Modeling - Modeling and Optimization of Air Cooling Heat Dissipation of Lithium-ion Battery Packs.

| | | | | | |
|---|---|---|---|---|---|
| **UNIT V** | **ALTERNATE ENERGY STORAGE TECHNOLOGIES** | **9** | **0** | **0** | **9** |

Flywheel, Supercapacitors, Principles and methods – Applications, Compressed air energy storage, Concept of Hybrid storage – Applications, Pumped hydro storage – Applications.

**Total (45L+0T)= 45 Periods**

**Text Books:**


| | |
|---|---|
| 1. | Ibrahim Dincer and Mark A. Rosen, 'Thermal Energy Storage Systems and Applications', John Wiley & Sons, 3rd Edition, 2021. |
| 2. | Ru-shi Liu, Lei Zhang and Xueliang sun, 'Electrochemical technologies for energy storage and conversion', Wiley publications, 2nd Volume set, 2012. |
| 3. | Junqiu Li, "Modeling and simulation of Lithium-ion power battery thermal management", Springer, 2020. |


**Reference Books:**


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|---|---|
| 1. | Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981, 1st Edition |
| 2. | Schmidt. F.W. and Willmott. A.J., 'Thermal Energy Storage and Regeneration', Hemisphere Publishing Corporation, 1981, 1st Edition |


**E-References:**

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|---|---|
| 1. | Prof. Subhasish Basu Majumder, "Electrochemical Energy Storage", NPTEL Course, https://nptel.ac.in/courses/113105102 |
| 2. | Prof. PK Das, "Energy conservation and waste heat recovery", NPTEL Course, https://nptel.ac.in/courses/112105221. |

| **Course Outcomes:** Upon completion of this course, the students will be able to: | | | **Bloom's Taxonomy Mapped** |
|---|---|---|---|
| CO1 | : | Understand different types of storage technologies. | L2: Understanding |
| CO2 | : | Model a thermal battery energy storage system | L1: Remembering |
| CO3 | : | Analyze the modeling of Lithium-ion batteries. | L4: Analyzing |
| CO4 | : | Analyze the appropriate storage technologies for different applications. | L3: Applying |
| CO5 | : | Explore the alternate energy storage technologies. | L2: Understanding |