*Course Structure & Curriculum*

*for*
*B. Tech. Programme*

*in*
**ELECTRICAL ENGINEERING**

**Effective from**

**Academic Session (2022-2023)**

**Department of Electrical Engineering**
**Motilal Nehru National Institute of Technology Allahabad**
**Prayagraj-211004, Uttar Pradesh**

**Vision of the Institute**

To establish a unique identity for the institute amongst national and international academic and research organizations through knowledge creation, acquisition and dissemination for the benefit of society and humanity.

**Mission of the Institute**

- To generate high quality human and knowledge resources in our core areas of competence and emerging areas to make valuable contribution in technology for social and economic development of the nation. Focused efforts to be undertaken for identification, monitoring and control of objective attributes of quality and for continuous enhancement of academic processes, infrastructure, and ambience.
- To efficaciously enhance and expand, even beyond national boundaries, its contribution to the betterment of technical education and offer international programmes of teaching, consultancy and research.

**Vision of the Department**

To produce globally competitive technical manpower with sound knowledge of theory and practice, with a commitment to serve the society and to foster cutting edge research in Electrical Engineering pertaining to the problems currently faced by the country and the world.

**Mission of the Department**

- Development of state of art lab facilities for research and consultancy.
- Development of relevant content for quality teaching.
- Development of infrastructure and procurement of cutting-edge tools/equipment.
- Improving symbiotic relationship with Industry for collaborative research and resource generation.

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# DEPARTMENT OF ELECTRICAL ENGINEERING

## Programme: B.Tech in Electrical Engineering

### Programme Educational Objectives (PEOs)

| | |
|---|---|
| **PEO1** | To produce students for Industry, Research, Academic Institutions and Government Organization |
| **PEO2** | To produce students who are at par with the world classified institutions and useful to society |
| **PEO3** | To generate adequate human resources for employment opportunities in the critically important and dynamic electrical industry and in the context of a socio-economic and sustainable society |
| **PEO4** | Uniquely combine practical, hands-on training with cutting-edge research and teaching and also to develop trained manpower with strong knowledge base to undertake and execute sponsored and collaborative research programmes and consultancies to promote long term academia industrial collaboration as well as for generating resources |

### Mapping of mission of the Department with the PEOs

| **Mission statement** | **PEO1** | **PEO2** | **PEO3** | **PEO4** |
|---|---|---|---|---|
| Development of state of art lab facilities for research and consultancy | **3** | **3** | **2** | **3** |
| Development of relevant content for quality teaching | **2** | **3** | **2** | **3** |
| Development of infrastructure and procurement of cutting edge tools/equipment | **3** | **2** | **3** | **3** |
| Improving symbiotic relationship with Industry for collaborative research and resource generation | **3** | **3** | **3** | **3** |



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## Programme Outcomes (POs)

**Engineering Graduates will be able to:**

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:**Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:**Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:**Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:**Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Programme Specific Outcomes (PSOs)**

**PSO1:** Able to apply fundamental knowledge of mathematics, science and engineering to investigate, identify, formulate and design complex problems in the Electrical Engineering and allied fields.

**PSO2:** Able to apply the appropriate techniques and modern engineering tools to solve complex Electrical Engineering and real time problems, by working with multi-disciplinary team and inculcate skills for life-long learning.

**PSO3:** To be an enabler for improved and new technologies for building cost-efficient, reliable, environment friendly and sustainable energy systems for society.

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## Curricular Components

**Credit structure of B. Tech in Electrical Engineering (Major):**

| Category Symbol | Category | Total Credit |
|---|---|---|
| CEF | Core Engg. Fundamental | 16 |
| PCE | Professional competence enhancing course | 19 |
| CEE | Core Engg. Essentials | 59 |
| EAA | Extra Academic Activity related courses | 8 |
| CES | Core Engg. Supporting Courses | 14 |
| CEL | Core Engg. Elective | 32 |
| IT/GP | Industrial Training /Group Project | 24 |
| | **Total Credits** | 172 |

**Credits details of B. Tech in Electrical Engineering (Major):**

| Category Symbol | 1st Sem | 2nd Sem | 3rd Sem | 4th Sem | 5th Sem | 6th Sem | 7th Sem | 8th Sem | Total Credit |
|---|---|---|---|---|---|---|---|---|---|
| CEF | 8 | 8 | - | - | - | - | - | - | 16 |
| PCE | 7 | 3 | 3 | 3 | - | - | 3 | - | 19 |
| CEE | 6 | 5 | 8 | 12 | 16 | 12 | - | - | 59 |
| EAA | 2 | 2 | 2 | 2 | - | - | - | - | 8 |
| CES | - | 3 | 7 | 4 | - | - | - | - | 14 |
| CEL | - | - | 4 | 8 | 4 | 8 | 8 | - | 32 |
| IT/GP | - | - | - | - | 2 | - | 8 | 14 | 24 |
| **Total** | **23** | **21** | **24** | **29** | **22** | **20** | **19** | **14** | 172 |

**Credits details of B. Tech with Minor:**

| Category Symbol | 1st Sem | 2nd Sem | 3rd Sem | 4th Sem | 5th Sem | 6th Sem | 7th Sem | 8th Sem | Total Credit |
|---|---|---|---|---|---|---|---|---|---|
| CEF | 8 | 8 | - | - | - | - | - | - | 16 |
| PCE | 7 | 3 | 3 | 3 | - | - | 3 | - | 19 |
| CEE | 6 | 5 | 8 | 12 | 16 | 12 | - | - | 59 |
| EAA | 2 | 2 | 2 | 2 | - | - | - | - | 6 |
| CES | - | 3 | 7 | 4 | - | - | - | - | 14 |
| CEL | - | - | 4 | 8 | 4 | 8 | 8 | - | 32 |
| IT/GP | - | - | - | - | 2 | - | 8 | 14 | 24 |
| MR | - | - | - | 4 | 4 | 4 | 4 | - | 16 |
| **Total** | **23** | **21** | **24** | **33** | **26** | **24** | **23** | **14** | 188 |

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**Credits details of B. Tech with Honours:**

| Category Symbol | 1st Sem | 2nd Sem | 3rd Sem | 4th Sem | 5th Sem | 6th Sem | 7th Sem | 8th Sem | Total Credit |
|---|---|---|---|---|---|---|---|---|---|
| CEF | 8 | 8 | - | - | - | - | - | - | 16 |
| PCE | 7 | 3 | 3 | 3 | - | - | 3 | - | 19 |
| CEE | 6 | 5 | 8 | 12 | 16 | 12 | - | - | 59 |
| EAA | 2 | 2 | 2 | 2 | - | - | - | - | 6 |
| CES | - | 3 | 7 | 4 | - | - | - | - | 14 |
| CEL | - | - | 4 | 8 | 4 | 8 | 8 | - | 32 |
| IT/GP | - | - | - | - | 2 | - | 8 | 14 | 24 |
| HN | - | - | - | - | 4 | 4 | 8 | - | 16 |
| **Total** | **23** | **21** | **24** | **29** | **26** | **24** | **27** | **14** | 188 |

**Credits details of B. Tech Honours with Minor:**

| Category Symbol | 1st Sem | 2nd Sem | 3rd Sem | 4th Sem | 5th Sem | 6th Sem | 7th Sem | 8th Sem | Total Credit |
|---|---|---|---|---|---|---|---|---|---|
| CEF | 8 | 8 | - | - | - | - | - | - | 16 |
| PCE | 7 | 3 | 3 | 3 | - | - | 3 | - | 19 |
| CEE | 6 | 5 | 8 | 12 | 16 | 12 | - | - | 59 |
| EAA | 2 | 2 | 2 | 2 | - | - | - | - | 6 |
| CES | - | 3 | 7 | 4 | - | - | - | - | 14 |
| CEL | - | - | 4 | 8 | 4 | 8 | 8 | - | 32 |
| IT/GP | - | - | - | - | 2 | - | 8 | 14 | 24 |
| HN | - | - | - | - | 4 | 4 | 8 | - | 16 |
| MR | - | - | - | 4 | 4 | 4 | 4 | - | 16 |
| **Total** | **23** | **21** | **24** | **33** | **30** | **28** | **31** | **14** | 204 |

**Credits details of B. Tech with Research:**

| Category Symbol | 1st Sem | 2nd Sem | 3rd Sem | 4th Sem | 5th Sem | 6th Sem | 7th Sem | 8th Sem | Total Credit |
|---|---|---|---|---|---|---|---|---|---|
| CEF | 8 | 8 | - | - | - | - | - | - | 16 |
| PCE | 7 | 3 | 3 | 3 | - | - | 3 | - | 19 |
| CEE | 6 | 5 | 8 | 12 | 16 | 12 | - | - | 59 |
| EAA | 2 | 2 | 2 | 2 | - | - | - | - | 6 |
| CES | - | 3 | 7 | 4 | - | - | - | - | 14 |
| CEL | - | - | 4 | 8 | 4 | 8 | 8 | - | 32 |
| IT/GP/RP | - | - | - | - | 2 | - | 12 | 14 | 28 |
| RS | - | - | - | - | 4 | 4 | 4 | - | 12 |
| **Total** | **23** | **21** | **24** | **29** | **26** | **24** | **27** | **14** | 188 |

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**Credits details of proposed B. Tech with Research & with Minor:**

| Category Symbol | 1st Sem | 2nd Sem | 3rd Sem | 4th Sem | 5th Sem | 6th Sem | 7th Sem | 8th Sem | Total Credit |
|---|---|---|---|---|---|---|---|---|---|
| CEF | 8 | 8 | - | - | - | - | - | - | 16 |
| PCE | 7 | 3 | 4 | 3 | - | - | 3 | - | 19 |
| CEE | 6 | 5 | 8 | 12 | 16 | 12 | - | - | 59 |
| EAA | 2 | 2 | 2 | 2 | - | - | - | - | 6 |
| CES | - | 3 | 7 | 4 | - | - | - | - | 14 |
| CEL | - | - | 4 | 8 | 4 | 8 | 8 | - | 32 |
| IT/GP/RP | - | - | - | - | 2 | - | 12 | 14 | 28 |
| RS | - | - | - | - | 4 | 4 | 4 | - | 12 |
| MR | - | - | - | 4 | 4 | 4 | 4 | - | 16 |
| **Total** | **23** | **21** | **25** | **33** | **30** | **28** | **31** | **14** | 204 |

# SCHEME OF INSTRUCTION

## B.Tech. Electrical Engineering
## Course Structure

### 1. B. Tech. Year-I, Semester-I

| Sl. No. | Course Code | Course | Cat. | L | T | P | Credit | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1. | CYN11501 | Engineering Chemistry-I | CEF | 2 | 1 | 2 | 4 | Branch specific Physics or Chemistry Courses (Alternate in each semester) |
| 2. | MAN11101 | Mathematics-I | CEF | 3 | 1 | 0 | 4 | Common course for all branches |
| 3. | HSN11600 | Professional Communication | PCE | 2 | 0 | 2 | 3 | Common course for all branches |
| 4. | EEN11101 | Essentials of Electrical Engineering | CEE | 2 | 0 | 2 | 3 | Branch specific course for students of Electrical Engg. |
| 5. | EEN11102 | Electrical Measurement & Instrumentation | CEE | 2 | 0 | 2 | 3 | Branch specific course for students of Electrical Engg. |
| 6. | MEN11602 | Workshop & Manufacturing Processes | PCE | 1 | 0 | 2 | 2 | Common course chosen by the department |
| 7. | IDN11600 | Introduction to Environment and Climate Change | PCE | 2 | 0 | 0 | 2 | Common course for all branches |
| 8. | - | Extra Academic Activity-A/ Extra Academic Activity-B | EAA | - | - | 4 | 2 | Common course for all branches (with different titles) Engagement beyond Academic activity duration & the evaluation of grading system should be worked out |
| Total | | | 14 | | 2 | 14 | 23 | |

### 2. B. Tech. Year-I, Semester-II

| Sl. No. | Subject Code | Sub | Cat. | L | T | P | Credit | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1. | PHN12501 | Engineering Physics -I | CEF | 2 | 1 | 2 | 4 | Branch specific Physic or Chemistry Courses (Alternate in each semester) |
| 2. | MAN12105 | Mathematics-II | CEF | 3 | 1 | 0 | 4 | Branch Specific Mathematics Course for students of Electrical Engg. |
| 3. | CSN12601 | Introduction to Artificial Intelligence & Machine Learning | PCE | 2 | 0 | 2 | 3 | Common course for all branches |
| 4. | Codes are given below | Core Engineering Supporting Course* | CES | 2 | 0 | 2 | 3 | Courses floated by department of Electrical Engg. (Only for the students of other branches) |
| 5. | EEN12101 | Network Analysis | CEE | 3 | 0 | 0 | 3 | Branch specific course for students of Electrical Engg. |
| 6. | EEN12102 | Electrical Workshop | CEE | 1 | 0 | 2 | 2 | Branch specific course floated by the department of Electrical Engg. in place of common course |
| 7. | EAN12700 | Professional Ethics & Social Values | EAA | 0 | 0 | 4 | 2 | Common course for all branches (with different titles) Engagement beyond Academic activity duration & the evaluation of grading system should be worked out |
| | | | | 12 | 2 | 14 | 21 | |
| | | | | | | | | |



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*** Core Engineering Supporting Course (Only for the students of other branches)**

| Sl. No. | Subject Code | Subject |
|---|---|---|
| 1 | EEN12400 | Basic Electrical Engineering |
| 2 | EEN12401 | Electrical Measurement & Measuring Instruments |
| 3 | EEN12402 | Electrical Circuits |
| 4 | EEN12403 | Introduction to Simulation Tools |

### 3. B. Tech. Year-II, Semester-III

| Sl. No. | Sub Code | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ECN13401 | Analog & Digital Electronics | CES | 3 | - | 2 | 4 | 5 | |
| 2 | CSN13101 | Data Structure & Operating System | CEE | 3 | - | - | 3 | 3 | |
| 3 | EEN 13101 | Signals & Systems | CEE | 3 | 1 | - | 4 | 4 | |
| 4 | HSN13602 | Business Economics | PCE | 3 | - | - | 3 | 3 | |
| 5 | | Elective-I | CEL | 3 | 1 | - | 4 | 4 | |
| 6 | EEN13102 | Simulation Tools for Electrical Engineering | CEE | 3 | - | 2 | 4 | 5 | |
| 7 | - | Extra Academic Activity-B-II | EAA | 3 | - | - | 2 | 3 | |
| | | **Total** | | **18** | **3** | **8** | **24** | **26** | |

**Elective-I**

1. Non-conventional Energy Resources : EEN13250
2. Electrical Engineering Material & Devices- AMN13250
3. Modern Computation Languages: CSN13251

### 4. B. Tech. Year-II, Semester-IV

| Sl. No. | Course Code | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EEN14101 | Electrical Machines-I | CEE | 3 | - | 2 | 4 | 5 | |
| 2 | EEN14102 | Control System – I | CEE | 3 | - | 2 | 4 | 5 | |
| 3 | EEN14103 | Power System - I | CEE | 3 | - | 2 | 4 | 5 | |
| 4 | ECN14402 | Computer Organization & Microcontrollers | CES | 3 | - | 2 | 4 | 5 | |
| 5 | | Elective-II | CEL | 3 | 1 | - | 4 | 4 | |
| 6 | | Elective-III | CEL | 3 | 1 | - | 4 | 4 | |
| 7 | HSN14601 | Management Concept and Applications | PCE | 3 | - | - | 3 | 3 | |
| 8 | - | Extra Academic Activity-B-II | EAA | | | 4 | 2 | 4 | |
| | **Total** | | | **21** | **2** | **10** | **29** | **35** | |



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| List of Elective-II/ Elective-III [L-T-P] is given in above table | | |
|---|---|---|
| **Sl No** | **Sub Code** | **Sub Name** |
| 1 | EEN14250 | Utilization of Electrical Energy |
| 2 | - | Analog & Digital Communications |
| 3 | EEN14251 | Advanced Instrumentation |
| 4 | EEN14252 | Network Synthesis |
| 5 | EEN14253 | Modelling & Simulation |
| 6 | EEN14254 | Modern Power Station Practice |
| 7 | EEN14255 | Power Plant Engineering |

**Minor:**

| Sl. No. | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Minor-I/II/III | MN | 3 | 1 | - | 4 | 4 | |
| | **Total** | | 3 | 1 | - | 4 | 4 | |

**Department offers three minors (Minor-I/II/III) for the students of other department. Each minor course is of four credits.**

**List of courses in each minor in 4th Semester:**

| Minor-I (Automation and Control) | Minor-II (Renewables and Electric Vehicles) | Minor-III (Smart Grid) |
|---|---|---|
| 1. Basic Electrical Engineering<br>2. Industrial Instrumentation<br>3. Electric Circuits | 1. Basic Electrical Engineering<br>2. Utilization of Electrical Engineering<br>3. Electric Circuits | 1. Basic Electrical Engineering<br>2. Modern Power Station Practice<br>3. Electric Circuits |

**Codes of Subjects:**

| Course Name | Course Code | Remark |
|---|---|---|
| Industrial Instrumentation | EEN14256 | Minor subject |
| Subjects for another Department | | |
| Automatic Control Systems | EEN 14401 | To be taught by EED for ECE Department |



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5. **B. Tech. Year-III, Semester-V**

| Sl. No. | Course Code | Course name | Cat. | L | T | P | Credit | Contact Hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EEN15101 | Electrical Machines-II | CEE | 3 | - | 2 | 4 | 5 | |
| 2 | EEN15102 | Control System-II | CEE | 3 | - | 2 | 4 | 5 | |
| 3 | EEN15103 | Power System-II | CEE | 3 | - | 2 | 4 | 5 | |
| 4 | EEN15104 | Power Electronics | CEE | 3 | - | 2 | 4 | 5 | |
| 5 | EEN15351 | Industrial Training /Summer Internship/Group project/Mini project | IT/GP | - | - | 2 | 2 | - | |
| **Elective Subjects** | | | | | | | | | **Remarks** |
| 4 | EEN15250 | Electrical System Design | CEL | 3 | 1 | 0 | 4 | 4 | Elective IV |
| 5 | EEN15251 | Digital Signal Processing | CEL | 3 | 1 | 0 | 4 | 4 | Elective IV/ Minor-I |
| 6 | EEN15252 | Microprocessor & Applications | CEL | 3 | 1 | 0 | 4 | 4 | Elective IV |
| 7 | EEN15253 | Neural Network & Deep Learning | CEL | 3 | 1 | 0 | 4 | 4 | Minor-I/Minor- II |
| 8 | EEN15270 | Finite Element Methods in Electrical Engineering | CEL | 3 | 1 | 0 | 4 | 4 | Honours/ Research Course-1 |
| 9 | EEN15271 | Virtual Instrumentation | CEL | 3 | 1 | 0 | 4 | | |
| 10 | EEN15272 | Artificial Intelligence in Engineering | CEL | 3 | 1 | 0 | 4 | | |
| 11 | EEN15273 | Expert Systems | CEL | 3 | 1 | 0 | 4 | | |
| 12 | EEN15274 | Embedded Systems | CEL | 3 | 1 | 0 | 4 | | |

*The student should undergo Industrial Training / Summer Internship / Group Project / Mini Project for a minimum period of ***three-weeks*** during the summer vacation after IV semester. Registration for this course shall be done along with the courses for V semester. Student can carry out this work in any reputed Industry or academic institution within the country (IISc/IITs/NITs/IIITs/CFTIs) or reputed research labs or the same may be pursued within the MNNIT Allahabad) or university abroad. A report is to be submitted to the Head of the Department and evaluation (2 credits) will be based on the report and viva-voce examination.

S. Sarangi 9/7/24

R. Chaney 9/7/24

### Honours (Electrical Engineering)

| Sl. No. | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Honours Course-1 | HR | 3 | 1 | - | 4 | 4 | |
| | **Total** | | 3 | 1 | - | 4 | 4 | |

### Research (Electrical Engineering)

| Sl. No. | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Course work (any one subject from Research Course-1) | RS | 3 | 1 | - | 4 | 4 | |
| | Total | | **3** | **1** | **0** | **4** | **4** | |

### List of Honours/Research course-1[Each Course of four credits] codes are given above

1. Finite Element Methods in Electrical Engineering
2. Virtual Instrumentation
3. Neural Network & Deep Learning
4. Artificial Intelligence in Engineering
5. Expert Systems
6. Embedded Systems

### Minor:

| Sl. No. | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Minor-I/II/III | MN | 3 | 1 | - | 4 | 4 | |
| | **Total** | | 3 | 1 | - | 4 | 4 | |

### List of courses in each minor in 5th semester [Each Course of four credits]:

| Minor-I (Automation and Control) | Minor-II (Renewables and Electric Vehicles) | Minor-III (Smart Grid) |
|---|---|---|
| 1. Digital Signal Processing<br>2. Neural Network & Deep Learning | 1. Non-Conventional Energy Resources<br>2. Neural Network & Deep Learning | 1. Electrical System Design<br>2. Neural Network & Deep Learning |

### 6. B. Tech. Year-III, Semester-VI

| Sl. No. | Course Code | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1. | EEN16101 | Electric Drives | CEE | 3 | - | 2 | 4 | 5 | |
| 2. | EEN16102 | Renewable Energy Sources and Distributed Generation | CEE | 3 | 1 | - | 4 | 4 | |
| 3. | EEN16103 | Advance Power Electronics | CEE | 3 | - | 2 | 4 | 5 | |
| 4. | Codes are given Below | Elective-V | CEL | 3 | 1 | - | 4 | 4 | |
| 5. | | Elective-VI | CEL | 3 | 1 | - | 4 | 4 | |
| | **Total** | | | **15** | **3** | **4** | **20** | **22** | |



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| Elective-V / Elective-VI |
|---|
| 1. Power Systems Dynamics & Control<br>2. Introduction to Electricity Markets<br>3. Industrial Instrumentation & Control<br>4. Optimization Techniques<br>5. Modern Electrical Machines<br>6. Distribution System Engineering<br>7. Advanced Semiconductor Devices<br>8. Digital Design & VHDL |

| Sl. No. | Course Code | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EEN16250 | Power Systems Dynamics & Control | CEL | 3 | 1 | - | 4 | 4 | |
| 2 | EEN16251 | Introduction to Electricity Markets | CEL | 3 | 1 | - | 4 | 4 | |
| 3 | EEN16252 | Industrial Instrumentation & Control | CEL | 3 | 1 | - | 4 | 4 | |
| 4 | EEN16253 | Optimization Techniques | CEL | 3 | 1 | - | 4 | 4 | |
| 5 | EEN16254 | Modern Electrical Machines | CEL | 3 | 1 | - | 4 | 4 | |
| 6 | EEN16255 | Distribution System Engineering | CEL | 3 | 1 | - | 4 | 4 | |
| 7 | EEN16256 | Advanced Semiconductor Devices | CEL | 3 | 1 | - | 4 | 4 | |
| 8 | EEN16257 | Digital Design & VHDL | CEL | 3 | 1 | - | 4 | 4 | |

**Honours (Electrical Engineering)**

**[Course selection for remaining three courses, each from three different specializations of Control System, Power Electronics and Power System verticals, listed in VI semester (Honours course-2) and VII semester (Honours course-3 and 4)**

| Sl. No. | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Honours Course-2 | HR | 3 | 1 | - | 4 | 4 | |
| | **Total** | | 3 | 1 | - | 4 | 4 | |

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**Research (Electrical Engineering)**

**[Course selection for remaining two courses from any one specialization of, Control System or Power Electronics or Power System verticals listed in VI semester (Research course-2) and VII semester (Research course-3 and 4)]**

## List of Honours/Research Baskets for Course-2 [Each Course of four credits]

| (Control System) | (Power System) | (Power Electronics) |
|---|---|---|
| 1. Special Topics in Control Systems :<br>2. Adaptive Control<br>3. Cyber Security<br>4. Stochastic Control and Optimization<br>5. Modern Digital and Embedded Controllers<br>6. System Identification and Estimation | 1. Power System Design<br>2. Distribution Automation<br>3. Electrical Energy Conservation & Auditing<br>4. Power System Planning<br>5. Distributed Generation Systems<br>6. Smart Grid Technology | 1. Active Power Conditioning<br>2. Electric Traction & Vehicles<br>3. Smart Grid Technology<br>4. Electromagnetic Interference & compatibility<br>5. HVDC Transmission<br>6. Modern Digital and Embedded Controllers |

| Sl. No. | Course name | | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Research Course (from respective specialization Research Course-2) | | RS | 3 | 1 | 0 | 4 | 4 | |
| | Total | | | **3** | **1** | **0** | **4** | **4** | |
| | | | | | | | | | |
| | **List of Honours Courses/ Research Course-2[Each Course of Four credits] Control System** | | | | | | | | |
| 1 | EEN16258 | Special Topics in Control Systems | - | 3 | 1 | - | 4 | 4 | |
| 2 | EEN16259 | Adaptive Control | - | 3 | 1 | - | 4 | 4 | |
| 3 | EEN16260 | Cyber Security | - | 3 | 1 | - | 4 | 4 | |
| 4 | EEN16261 | Stochastic Control and Optimization | - | 3 | 1 | - | 4 | 4 | |
| 5 | EEN16262 | Modern Digital and Embedded Controllers | - | 3 | 1 | - | 4 | 4 | |
| 6 | EEN16263 | System Identification and Estimation | - | 3 | 1 | - | 4 | 4 | |
| | **List of Honours Courses/ Research Course-2[Each Course of Four credits] Power System** | | | | | | | | |
| 1 | EEN16264 | Power System Design | - | 3 | 1 | - | 4 | 4 | |
| 2 | EEN16265 | Distribution Automation | - | 3 | 1 | - | 4 | 4 | |
| 3 | EEN16266 | Electrical Energy Conversion and auditing | - | 3 | 1 | - | 4 | 4 | |
| 4 | EEN16267 | Power System Planning | - | 3 | 1 | - | 4 | 4 | |
| 5 | EEN16268 | Distributed Generation System | - | 3 | 1 | - | 4 | 4 | |
| 6 | EEN16269 | Smart Grid Technology | - | 3 | 1 | - | 4 | 4 | |
| | **List of Honours Courses/ Research Course-2[Each Course of Four credits] Power Electronics** | | | | | | | | |
| 1 | EEN16270 | Active Power Conditioning | - | 3 | 1 | - | 4 | 4 | |
| 2 | EEN16271 | Electric Traction & Vehicles | - | 3 | 1 | - | 4 | 4 | |



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| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3 | EEN16272 | Electromagnetic Interference & compatibility | - | 3 | 1 | - | 4 | 4 | |
| 5 | EEN16274 | HVDC Transmission | - | 3 | 1 | - | 4 | 4 | |

**Minor:**

| Sl. No. | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Minor-I/II/III | MN | 3 | 1 | - | 4 | 4 | |
| | **Total** | | 3 | 1 | - | 4 | 4 | |

**List of courses in each minor in 6th semester [Each Course of four credits]:**

**Codes are available in the above table**

| Minor-I (Automation and Control) | Minor-II (Renewables and Electric Vehicles) | Minor-III (Smart Grid) |
|---|---|---|
| 1. Industrial Instrumentation & Control<br>2. Optimization Techniques<br>3. Digital Design & VHDL | 1. Advanced Semiconductor device<br>2. Optimization Techniques<br>3. Electric Traction & Vehicles | 1. Introduction to Electricity Markets<br>2. Optimization Techniques<br>3. Smart Grid Technology |

## 7. B. Tech. Year-IV, Semester-VII

| Sl. No. | Course name | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1. | EEN17351 | Group Project | GP | - | - | - | 6 | 6 | |
| 2. | Codes are given below | Elective-VII | CEL | 3 | 1 | - | 4 | 4 | |
| 3. | | Elective-VIII | CEL | 3 | 1 | - | 4 | 4 | |
| 4. | EEN17352 | #Industrial Training /Internship/Summer Project | IT | - | - | - | 2 | - | |
| 5. | | Managerial and Interpersonal Skills/ MOOCs/Online | PCE | 3 | 0 | - | 3 | 3 | |
| | Total | | | **2** | **0** | **0** | **19** | **17** | |

#The student should undergo Industrial Training /Internship/Summer Project for a minimum period of ***Four-weeks*** during the summer vacation after VI semester. Registration for this course shall be done along with the courses for VII semester. Student can carry out this work in any reputed Industry or academic institution within the country (IISc/IITs/NITs/IIITs/CFTIs) or reputed research laboratory or the same may be pursued within the MNNIT Allahabad or university abroad. A report is to be submitted to the Head of the Department and evaluation (2 credits) will be based on the report and viva-voce examination.

| Elective-VII/ Elective-VIII |
|---|



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1. Power System Protection & Switchgear
2. Neuro-Fuzzy Control Systems
3. Flexible AC Transmission Systems
4. Power Quality

**Codes for Elective Subjects**

| Sl. No. | Course Code | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EEN17250 | Power System Protection & Switchgear | CEL | 3 | 1 | - | 4 | 4 | |
| 2 | EEN17251 | Neuro-Fuzzy Control Systems | CEL | 3 | 1 | - | 4 | 4 | |
| 3 | EEN17252 | Flexible AC Transmission Systems | CEL | 3 | 1 | - | 4 | 4 | |
| 4 | EEN17253 | Power Quality | CEL | 3 | 1 | - | 4 | 4 | |

## Honours (Electrical Engineering)

| Sl. No. | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Honours Course-3 | HR | 3 | 1 | - | 4 | 4 | |
| 2 | Honours Course-4 | HR | 3 | 1 | - | 4 | 4 | |
| | Total | | **6** | **2** | **0** | **8** | **8** | |

## Research (Electrical Engineering)

| Sl. No. | | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EEN17353 | Research Project | RP | - | - | - | 4 | 4 | |
| 2 | | Research Course (from respective specialization of Research Course-3 and 4) | RS | 3 | 1 | - | 4 | 4 | |
| | | Total | | **3** | **1** | **0** | **8** | **8** | |

## List of Honours/ Research Course-3 and 4 [Each Course of four credits]

| (Control System) | (Power System) | (Power Electronics) |
|---|---|---|
| 1. Process Control & Instrumentation<br>2. Advanced Digital Control<br>3. Biomedical Instrumentation<br>4. Introduction to Probability Theory & Stochastic Process<br>5. Smart Sensors & Actuators<br>6. Robot Modelling and Control | 1. Energy Storage System<br>2. EHV Transmission Technologies<br>3. Computer Relaying for Power System Protection<br>4. Computer Aided Power System Analysis<br>5. Advanced Energy management system<br>6. Power Plant Operation & Control | 1. Control Techniques in Power Electronics<br>2. Renewable Energy & Grid Integration<br>3. Power Electronic Converters for Microgrids<br>4. Electric Vehicle Technology<br>5. Intelligent Control of Drives<br>6. Energy Storage Systems |

| Sl. No. | Course Code | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EEN17353 | Research Project | RP | - | - | - | 4 | 4 | |
| 2 | Research Course (from respective Research Course-3 and 4) | | RS | 3 | 1 | - | 4 | 4 | |
| | Total | | | **3** | **1** | **0** | **8** | **8** | |
| | | | | | | | | | |
| | **List of Honours Courses/ Research Course-3 and 4[Each Course of Four credits] Control System** | | | | | | | | |
| 1 | EEN17254 | Process Control & Instrumentation | - | 3 | 1 | - | 4 | 4 | |
| 2 | EEN17255 | Advanced Digital Control | - | 3 | 1 | - | 4 | 4 | |
| 3 | EEN17256 | Biomedical Instrumentation | - | 3 | 1 | - | 4 | 4 | |
| 4 | EEN17257 | Introduction to Probability Theory & Stochastic Process | - | 3 | 1 | - | 4 | 4 | |
| 5 | EEN17258 | Smart Sensors & Actuators | - | 3 | 1 | - | 4 | 4 | |
| 6 | EEN17259 | Robot Modelling and Control | - | 3 | 1 | - | 4 | 4 | |
| | **List of Honours Courses/ Research Course-3 and 4 [Each Course of Four credits] Power System** | | | | | | | | |
| 1 | EEN17260 | Energy Storage System | - | 3 | 1 | - | 4 | 4 | |
| 2 | EEN17261 | EHV Transmission Technologies | - | 3 | 1 | - | 4 | 4 | |
| 3 | EEN17262 | Computer Relaying for Power System Protection | - | 3 | 1 | - | 4 | 4 | |
| 4 | EEN17263 | Computer Aided Power System Analysis | - | 3 | 1 | - | 4 | 4 | |
| 5 | EEN17264 | Advanced Energy management system | - | 3 | 1 | - | 4 | 4 | |
| 6 | EEN17265 | Power Plant Operation & Control | - | 3 | 1 | - | 4 | 4 | |
| | **List of Honours Courses/ Research Course-3 and 4 [Each Course of Four credits] Power Electronics** | | | | | | | | |
| 1 | EEN17266 | Control Techniques in Power Electronics | - | 3 | 1 | - | 4 | 4 | |
| 2 | EEN17267 | Renewable Energy & Grid Integration | - | 3 | 1 | - | 4 | 4 | |
| 3 | EEN17268 | Power Electronic Converters for Microgrids | - | 3 | 1 | - | 4 | 4 | |
| 4 | EEN17269 | Electric Vehicle Technology | - | 3 | 1 | - | 4 | 4 | |
| 5 | EEN17270 | Intelligent Control of Drives | - | 3 | 1 | - | 4 | 4 | |
| 6 | EEN17271 | Energy Storage Systems | - | 3 | 1 | - | 4 | 4 | |

**Minor:**

| Sl. No. | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | Minor-I/II/III | MN | 3 | 1 | - | 4 | 4 | |
| | Total | | **3** | **1** | **0** | **4** | **4** | |

**List of courses in each minor in 7th semester [Each Course of four credits]:**

**Coes are given in the above table**

| Minor-I(Automation and Control) | Minor-II (Renewables and Electric Vehicles) | Minor-III (Smart Grid) |
|---|---|---|
| 1. Process Control & Instrumentation<br>2. Smart Sensors & Actuators | 1. Renewable Energy & Grid Integration<br>2. Electric Vehicle Technology | 1. Energy Storage System<br>2. Advanced Energy management system |

## 8. B. Tech. Year-IV, Semester-VIII

| Sl. No. | | Course name | Cat. | L | T | P | Credit | Contact hours | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| 1 | EEN18351 | Entrepreneurship/Project/R&D Project/Industrial Placement | IT | - | - | - | 14 | 14 | Non-contact classes based professional engagement |
| | | **Total** | | - | - | - | **14** | **14** | |

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<u>**List of Course Works in Minor Basket**</u>

Department: Electrical Engineering

| Minor-I | | Course works in Minor-I basket | Minor-II | | Course works in Minor-I basket | Minor-III | | Course works in Minor-I basket |
|---|---|---|---|---|---|---|---|---|
| Minor-I: **Automation & Control** | 4th Sem. | Basic Electrical Engineering | Minor-II: **Renewables and Electric Vehicles** | 4th Sem. | Basic Electrical Engineering | Minor-III: **Smart Grid** | 4th Sem. | Basic Electrical Engineering |
| | | Industrial Instrumentation | | | Utilization of Electrical Engineering | | | Modern Power Station Practice |
| | | Electric Circuits | | | Electric Circuits | | | Electric Circuits |
| | 5th Sem. | Digital Signal Processing | | 5th Sem. | Non-Conventional Energy Resources | | 5th Sem. | Electrical System Design |
| | | Neural Network & Deep Learning | | | Neural Network & Deep Learning | | | Neural Network & Deep Learning |
| | 6th Sem. | Industrial Instrumentation & Control | | 6th Sem. | Advanced Semiconductor device | | 6th Sem. | Introduction to Electricity Markets |
| | | Optimization Techniques | | | Optimization Techniques | | | Optimization Techniques |
| | | Digital Design & VHDL | | | Electric Traction & Vehicles | | | Smart Grid Technology |
| | 7th Sem. | Process Control & Instrumentation | | 7th Sem. | Renewable Energy & Grid Integration | | 7th Sem. | Energy Storage System |
| | | Smart Sensors & Actuators | | | Electric Vehicle Technology | | | Advanced Energy management system |

<u>**List of Course Works in Honours/Research Basket**</u>

**Department: Electrical Engineering**

| Semester | Course works in Honours/Research Basket | |
|---|---|---|
| 5th | 1. Finite Element Methods in Electrical Engineering<br>2. Virtual Instrumentation<br>3. Neural Network & Deep Learning<br>4. Artificial Intelligence in Engineering<br>5. Expert Systems<br>6. Embedded Systems | |
| 6th | Control System | 1. Special Topics in Control Systems<br>2. Adaptive Control<br>3. Cyber Security<br>4. Stochastic Control and Optimization<br>5. Modern Digital and Embedded Controllers<br>6. System Identification and Estimation |
| | Power System | 1. Power System Design<br>2. Distribution Automation<br>3. Electrical Energy Conservation & Auditing<br>4. Power System Planning<br>5. Distributed Generation Systems<br>6. Smart Grid Technology |
| | Power Electronics | 1. Active Power Conditioning<br>2. Electric Traction & Vehicles<br>3. Smart Grid Technology<br>4. Electromagnetic Interference & compatibility<br>5. HVDC Transmission<br>6. Modern Digital and Embedded Controllers |
| 7th | Control System | 1. Process Control & Instrumentation<br>2. Advanced Digital Control<br>3. Biomedical Instrumentation<br>4. Introduction to Probability Theory & Stochastic Process<br>5. Smart Sensors & Actuators<br>6. Robot Modelling and Control |
| | Power System | 1. Energy Storage System<br>2. EHV Transmission Technologies<br>3. Computer Relaying for Power System Protection<br>4. Computer Aided Power System Analysis<br>5. Advanced Energy management system<br>6. Power Plant Operation & Control |
| | Power Electronics | 1. Control Techniques in Power Electronics<br>2. Renewable Energy & Grid Integration<br>3. Power Electronic Converters for Microgrids<br>4. Electric Vehicle Technology<br>5. Intelligent Control of Drives<br>6. Energy Storage Systems |

# Course Detail and Syllabus

| Course Title | **Physics** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/Elective | CEF | Semester | I/II |
| Prerequisite Knowledge | Basic Knowledge of Physics | | |

| CO | Statement |
|---|---|
| PH11101.1 | The course provides basics of electromagnetism and electrodynamics which are required for Electrical Engineering, Electronics & Communication Engineering, Computer Science & Engineering professionals for development of advance technology. |
| PH11101.2 | Development of basic understanding of quantum mechanics to address the engineering based problems at molecular level, required for Electrical Engineering, Electronics & Communication Engineering, Computer Science & Engineering professionals for the development of advance technologies such as quantum computation and quantum devices. |
| PH11101.3 | The solid state and semiconductor devices are fundamental units of every electronic equipment. The course provides basic understanding of solid state physics to discover efficient electronic devices. It also helps in the development of new materials. |

**Syllabus**

**Electrodynamics**

Gradient, divergence and curl operations, Spherical and Cylindrical Coordinates.Gauss divergence theorem and Stoke'stheorem.Poisson's and Laplace equation, Working of Helmholtz galvanometer. Magnetic vector potential, Displacement current, Maxwell's equations (Integral and differential forms) in free space, Propagation of electromagnetic waves in free space

**Quantum Mechanics**

Wave particle duality, Wave packets, Phase and group velocity, Heisenberg's uncertainty principle and its application, Wave function and its physical interpretation, Probabilities and Normalization, Time independent and dependent Schrodinger wave equation and its simple applications.

**Solid State Physics**

Crystal structure, Space lattice, Unit cell, Miller indices, Interplaner spacing, X-ray diffraction and Bragg's law, Diamagnetism, Paramagnetism and Ferromagnetism, Hysteresis curve, Curie-Weiss Law.

**Practical: List of Experiments**

1. To measure height of a building using Sextant.
2. To measure co-efficient of thermal conductivity of rubber by Lee's disc method.
3. To study variation of magnetic field along the axis of a current carrying coil.
4. Magnetic field distribution due to Helmholtz coil setup.
5. To determine resistivity by four probe method.
6. To study variation of magnetic field along axis of Helmboltz coil.
7. To measure surface tension using the "break-away" method.

8. To determine specific heat of copper, lead and glass.

**Reference Books**


1. D. J. Griffths, Introduction to Electrodynamics, Prentice Hall of India.
2. S. Gasiorowiez, Quantum Physics, John Wiley & Sons.
3. R. Eisberg and R. Resnik, Quantum Physics, John Wiley & Sons.
4. A. Beiser, Concepts of Modern Physics, Tata McGraw-Hill.
5. Charles Kittel, Introduction to Solid State Physics, Wiley India Edition.


| **Course Title** | **Chemistry** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/Elective | CEF | Semester | I/II |

1. **Chemical Kinetics:** Rate of a chemical reaction, factors affective the rate of reactions: concentration, temperature, pressure and catalyst: elementary and complex reactions, order and molecularity of reactions, rate law, rate constant and its units.

2. **Electrochemistry:** Electrochemical cells and EMF, Applications of EMF, Rechargeable battery, solar cells.

3. **Organic and Polymer Molecules:** Organic optoelectronic molecules & devices, chemical sensors, memory cells, electro chronic devices and non-linear optics.
   Conducting polymers, Thermo sensitive polymers, liquid crystalline polymers, piezoelectric polymers, polymers for optical data storage, fibre-optics.

4. **Chemistry, properties and application**
   - Atomic and Molecular Orbitals
   - Schrodinger equation and applications
   - Semiconductors, insulators, doping in semiconducting materials
   - Organic light-emitting devices
   - Mechanical actuators and switches
   - Printed Circuit Boards

| Course Title | **Mathematics-I** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/Elective | CEF | Semester | I |
| Prerequisite Knowledge | Basic Knowledge of Mathematics | | |

**MATHEMATICS-I (MA-1101)**

**UNIT1: Continuity and Differentiability** 5(L)

Limit and Continuity (ε-δdefinition of one variable, Rolle's Theorem, Mean Value Theorems, Limit and Continuity (ε-δdefinition for several variables) and Differentiability for several variables.

**UNIT2: Partial Derivatives and Taylors Theorem** 5(L)

Partial Derivatives, Euler's theorem, Implicit function,Change of variables, Jacobian, Taylor's theorem for functions of several variables, Extrema of functions of several variables, Lagrange method of undetermined multipliers.

**UNIT3: Integral Calculus** 7(L)

Multiple Integrals (Double & Triple Integral), Change of order of integration, Area of bounded region, Arc length of Curve, Volume and Surface area of solid of revolution, Multiple integral by change of variables, Dirichlet integrals, Moment of Inertia, Center of gravity

**UNIT4: Beta and Gamma Functions** 5(L)

ImproperIntegrals, Convergence of improper integral, Beta function, Gamma function, Improper integrals involving parameter.

**UNIT5: Vector Calculus** 8(L)

Gradient, Directional derivatives, Divergence and curl, Line integral, Green's theorem, Surface and volume integrals, Gauss Theorem, Stoke's theorems and their Applications

**UNIT6: Ordinary Differential Equation** 10(L)

Existence and uniqueness of solutions of first order ODE, Exact differential equation, Solution of linear differential equation, Higher order linear differential equation, Solutions of homogeneous and non-homogeneous ODE (CF+PI), Variation of parameters, Method of undetermined coefficients.

**Text Reference Books:**


- R.K. Jain and S.R. K lyengar, Advanced Engineering Mathematics, Narosa Pub. House
- Erwin Rreyszig. Advanced Engineering Mathematics, John Wiley & Sons INC.
- B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers

| | | | |
|---|---|---|---|
| Course Title | **Essentials of Electrical Engineering** | | |
| Course Code | | Credit | 3 |
| Core/ Elective | CEE | Semester | I |
| Prerequisite Knowledge | 1. Fundamental of Physics<br>2. Mathematics | | |
| Course Aim | This course aims to (i) demonstrate the fundamental theories of DC/AC circuits/networks, (ii) assist to solve electrical circuits using network theorems, (iii) revisit magnetic circuits and characterize the same. | | |
| Course Outcomes (COs) | At the end of the course students will be able to:<br>CO1: understand DC circuits/networks elements.<br>CO2: apply different network theorems to solve electrical circuits/networks.<br>CO3: understand AC circuits, and able to compute power in AC circuits.<br>CO4: demonstrate the characteristics of magnetic circuits.<br>CO5: analyze networks using graph theory. | | |

Mapping of COs with POs

| | **CO1** | **CO2** | **CO3** | **CO4** | **CO5** |
|---|---|---|---|---|---|
| **PO1** | H | H | H | M | M |
| **PO2** | H | H | H | H | H |
| **PO3** | M | H | H | H | M |
| **PO4** | L | M | H | H | M |
| **PO5** | H | L | H | H | H |
| **PO6** | M | L | H | M | M |
| **PO7** | M | L | M | M | M |
| **PO8** | L | L | M | L | M |
| **PO9** | H | L | M | M | M |
| **PO10** | L | M | L | L | L |
| **PO11** | L | L | L | L | L |
| **PO12** | M | M | M | M | L |

Mapping of COs with PSOs

| | **CO1** | **CO2** | **CO3** | **CO4** |
|---|---|---|---|---|
| PSO1 | H | H | H | H |
| PSO2 | H | H | H | H |
| PSO3 | M | M | M | M |

**Module 1: Introduction to DC Networks** **(5 Hours)**

Introduction to DC and AC circuits, Active & passive elements, unilateral & bilateral elements, Voltage Sources and Current Sources, Ohm's law, Voltage-Current relations for resistor, inductor, and capacitor, Kirchhoff's laws, Node voltage & Mesh Current analysis, Ideal sources Star-Delta Transformation, Independent and dependent/controlled sources with examples.

**Module 2: Network Theorems** **(5 Hours)**

Superposition theorem, Thevenin's and Norton Theorems, Maximum power transfer theorem, Millman's theorem, Reciprocity theorem.

**Module 3: AC Fundamentals** **(10 Hours)**

Single-phase AC generation, Average and RMS values of sinusoid, Form and peak factors, Concept of phasor representation, the *j* operator, Power factor, Power in complex notation, Analysis of R-L, R-C, R-L-C circuits.
Resonance: Series and Parallel, Q-factor.
Three phase EMF generation, delta and Y – connection, relationship between line and phase quantities, balanced supply voltage and balanced load, phasor diagram, measurement of power in three phase circuits.

**Module 4: Magnetic Circuits** **(4 Hours)**

Introduction to magnetic circuits, analogy between electrical and magnetic circuits, Simple magnetic circuit with DC and AC excitations-Faraday's laws, induced emfs and inductances, magnetic leakages, B-H curve, hysteresis and eddy current loss, magnetic circuit calculations, mutual coupling.

**Module 5: Graph theory/topology** **(4 Hours)**

Graph of a network, Tree, Co-tree, fundamental cut-set, Link, Incidence matrix, Cut set matrix, Tie set matrix.

**Text / Reference books**


1. Dash. S.S, Subramani. C, Vijayakumar. K," Basic Electrical Engineering", First edition, Vijay Nicole Imprints Pvt.Ltd,2013
2. V. Deltoro, "Principle of Electrical Engineering" PHI
3. SmarajtGhosh, "Fundamentals of Electrical & Electronics Engineering", Second edition, PHI Learning, 2007.
4. Metha V.K, RohitMetha, "Basic Electrical Engineering", Fifth edition, Chand. S & Co, 2012.
5. Kothari. D.P and Nagrath. I.J, "Basic Electrical Engineering", Second edition, Tata McGraw - Hill, 2009.
6. Bhattacharya. S.K, "Basic Electrical and Electronics Engineering", First edition, Pearson Education, 2011.

| Course Title | **Electrical Measurement & Instrumentation** | | |
|---|---|---|---|
| Course Code | | Credit | 3 |
| Core/ Elective | CEE | Semester | I |
| Prerequisite Knowledge | Fundamental of Physics and Mathematics | | |
| Course Aim | To teach the basic electrical and electronics measurements | | |
| Course Outcomes (COs) | **CO 1.** To analyze various errors in the measurement.<br>**CO 2.** To perform an extensive comparative study among the performance of analog instruments and electronic instruments.<br>**CO 3.** To analyses the new measurements techniques for measurement of Electrical quantity.<br>**CO 4.** To analyses the reasons of the errors in measurements and develop new techniques to reduce the error. | | |

Mapping of COs with POs

| CO ↓ | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | H | H | H | H | H | H | L | M | L | L | M | M | H | H | L |
| **2** | H | H | M | H | M | M | M | M | L | H | H | M | H | H | M |
| **3** | H | M | H | H | M | M | L | L | M | M | M | M | H | M | H |
| **4** | H | H | H | H | M | M | L | L | L | L | L | L | H | H | L |

L=Low, M=Medium, H=High

**UNIT 1 –PRINCIPLES OF MEASUREMENTS AND ANALOG INSTRUMENTS** [**8 Hours**]

Methods of measurement, Characteristics of instruments & measurement systems, Errors in measurement & its analysis.Principle of operation of Permanent Magnet Moving Coil (PMMC) and Moving Iron Instruments, Voltmeters & ammeters, Errors in Voltmeter and Ammeters, Range extension, Advantages and disadvantages, Electrodynamometer Instruments, Power (Single Phase and Three Phase) measurement, Compensation due to low Power factor. Induction Types Instruments, Energy (Single Phase and Three Phase) measurement.

**UNIT 2 – ELECTRONIC INSTRUMENTS** [**3 Hours**]

Digital Instruments for measurement of current, voltage, resistance etc., Measurement of frequency and phase angle,Cathode Ray Oscilloscopes (CRO) –Analog CRO, Lissajous Pattern

**UNIT 3 – POTENTIOMETERS & BRIDGES** [5 **Hours**]

D.C. Potentiometers, D.C. & A.C. Bridges, Measurement of inductance and capacitance & quality factor, Measurement of low, medium, high resistances. Advantages and Disadvantages of bridges.

**UNIT 4 – INSTRUMENT TRANSFORMERS** [**6 Hours**]

Principle of operation and applications, Current transformer and its error analysis, Potential transformer and its error analysis, Misc. Measurement**,** Frequency measurement.

**UNIT 5-MEASUREMENTOF NON-ELECTRICAL QUANTITY**: [**5 Hours**]

Transducers for measurement of displacement, strain, velocity, etc

**UNIT 6 – INSTRUMENTATION SYSTEMS:**

Role of Instrumentation, Elements of instrumentation system; Use of monitored information; Classification of data acquisition systems; Standards of instrumentation; Calibration; Recent developments, Transducer types.

**Text / Reference books**


1. E.W.Golding& F.C. Widdis, "Electrical measurement & measuring instruments," A.H.Wheeler&Co.Pvt. Ltd. India, 2011.
2. A. D.Helfrick&W.D.Cooper, "Electronic Instruments & Measurement Technique" Prentice Hall of India, 2008.
3. David A. Bell, "Electronic Instrumentation & Measurement," Oxford University Press-New Delhi, 3rdEdition, 2013.
4. M.B.Stout, "Basic Electrical measurement," Prentice Hall, 2ndEdition, 1965. 5. H. S. Kalsi, "Electronic Instrumentation;" McGraw Hill Education (India) Pvt. Ltd., 3rdEdition
5. D. Patranabis, “Principles of industrial instrumentation,” Tata McGraw Hill Education, 3rd Edition, 2010.


<table>
<tr><td colspan="2">Course Code:</td><td colspan="2">Workshop and Manufacturing Processes</td><td>Credits:<br>2</td></tr>
<tr><td>Core/<br>Elective</td><td colspan="2">PCE</td><td>Semester</td><td>I</td></tr>
</table>

**Prerequisites:** Nil

**Course Outcomes:**

| | |
|---|---|
| CO1 | Students will be able to understand the importance of manufacturing which comprises materials, processes and systems. |
| CO2 | Students will be able to understand the metal casting, metal working process and able to perform casting of metals, forging and sheet metal operations through practical classes. |
| CO3 | Students will be able to understand the machining operations, permanent joining processes. They will be able to perform machining operations on Lathe machine and joining through arc and gas welding processes. |
| CO4 | Students will be able to learn and perform operations related to carpentry, fitting, plastic molding, and Computer Numerical Control (CNC) machines. |

## Course Articulation Matrix:

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO1 0 | PO1 1 | PO1 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | - | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 |
| CO2 | 2 | 1 | 1 | - | - | 1 | 1 | - | 1 | 1 | 1 | 1 |
| CO3 | 2 | 1 | 1 | - | - | 1 | 1 | - | 1 | 1 | 1 | 1 |
| CO4 | 2 | 1 | 1 | - | 3 | 1 | 1 | - | 1 | 1 | 1 | 1 |
| ME1110 2 | 2 | 1 | 1 | - | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 |

**Correlation between ME11102 Workshop subject and the PSOs**

| Name of the B. Tech. Program | PSO1 | PSO2 | PSO3 | PSO4 |
|---|---|---|---|---|
| B. Tech. (Civil Engineering) | 2 | 1 | 1 | - |
| B. Tech (Mechanical Engineering) | 3 | 3 | | |
| B. Tech (Production & Industrial Engineering) | 3 | 3 | | |

| Unit | Details | No. Hrs |
|---|---|---|
| 1 | **Concept of Manufacturing-** Manufacturing definition; Role of materials, processes and systems in manufacturing; Classification and brief introduction of engineering materials such as metals & alloys, Classification and brief introduction of manufacturing processes | 4 |
| 2 | **Sand Casting Process of Metals-** Elements of Green Sand Mould; Pattern design and making, Method of Preparation of Green Sand Mould; Casting Defects | 2 |
| 3 | **Metalworking Processes-** Classification of Metalworking Processes-brief introduction of bulk and sheet metal processes, Hot Vs Cold Working; Hot and Cold Rolling; Types of Rolling Mills, Forging, Extrusion, Drawing | 3 |
| 4 | **Machining Processes:** Classification of machining processes & machine tools; Construction, Specification, and operations on Lathe Machine and Drilling machine | 2 |
| 5 | **Fabrication Processes-** Classification of Welding Operations, Types of Joints & Welding Positions; Brief description of Arc, Resistance and Gas welding techniques. Brazing and Soldering | 3 |

**List of Practical**

1. **Safety in Workshop (Demonstration)**
   Safety precautions and utilization of hand tools and machines of different shops with safe working habits.Introduction to measuring equipments and gauges of different shops.
2. **Carpentry**

Study of wood works, types of hand tools and machine. Making of one job involving wood work joint

3. **Fitting**
   Study of different fits and hand tools. Making of one job involving fitting to size, male-female fitting with drilling and tapping
4. **Welding**
   Study of electric arc welding and gas welding, tools, types of weld joints and safety precaution during welding.Making of one joint using electric and gas welding. Students will be introduced to brazing and soldering (demonstration)
5. **Sheet Metal Work**
   Study of different hand tools, machine and sheet metal joints. Making of one utility job in sheet metal
6. **Foundry**
   Principles of molding, methods, core & core boxes, preparation of sand mould of given pattern and casting (demonstration)
7. **Black Smithy**
   Introduction to hot working and Study of forging hand tools, furnace and machine. Making a job on hot upset forging.
8. **Machining**
   Study of lathe machine, cutting tools and turning related operations.Making of one job on lathe machine including facing, step and taper turning, threading operations.
9. **Plastic Processing**
   Introduction to plastics and different plastic moldingtechniques.Study of injection molding process with demonstration.
10. **Computer Numerical Control (CNC)**
    Introduction to automation & CNC, Assembly of models of CNC, CNC wood router, engraving and exposure to part programming.Preparation of part program for simple profiles.Making a job on CNC (Demonstration).
11. **Mini Project**
    Team activity – Fabrication of prototype model based on above practical.

**Textbooks:**

1 Fundamental of Modern Manufacturing: Materials, Processes and Systems Mikell P. Groover John Wiley

**References:**

1. Elements of Workshop Technology (Volume 1: Manufacturing Processes, Volume 2: Machine Tools), S. K. HajraChoudhury, A. K. HajraChoudhury and N. Roy, Media Promoters & Publishers Pvt Ltd., 2010
2. Manufacturing Engineering and Technology, SeropeKalpakjian and Steven R. Schmid Pearson, 2013
3. Machinery's Handbook Erik Oberg, Franklin D. Jones, Holbrook L. Horton, Henry H. Ryffel, and Christopher J. McCauley Laura Brengelman Industrial Press, Inc., 2020
4. Mechatronics HMT McGraw Hill Education, 2017
5. Manufacturing Processes I,https://nptel.ac.in/courses/112107144, NPTEL course
6. Fundamentals of manufacturing processes, ttps://onlinecourses.nptel.ac.in/noc22_me71/preview

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|---|---|---|---|
| Course Title | **Mathematics-II** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEF | Semester | II |

**Unit –I Linear Algebra:(6 Lectures)**

Vector spaces, Subspaces, Linear dependence and independence, Basis and dimension, Dimension theorem. Linear Transformation, Rank – Nulity Theorem (Statement only), Computation of Rank and nullity of LT, Solution of linear simultaneous algebraic equations

**Unit –II Eigenvalues and Eigenvectors:(6 Lectures)**

Eigenvalues and Eigenvectors, Cayley-Hamilton theorem, Application of Eigen Values and Eigen Vectors: Quadratic form, Diagonalization, Canonical forms and solving system of first order differential equations.

**Unit – III Partial Differential Equation: (8 Lectures)**

First order PDE, Formation of PDE, Classification of solution: Complete, General and Particular solution, Lagrange's linear PDE, Non-Linear First Order PDE, Some Standard form -I, II, III, IV. Charpit's method. Higher Order Homogeneous linear PDE with constant coefficients, C. F. & P.I, Non-homogeneous PDE with constant coefficients, C. F. & P. I. Method of separation of variables.

**Unit- IV Laplace Transform: (7 Lectures)**

Laplace transformation and its properties, Unit – step, Impulse and Periodic functions, Error Function. Inverse Laplace Transform, Convolution Theorem, Evaluation of Integral by Laplace Transform, Application of Laplace transform to solution of ODE & PDE.

**Unit-V Fourier Series (6 Lectures):**

Fourier series, Convergence of Fourier Series, Half range series. Fourier Integral, Fourier sine and Cosine Integral, Complex form of Fourier Integral.

**Unit-VI Fourier Transform: (7 Lectures):**

Fourier Transform, Fourier Sine and Cosine Transform, Finite sine and cosine transform, Convolution theorem, Application of Fourier Transform to solve boundary value problems (ODE & PDE).

**Reference Books:**

1. R. K. Jain and S. R. K. Iyenger, Advanced Engineering Mathematics, Narosa Pub. House
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
4. QaziZameeruddin & Surjeet Singh, Modern Algebra, S Chand Publication

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|---|---|---|---|
| Course Title | **BASIC ELECTRICAL ENGINEERING (Core Engg. Supporting Courses)**<br>**(For Other Department)** | | |
| Course Code | | Credit | 3 |
| Core/ Elective | CES | Semester | II |
| Prerequisite Knowledge | Basic Knowledge of Physics | | |
| Course Aim | To provide comprehensive idea about AC and DC circuit analysis, working principles and applications of basic machines in electrical engineering, and general electrical safety procedures. | | |
| Course Outcomes (COs) | At the end of the course students will<br>**CO1:** be able to conceptualize DC circuits, andanalyze and simulate the DC networks/ circuits.<br>**CO2:** be able to conceptualize magnetic circuits, and to analyze and simulate them.<br>**CO3:** be able to conceptualize AC circuits, and to analyze and simulate them.<br>**CO4:** be able to draw the construction of basic electrical machines, i.e., transformer and DC motor/ generators. Understand the working principle of these machines.<br>**CO5:** acquire the general idea of electrical safety. | | |

**UNIT 1 – FUNDAMENTALS OF DC CIRCUITS: (6 Hours)**

Introduction to DC and AC circuits, Active and passive two terminal elements, Ohms law, Voltage-Current relations for resistor, inductor, capacitor , Kirchhoff's laws, Mesh analysis, Nodal analysis, Ideal sources –equivalent resistor, current division, voltage division, Star-Delta Transformation, DC Network Theorems

**UNIT 2 – MAGNETIC CIRCUITS: (6 hours)**

Introduction to magnetic circuits, analogy between electrical and magnetic circuit, Simple magnetic circuit with DC and AC excitations-Faraday's laws, induced emfs and inductances, magnetic leakages, B-H curve, hysteresis and eddy current loss, magnetic circuit calculations, mutual coupling

**UNIT 3– AC CIRCUITS: (6 hours)**

Sinusoids, Generation of AC, Average and RMS values, Form and peak factors, concept of phasor representation, J operator Analysis of R-L, R-C, R-L-C circuits Introduction to three phase systems - types of connections, relationship between line and phase values.

**UNIT 4 –SINGLE- PHASE TRANSFORMER: (6 hours)**

Principle of operation, construction, emf equation, equivalent circuit, power losses, efficiency, introduction to auto transformer

**UNIT 5 – ELECTRICAL MACHINES: (6 hours)**

Working principle, construction and applications of DC machines and AC machines, single phase induction motors, Double revolving field theory, Equivalent circuit, No load and blocked rotor tests, Starting methods, Repulsion Motor, split phase, capacitor start and capacitor start & run motors).

**Text / Reference books**


1. Dash. S.S, Subramani. C, Vijayakumar. K, "BasicElectrical Engineering", First edition, Vijay Nicole Imprints Pvt.Ltd,2013
2. V. Deltoro,"Principle of Electrical Engineering" PHI
3. SmarajtGhosh, "Fundamentals of Electrical & Electronics Engineering", Second edition, PHI Learning, 2007.
4. Metha V.K, RohitMetha, "Basic Electrical Engineering", Fifth edition, Chand. S & Co, 2012.
5. Kothari.D.P and Nagrath.I.J, "Basic Electrical Engineering", Second edition, Tata McGraw - Hill, 2009.
6. Bhattacharya.S.K, "Basic Electrical and Electronics Engineering", First edition, Pearson Education, 2011.


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|---|---|---|---|
| Course Title | **ELECTRICAL MEASUREMENT AND MEASURING INSTRUMENTS**<br>(Core Engg. Supporting Course)**(For Other Department)** | | |
| Course Code | | Credit | 3 |
| Core/ Elective | CES | Semester | II |
| Prerequisite Knowledge | Physics, Mathematics | | |
| Course Aim | To understand the operating principle of various measuring devices and thereby able to select appropriate device for measuring different process variables. | | |
| Course Outcomes (COs) | At the end of the course students will be able<br>**CO1:** to analyze various errors in the measurement.<br>**CO2:** to perform an extensive comparative study among the performance of analog instruments and electronic instruments.<br>**CO3:** to calculate different circuit parameters AC & DC bridges.<br>**CO4:** to compute the errors of instrumentation transformer(s).<br>**CO5:** to understand the operating principles of D/A & A/D converters. | | |

**UNIT 1 –PRINCIPLES OF MEASUREMENT AND ERROR ANALYSIS:**

Methods of measurement, Characteristics of instruments & measurement systems, Errors in measurement & its analysis.

**UNIT 2 –ANALOG INSTRUMENTS:**

Classification, Principle of operation of Permanent Magnet Moving Coil (PMMC) and Moving Iron Instruments, Voltmeters & ammeters, Errors in Voltmeter and Ammeters, Range extension, Advantages and disadvantages, Electrodynamometer Instruments, Power & Energy measurement

**UNIT 3 – ELECTRONIC INSTRUMENTS:**

Digital Instruments for measurement of current, voltage, resistance etc., Measurement of frequency & phase, Cathode Ray Oscilloscopes (CRO) –analog and special CRO.

**UNIT 4 – POTENTIOMETERS & BRIDGES:**

D.C. & A.C. Potentiometers, D.C. & A.C. Bridges, Measurement of inductance and capacitance & quality factor, Measurement of low, medium, high resistances and earth Resistances.

**UNIT 5 – INSTRUMENT TRANSFORMERS:**

Principle of operation and applications, Current transformer and its error analysis, Potential transformer and its error analysis, Misc. Measurement**,** Frequency & power factor, Harmonic analyser, Power analyser.

**UNIT 6–INTRODUCTION TO DAC & ADC SYSTEM:**

Analog to Digital Conversion: Ramp, Voltage to Frequency Converter (Integrating type), Dual slope integration Techniques, Digital to Analog Conversion: Weighted Resistor type, R-2R Ladder type, Specification of D/A Converter -Resolution, Accuracy.

**Text/ Reference Books:**


1. E.W.Golding&F.C.Widdis, "Electrical measurement & measuring instruments," A.H.Wheeler&Co.Pvt. Ltd. India, 2011.
2. A.D.Helfrick&W.D.Cooper, "Electronic Instruments & Measurement Technique" Prentice Hall of India, 2008.
3. David A. Bell, "Electronic Instrumentation & Measurement," Oxford University Press-New Delhi, 3rd Edition, 2013.
4. M.B.Stout, "Basic Electrical measurement," Prentice Hall, 2nd Edition, 1965.
5. H. S. Kalsi, "Electronic Instrumentation," McGraw Hill Education (India) Pvt. Ltd., 3rd Edition, 2010.

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|---|---|---|---|
| Course Title | **Introduction to Simulation Tools** (Core Engg. Supporting Course)<br>**(For Other Department)** | | |
| Course Code | | Credit | 3 |
| Core/ Elective | CES | Semester | II |
| Prerequisite Knowledge | Physics, Mathematics, Basic Electrical Engineering. | | |
| Course Aim | To teach the basics electrical engineering and application of mathematics with Simulation Software. | | |
| Course Outcomes (COs) | At the end of the course students will (Number may vary)<br>**CO 1.** To understand the Modeling of Electrical Circuits and other Physical system.<br>**CO 2.** To analyze the transient and steady state response of electrical Circuit .<br>**CO 3.** To understand system characteristic with MATLAB/SIMULINK and other simulation software.<br>**CO 4.** To understand system characteristic with PSCAD/EMTDC and PSpice simulation software. | | |

Mapping of COs with POs

| CO ↓ | PO 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | H | H | H | H | M | H | M | L | M | L | L | L | H | M | M |
| **2** | H | H | M | H | M | M | M | M | L | H | H | M | H | M | M |
| **3** | H | M | H | H | M | L | L | L | M | M | M | M | H | M | H |
| **4** | H | H | H | H | M | L | L | L | L | L | L | L | H | H | H |

L=Low, M=Medium, H=High

**UNIT 1 –INTRODUCTION TO MODELING OF ELECTRICAL CIRCUITS [6 Hours]**

Fundamental Concepts in Mathematical Modelling: Basic properties– linearity and superposition – balance and conservation laws and the system – boundary approach. Lumped – Element Modelling: Mechanical systems – Translational, rotational. RLC Electrical Systems, Transients in Electrical Circuit. Pole-Zero approach

**UNIT 2: Basics of MATLAB Coding [5 Hours]**

**UNIT 3 – Introduction to MATLAB/SIMULINK [7 Hours]**

Different simulations tools boxes for Electrical Engineering in MATLAB/SIMULINK. Introduction to MATLAB/SIMULINK software, Simulation of BASIC RLC circuit using MATLAB, Transfer of data to MATLAB and Different Types of the Non Linearities: Saturation, Delay, etc Numerical Solution of Linear and Non-Liner Equation. GAUSS elimination method, LU Matrix Decomposition method, GAUSS-SEIDEL method, Newton iterative method, Chebyshev Polynomials. EULERS method.

**UNIT 4 – Introduction to LabView**

**Unit 5- Introduction to HIL Simulation**

**Text / Reference books**

1. S. Rosloneic,"Fundamental numerical methods of Electrical Engineering, lecture Notes in Electrical Engineering, Springer 2018
2. J. Robert, D.K. Tran, Modelling and Simulation of Electrical Machines and Power Systems: International Symposium Proceedings Hardcover – Import, 1 May 1988.
3. Dr. V P Singh , System Modeling And Simulation by, New Age International (P) Ltd., Publishers,2016
4. Dac-Nhuong Le, SairamTadepalli, Jyotir Moy Chatterjee, Pramod Singh Rathore, Abhishek Kumar Pandey Network Modeling, Simulation and Analysis in MATLAB: Theory and Practices, PHI 2018

| | | | |
|---|---|---|---|
| Course Title | **Electrical Circuits** (Core Engg. Supporting Course)<br>**(For Other Department)** | | |
| Course Code | | Credit | 3 |
| Core/ Elective | CES | Semester | II |
| Prerequisite Knowledge | 1. Basic Electrical Engineering<br>2. Mathematics-I | | |
| Course Aim | Understand the basic concepts, basic laws and methods of analysis of DC and AC networks and reduce the complexity of network using source shifting, source transformation and network reduction using transformations. | | |
| Course Outcomes (COs) | At the end of the course students will be able to:<br>CO1: Solve complex electric circuits using network theorems.<br>CO2: Discuss resonance in series and parallel circuits and also the importance of initial conditions and their evaluation.<br>CO3: Synthesize typical waveforms using Laplace transformation.<br>CO4: Solve unbalanced three phase systems and also evaluate the performance of two port networks. | | |

| | |
|---|---|
| Mapping of COs with POs | (see table below) |

| | CO1 | CO2 | CO3 | CO4 |
|---|---|---|---|---|
| **PO1** | H | H | H | M |
| **PO2** | H | H | H | H |
| **PO3** | M | H | H | H |
| **PO4** | L | M | H | H |
| **PO5** | H | L | H | H |
| **PO6** | M | L | H | M |
| **PO7** | M | L | M | M |
| **PO8** | L | L | M | L |
| **PO9** | H | L | M | M |
| **PO10** | L | M | L | L |
| **PO11** | L | L | L | L |
| **PO12** | M | M | M | M |

Mapping of COs with PSOs

| | CO1 | CO2 | CO3 | CO4 |
|---|---|---|---|---|
| PSO1 | H | H | H | H |
| PSO2 | H | H | H | H |
| PSO3 | M | M | M | M |

**Module 1: Basic Concepts: (9 Hours)**

Active and passive elements, Concept of ideal and practical sources. Source transformation and Source shifting, Concept of Super-Mesh and Super node analysis. Analysis of networks by (i) Network reduction method including star – delta transformation, (ii) Mesh and Node voltage methods for ac and DC circuits with independent and dependent sources. Duality

**Module 2: Network Theorems: (8 Hours)**

Super Position theorem, Reciprocity theorem, Thevenin’s theorem, Norton’s theorem, Maximum power transfer theorem and Millman’s theorem. Analysis of networks, with and without dependent ac and DC sources.

**Module 3: Resonant Circuits: (4 Hours)**

Analysis of simple series RLC and parallel RLC circuits under resonances. Problems on Resonant frequency, Bandwidth and Quality factor at resonance

**Module 4:Transient Analysis: (5 Hours)**

Transient analysis of RL and RC circuits under DC excitations: Behavior of circuit elements under switching action($t=0$ and $t=\infty$) , Evaluation of initial conditions.

**Module 5: Two Port networks: (4 Hours)**

Definition, Open circuit impedance, Short circuit admittance and Transmission parameters and their evaluation for simple circuits, relationships between parameter sets.

**Textbooks**

1 Engineering Circuit Analysis William H Hayt et al McGraw Hill 8th Edition , 2014

2 Network Analysis M.E.Vanvalkenburg Pearson 3rd Edition , 2014
3 Fundamentals of Electric Circuits Charles K Alexander Matthew N O SadikuMcGraw Hill 5th Edition,2013

**Reference Books**

1 Engineering Circuit Analysis J David Irwin et al Wiley India 10th Edition, 2014
2 Electric Circuits MahmoodNahviMcGraw Hill 5th Edition, 2009
3 Introduction to Electric Circuits Rich ard C Dorf and James A Svoboda Wiley 9th Edition, 2015
4 Circuit Analysis ; Theory and Practice Allan H Robbins Wilhelm C Miller Cengage 5th Edition, 2013
5 Basic Electrical Engineering V K Mehta, Rohit Mehta S Chand 6th Edition 2015

| | | | |
|---|---|---|---|
| Course Title | **Network Analysis** | | |
| Course Code | | Credit | 3 |
| Core/ Elective | CEE | Semester | II |
| Prerequisite Knowledge | 1. Basic Electrical Engineering<br>2. Mathematics-I | | |
| Course Aim | To perform transient analysis of electrical networks applying Laplace transform, learn about coupling circuits and network synthesis, evaluate the various electrical parameters using two-port networks etc. | | |
| Course Outcomes (COs) | At the end of the course students will be able to:<br>CO1: to perform transient analysis applying Laplace transform.<br>CO2: get the idea of 2-port networks and their applications.<br>CO3: solve coupling electrical circuits.<br>CO4: get the basic idea of network synthesis. | | |
| Mapping of COs with POs | (see table below) | | |

Mapping of COs with POs:

| | **CO1** | **CO2** | **CO3** | **CO4** |
|---|---|---|---|---|
| **PO1** | H | H | H | M |
| **PO2** | H | H | H | H |
| **PO3** | M | H | H | H |
| **PO4** | L | M | H | H |
| **PO5** | H | L | H | H |
| **PO6** | M | L | H | M |
| **PO7** | M | L | M | M |
| **PO8** | L | L | M | L |
| **PO9** | H | L | M | M |
| **PO10** | L | M | L | L |
| **PO11** | L | L | L | L |
| **PO12** | M | M | M | M |

| | |
|---|---|
| Mapping of COs with PSOs | <table><tr><th></th><th>CO1</th><th>CO2</th><th>CO3</th><th>CO4</th></tr><tr><td>PSO1</td><td>H</td><td>H</td><td>H</td><td>H</td></tr><tr><td>PSO2</td><td>H</td><td>H</td><td>H</td><td>H</td></tr><tr><td>PSO3</td><td>M</td><td>M</td><td>M</td><td>M</td></tr></table> |

**Module 1: Laplace transform and transient analysis (9 Hours)**

Representation of LTI system (Continuous time), Laplace transform: Revisited, Initial and Final value theorems, Standard test functions: step, ramp, Dirac delta.
Transient analysis using Laplace transform: 1st Order (RL, RC) and 2nd Order (RLC) Systems.

**Module 2: Two-port Networks (8 Hours)**

Interconnection of two-port networks, two-port network parameters (Z, Y, T, $T^{-1}$, h, g), Symmetrical & Reciprocal networks, Inter-conversion of two-port network parameters, Ladder networks, T-M transformation, Image & characteristic impedance. Network functions: Driving point and Transfer functions.

**Module 3: Magnetically coupled Circuits (4 Hours)**

Magnetic coupling, DOT conventions, Polarity of coils, Polarity of induced voltage, Concept of Self and Mutual inductance, Coefficient of coupling, Modeling of coupled circuits: Series, Parallel, & Parallel opposing.

**Module 4:Positive Real Function (5 Hours)**

Positive real functions and network synthesis, Definition and properties and testing, Synthesis of LC, RL & RC circuits using Cauer and Foster's first and second form, Passive filter synthesis.

**Text / Reference books**


1. M.E. Van Valkenberg, "Network Analysis," Prentice Hall of India, 3rd Edition, 2014.
2. D. Roy Choudhary, "Networks & Systems," New Age International, 2nd Edition, 2013.
3. W. H. Haytand J. E. Kemmerly, "Engineering circuit Analysis," Tata McGraw-Hill, 8th Edition, 2013.
4. A Chakrabarti& S. Bhadra, "Network Analysis and Synthesis," McGraw Hill education, 1st Edition, 2009.


| Course Title | **Electrical Workshop** | | |
|---|---|---|---|
| Course Code | | Credit | 2 |
| Core/ Elective | CEE | Semester | II |
| Prerequisite Knowledge | NIL | | |

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|---|---|
| Course Aim | • To explain the various types of cables, connectors, switches, protective devices<br>• To explain the house wiring with protection devices<br>• To teach the various grounding techniques<br>• To teach the modelling of inductors |
| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:**Understand the various types of cables, connectors and switches<br>**CO2:**Understand the various protection devices, such as fuse, relays, MCB, MCCB and ELCB<br>**CO3:**Provide wiring connections in houses<br>**CO4:**Provide grounding/earthing<br>**CO5:**Model the inductors and transformers |
| Mapping of COs with POs | (see table below) |

| | PO | | | | | | | | | | | | PSO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** | **3** |
| **CO1** | H | H | H | H | H | H | M | L | H | L | L | L | H | L | L |
| **CO2** | H | H | H | H | H | H | M | L | H | L | L | L | H | L | L |
| **CO3** | H | H | H | H | H | H | M | L | H | L | L | L | H | L | L |
| **CO4** | H | H | H | H | H | H | M | L | H | L | L | L | H | L | L |
| **CO5** | H | H | H | H | H | H | M | L | H | L | L | L | H | L | L |

**UNIT 1** **[6 hours]**

CABLES: General specifications of cables- characteristic impedance, current carrying capacity, flexibility. Types of cables – SWG Single core, Multi core, Single strand, Multi strand and their types, Armoued cable, Shielded wires, Coaxial cables, Twisted pair, Flat ribbon cable' Teflon coated wires etc.

CONNECTORS: General specifications of connectors- contact resistance, breakdown voltage, insulation resistance, etc.

**UNIT 2** **[3 hours]**

SWITCHES: Toggle switch- SPDT, DPDT,TPDT, Centre off, Without centre off, Rotary switch types depending on their poles and positions Rocker switch, Push button latch and non latch, Tactile switch, Micro switch, Limit switch, DIP switch, Thumb wheel switch- BCD, Decimal, Membrane switch, , Power electronic switches.

**UNIT 3** **[8 hours]**

FUSES: Glass ,Ceramic fuse, Resettable fuse, Shunt fuse- MOV, HRC fuse

RELAYS: construction, working and application of General purpose relay, NO,NC contact, Difference between switch & relay

MCB, MCCB, ELCB: Construction working and applications.

**UNIT 4** **[8 hours]**

WIRING: Wiring of simple light circuit for controlling light/ fan point (PVC conduit wiring), Wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter,

STAR RATING: Energy saving and star rating of electrical appliances,

**UNIT 5** **[7 hours]**

GROUNDING and INSULATION: Different types of grounding techniques, measure earth resistance, testing of insulation resistance, purpose of test lamp, Lightning and surge arrestors, substation equipments.

**UNIT 6** **[6 hours]**

RATINGS: Ratings of Common Electrical Appliances: Transformer, Motors, Batteries, UPS, Inverters, Chargers, EVs etc.

| | | | |
|---|---|---|---|
| Course Title | **DATA STRUCTURE AND OPERATING SYSTEMS** | | |
| Course Code | | Credit | 3 |
| Core/ Elective | CES | Semester | III |
| Prerequisite Knowledge | **1.** Mathematics<br>**2.** C-Language | | |
| Course Aim | To expertise students in problem solving and computer programming. | | |
| Course Outcomes (COs) | **After completion of the course students shall be able to:**<br>CO1 Understand the concept of ADT, identify data structures suitable to solve problems<br>CO2 Develop and analyze algorithms for stacks, queues<br>CO3 Develop algorithms for binary trees and graphs<br>CO4 Implement sorting and searching algorithms<br>CO5 Implement symbol table using hashing techniques and multi-way search trees | | |

Mapping of COs with POs

| | **CO 1** | **CO 2** | **CO 3** | **CO 4** | **CO 5** |
|---|---|---|---|---|---|
| **PO 1** | High | High | High | Low | Low |
| **PO 2** | High | High | High | Medium | Low |
| **PO 3** | High | Low | High | High | High |
| **PO 4** | Medium | High | Low | High | Medium |
| **PO 5** | Medium | High | Low | High | Medium |
| **PO 6** | Medium | Medium | Medium | Low | Low |
| **PO 7** | Medium | Medium | Medium | Low | Medium |
| **PO 8** | Low | Low | Medium | Low | Low |
| **PO 9** | Medium | Low | Medium | Medium | Low |
| **PO 10** | Medium | Medium | Medium | Medium | Medium |
| **PO 11** | Low | Medium | Medium | Low | Low |
| **PO 12** | Low | Medium | Medium | Low | Low |

UNIT 1 - Basic Computer Architecture, Function and structure of Hardware and Software Components, CPU, ALU, Memory, 110 devices, System Software, Application Software.

UNIT 2 - Introduction, Motivation, and Overview of an Operating System with an emphasis onits role as a Manager of Hardware Resources, History of Computer Hardware (including areview ofH/W structures) and how Operating Systems Evolved in tandem with the Hardware.

UNIT 3 - Programming software (Writing software),Program and Process, Program specifications and' design, Abstract data types, Basics of C, Time and space complexity ofPrograms.

UNIT 4 - Need of Data Structures, Linear and nonlinear Data structure, Stack, Queue, Tree, Graph, B-tree.

UNIT 5 - Processor and Memory Management, Process Management, Concurrent Process,Semaphores, Fork and Join, CPU Scheduling including Preemptive, and Non-Preemptive,Application of Stack and Queue, Sequential and linked implementation, in designing programfor CPU and Disk scheduling, Page Tables, Page Replacement Algorithms.

References:


1. Horowitz and Sahni, "Pundamentals of data structures,"Computer Science Press, ReprintedEdition, 1988.
2. Tanenbaum, "Data StructurelJsing C," Pearson India, 1st Edition, 1998.
3. Abraham Silberschatz and Peter Galvin,"Operating System Concepts,"John Wiley &Sons Inc, 9th Edition, 2012.


| Course Title | **ANALOG AND DIGITAL ELECTRONICS** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CES | Semester | III |
| Prerequisite Knowledge | **1.** Mathematics<br>**2.** Basic Electrical Engineering<br>**3.** Principle of Electronics | | |
| Course Aim | | | |
| Course Outcomes (COs) | **After completion of the course students shall be able to:**<br>CO1 Design digital components including - decoders, multiplexers, arithmetic circuits<br>CO2 Design of synchronous sequential circuits<br>CO3 Analyze digital systems and improve the performance by reducing complexities.<br>CO4 Test digital systems and analyze faults. | | |

Mapping of COs with POs

| | CO 1 | CO 2 | CO 3 | CO 4 | CO 5 |
|---|---|---|---|---|---|
| **PO 1** | High | High | High | Low | Low |
| **PO 2** | High | High | High | Medium | Low |
| **PO 3** | High | Low | High | High | High |
| **PO 4** | Medium | High | Low | High | Medium |
| **PO 5** | High | High | Low | High | Medium |
| **PO 6** | High | Medium | Medium | Low | Low |
| **PO 7** | High | Medium | Medium | Low | Medium |
| **PO 8** | Low | Low | Medium | Low | Low |
| **PO 9** | Medium | Low | Low | Medium | Low |
| **PO 10** | Medium | Medium | Low | Medium | Medium |
| **PO 11** | Low | Medium | Medium | Low | Low |
| **PO 12** | Low | Medium | Medium | Low | Low |

**Part-A: Analog Electronics**

1. Introduction to electronics: Overview of semiconductor physics, review of P-N junction operation,Characteristics of PN-Junction diode, Zener diode, Schottky diode, LED, LCD. Applications of diodes:Rectifiers with filters (C, L, LC and $\pi$), Zener diode as a voltage regulator, Problem solving.
2. BJT- CE, CB and CC configurations, CE Transistor Characteristics, Low frequency h-parametermodel, Transistor Biasing, Stability and Thermal Runaway; JFET Characteristics, MOSFET:Enhancement and depletion mode characteristics.

Applications: Single stage RC coupled amplifier andit's frequency response, gain-band width product, differential amplifier, CMRR, Transistor as a switch, Problem Solving.

3. Feedback in Amplifiers: feedback topology-negative feedback, voltage series and shunt feedbacks, positive feedback, Bark-Hausen criterion, Oscillators- RC and LC Oscillators.
4. Integrated circuits: Introduction, Operational amplifiers(μA 741)- Ideal and practical characteristicsand linear applications, V-I Converter and I-V Converters, Precision Rectifiers, Log and Antilog Amplifiers, Comparator Principle, Astable and monostable multivibrators, Sine wave and Triangularwave generators 555 Timer: Functional block diagram, Astable and monostable multivibrators Problem Solving.
5. Regulated power supply: Shunt and series voltage regulators, UPS, Linear voltage regulator IC723, high and low voltage design, current boosting and current folding operation, 3-terminal regulator ICs.

**Part- B : Digital Electronics**

1. Number system and codes:Analog versus digital system, number systems, base conversions, complements of numbers weighted and unweighted codes and error detecting and correcting codes, Alpha numeric code (ASCII), Errordetecting and correcting codes.
2. Switching algebra and switching functions: Boolean algebra, postulates, theorems and switchingalgebra, completely and incompletely specified switching functions, Representation of Booleanfunctions in sum of products form and product of sums form, minimization of Boolean functions using Karnaugh map and Quine McCluskey methods. Problem solving.
3. Combinational logic circuits and logic families: Logic gates, Logic gates operation using discretecomponents, Universal Logic gates, Logic design of combinational circuits: adders, Code converters,Comparators, multiplexers, de-multiplexers, encoders, decoders, buffers, tri-state buffers. Transistor asan inverter, Classification of logic families and their developments. TTL NAND gate analysis, ECLand CMOS logic family. Comparison TTL CMOS and ECL logic families.
4. Sequential Logic circuits: Flip-Flops- RS Flip flop, Clocked RS flip-flop, JK flip-flop, T-flip-flop, JK flip-flops and M/S JK flip flop, Conversion of flip-flops. Registers: Buffer Register, Controlled bufferregister, Shift Registers,Universal shift register: SISO, SIPO, PISO, PIPO, Ring counter and twistedring counter, Counters: Design of Asynchronous and Synchronous counters.

Text Books / Reference Books / Online Resources:


***1.*** Jacob Millman, Christos Halkias, Chetan Parikh, "Millman's Integrated Electronics", 2nd Edition, McGraw Hill Education, 2017.
***2.*** Bhargava N. N., D C Kulshreshtha and S C Gupta, "Basic Electronics & Linear Circuits", Tata McGraw Hill, 2nd Edition, 2013.
***3.*** D.RoyChoudhury, Shail B. Jain, "Linear Integrated Circuits", 4th Edition, New Age International Publishers, 2018.
***4.*** Ramakant A. Gayakwad, "Operational Amplifiers and Linear IC Technology", PHI,1987.
***5.*** Donald P. Leach, Malvino and Saha, "Digital Principles and Applications (SIE)", 8th Edition Paperback, McGraw Hill Education, 2014.
***6.*** ZviKohavi, Niraj K Jha, "Switching and Finite Automata Theory", 8th Edition, McGraw-Hill Eighth edition
***7.*** Robert L.Morris John R.Miller, "Designing with TTL Integrated Circuits", McGraw-Hill
***8.*** Herbert Taub, Donald Schilling, "Digital Integrated Electronics", McGraw-Hil.


| | | | |
|---|---|---|---|
| Course Title | **SIGNALS AND SYSTEM** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | III |
| Prerequisite Knowledge | Mathematics | | |
| Course Aim | To understand the fundamental characteristics of signals and systems, concepts of continuous-time and discrete-time LTI systems with their analysis, time and transform domains, mathematical skills to solve problems involving convolution, filtering, modulation and sampling. | | |

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|---|---|
| Course Outcomes (COs) | At the end of this course students will be able to:<br>**CO1:** Understand the basics of signals and systems.<br>**CO2:**Analyze the characteristics of continuous-time periodic and aperiodic signals using Fourier analysis.<br>**CO3:** Classify systems based on their properties and determine the response of LTI system using convolution.<br>**CO4:**Analyze system properties based on impulse response and Fourier analysis.<br>**CO5:** Apply the Laplace transform and Z-transform for analyze of continuous-time and discrete-time signals and systems, understand the process of sampling. |

**UNIT 1–**Classification of signals and systems; Continuous-time and discrete-time signals: exponential and sinusoidal signals, unit impulses and unit step functions; Continuous-time and discrete-time systems; Basic system properties.

**UNIT2–** Continuous-time and discrete-time LTI systems; Properties of LTI systems; Unit step response of an LTI system; Causal LTI systems described by differential and difference equations.

**UNIT3–** Analysis and characterisation of LTI systems using Laplace transform; Continuous-time Fourier transform of aperiodic and periodic signals; Properties of continuous-time Fourier transform.

**UNIT4–** Representation of continuous-time signals by its samples; The sampling theorem; Reconstruction of sampled signals; The aliasing effect; Discrete-time processing of continuous-time signals.

**UNIT5–**Thez-transform and its properties; Analysis and characterisation of LTI systems using z-transform; Discrete-time Fourier transform of aperiodic and periodic signals; Properties of discrete-time Fourier transform; The discrete Fourier transform; Introduction to linear feedback systems.

**Books/References:**

1. A. V. Oppenheim, A. S. Wilsky and H. Nawab, “Signals & Systems,” 2nd Edition, Prentice-Hall, 1997.
2. Simon Haykin and Barry Van, “Signals & Systems,” 2nd Edition, Wiley, 2007.
3. H. P. Hsu, “Signals & Systems,” 2nd Edition, Schaum’s Outline Series, 2009.

| | | | |
|---|---|---|---|
| Course Title | **Principles of Management** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | PCE | Semester | III |
| Prerequisite Knowledge | Nil | | |
| Course Aim | To enable the students to study the evolution of Management | | |

**Course Outcomes (COs)**

At the end of the course the students will

**CO 1.** have clear understanding of managerial functions like planning, and have same basicknowledge on international aspect of management

**CO 2.** understand the planning process in the organization

**CO 3.** understand the concept of organization

**CO 4.** demonstrate the ability to directing,leadership and communicate effectively

**Mapping of COs with POs**

| CO ↓ | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | H | | M | L | | M | M | H | H | L |
| 2 | | | | | | M | | M | L | H | | | L | H | M |
| 3 | | | | | | M | | L | M | M | | | H | M | H |
| 4 | | | | | | M | | L | L | L | L | L | H | H | L |

L=Low, M=Medium, H=High

**UNIT 1** -INTRODUCTION TO MANAGEMENT: Definition of Management - Science or Art - Management and Administration, Functions of Management - Types of Business Organization. Levels of management and Managerial skills

**UNIT 2** -SCHOOL OF MANAGEMENT THOUGHTS: Evolution of Management thoughts, classical approach, neo- classical approach, contribution of Taylor, Weber and Fayol, modern approach

**UNIT 3** -PLANNING: Nature & Purpose - Steps involved in Planning ,Objectives, Setting Objectives, Process of Managing by Objectives ,Strategies, Policies & Planning Premises Forecasting Decisionmaking.

**UNIT 4** - ORGANIZING: Nature and Purpose - Formal and informal organization - Organization Chart - Structure and Process - Depart mentation by difference strategies - Line and Staff authority -- Benefits and Limitations - De-Centralization and Delegation of Authority - Staffing - Selection ProcessTechniques-HRD-Managerial-Effectiveness. Directing: Scope - Human Factors - Creativity and Innovation - Harmonizing Objectives - Leadership - Types of Leadership Motivation - Hierarchy of needs - Motivation theories -

| |
|---|
| Motivational Techniques - Job Enrichment - Communication - Process of Communication - Barriers and Breakdown - Effective Communication - Electronic media in Communication.<br><br>**UNIT 5** -CONTROLLING: System and process of Controlling - Requirements for effective control - The Budget as Control Technique-- Information Technology in Controlling - Use of computers in handling the information - Productivity - Problems and Management - Control of Overall Performance. Coordination.<br><br>**UNIT 6** -ORGANISATIONAL BEHAVIOUR: Organisational change, Conflict Management and Stress Management, Functional management: Human Resource Management, Financial management, Marketing Management.<br><br>**Text/Reference Books:**<br>I. P. C Tripathi&P.N. Reddy, "Principles of Management," Tata McGraw-Hill, 4th Edition, 2008.<br>2. D.A Decenzo, S.P Robbino, "Personnel and Human Reasons Management," Wiley India Pvt. Ltd, 10th idition, 20II. 3. J. A. F Stomer, R.E .. Freeman and D.R Gilbert, JR. "Management", Pearson Education, 6th Edition, 2003.<br>4. I-I.Kooritz& 1-1. Weihrich, "Essentials of Management," Mcgraw Hill Education, 9th 2012. |

| **Course Title** | **Simulation Tools for Electrical Engineering** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | III |
| Prerequisite Knowledge | Physics, Mathematics, Basic Electrical Engineering. | | |
| Course Aim | To teach the basics electrical engineering and application of mathematics with Simulation Software. | | |
| Course Outcomes (COs) | At the end of the course students will (Number may vary)<br>**CO 1.** To understand the Modeling of Electrical Circuits and other Physical system.<br>**CO 2.** To analyze the transient and steady state response of electrical Circuit .<br>**CO 3.** To understand system characteristic with MATLAB/SIMULINK and other simulation software.<br>**CO 4.** To understand system characteristic with PSCAD/EMTDC and PSpice simulation software. | | |

| Mapping of COs with POs | |
|---|---|

| CO ↓ | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H | H | H | H | M | H | M | L | M | L | L | L | H | M | M |
| 2 | H | H | M | H | M | M | M | M | L | H | H | M | H | M | M |
| 3 | H | M | H | H | M | L | L | L | M | M | M | M | H | M | H |
| 4 | H | H | H | H | M | L | L | L | L | L | L | L | H | H | H |

L=Low, M=Medium, H=High

**UNIT 1 –INTRODUCTION TO MODELING OF ELECTRICAL CIRCUITS [6 Hours]**
Fundamental Concepts in Mathematical Modelling: Basic properties– linearity and superposition – balance and conservation laws and the system – boundary approach. Lumped – Element Modelling: Mechanical systems – Translational, rotational. RLC Electrical Systems, Transients in Electrical Circuit. Pole-Zero approach, ideal switches.

**UNIT 2 –INTRODUCTION TO DIFFERENT SIMULATION SOFTWARE [6 Hours]**
Software Tools available for electrical Engineering. Introduction to PSpice software. Simulation of RLC circuit in PSpice software. Plotting of waveform with data extraction. Different tool boxes for Electrical Engineering, Transfer function approach for simulation, transient simulation in PSpice Software, LTspice.

**UNIT 3 – SIMULATION USING MATLAB/SIMULINK [7 Hours]**
Different simulations tools boxes for Electrical Engineering in MATLAB/SIMULINK. Introduction to MATLAB/SIMULINK software, Simulation of BASIC RLC circuit using MATLAB

**UNIT 4 – Introduction to Power system softwares [6 Hours]**
Introduction to PSCAD/ETAP/PSim Software.

**Text / Reference books**

1. S. Rosloneic,"Fundamental numerical methods of Electrical Engineering, lecture Notes in Electrical Engineering, Springer 2018
2. J. Robert, D.K. Tran, Modelling and Simulation of Electrical Machines and Power Systems: International Symposium Proceedings Hardcover – Import, 1 May 1988.
3. Dr. V P Singh , System Modeling And Simulation by, New Age International (P) Ltd., Publishers,2016
4. Dac-Nhuong Le, SairamTadepalli, Jyotir Moy Chatterjee, Pramod Singh Rathore, Abhishek Kumar PandeyNetwork Modeling, Simulation and Analysis in MATLAB: Theory and Practices, PHI 2018

| Course Title | **Non-conventional Energy Resources** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-I) | Semester | III |
| Prerequisite Knowledge | Basic concepts of physics, electrical engineering sensors and electrochemical processes. | | |
| Course Aim | To understand the recent and modern developments in the Energy harvesting, generation and integration techniques and apply for reducing carbon emission and green house. | | |

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|---|---|
| Course Outcomes (COs) | At the end of the course the students will be able to:<br>CO 1:have introductory idea of all types of nonconventional energy resources<br>CO 2:know how the energy is generated and integrated using wind.<br>CO 3:know how to use solar energy for electrical energy generation and various schemes for design, integration and control with existing system.<br>CO 4: know how the bio wastes are used for making biofuels and accomplish partial energy demand. Also the hydrogen and fuel cell technology for energy generation is studied.<br>CO 5:know how the geothermal, and ocean tidal and thermal energy is utilized to generate electricity.<br>CO6: to know the modern developments and resources for energy apart from previously discussed. |
| Mapping of COs with POs | (see table below) |

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | L | L | M | L | L | H | L | L | L | L | L | M | L | L | L |
| **CO2** | M | M | H | L | M | M | L | M | L | L | L | H | M | M | M |
| **CO3** | H | H | H | H | M | L | L | M | L | L | L | H | H | H | H |
| **CO4** | M | M | H | L | L | M | H | L | L | L | L | H | H | H | H |
| **CO5** | L | M | H | L | L | L | L | L | L | L | L | H | H | H | H |

1. **Introduction,** The place of renewable energy as an energy source, Energy source, India's production and reserves of commercial energy sources, need for nonconventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear, advantages and disadvantages, comparison. system considerations, Environment Integration of renewable energy sources in electrical power systems, Economics of renewable energy sources
2. **Wind energy** Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis wind mills, elementary design principles; coefficient of performance of a wind mill rotor, aerodynamic considerations of wind mill design, $C_P$-$\lambda$ curve, tip speed ratio, Optimum power extraction, SCIG, DFIC, Rotor side and grid side converters (RSC and GSC).
3. **Solar thermal technologies and photovoltaics**, Solar Radiation, Extra-Terrestrial radiation, spectral distribution and solar radiation data, Measurement of Solar Radiation: Pyrometer, shading ring pyrheliometer, sunshine recorder, schematic diagrams and principle of working, Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expressions, Radiation Flux on a Tilted Surface, Solar Thermal Conversion concentrating and nonconcentrating types of solar collectors, various solar thermal applications, Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, Performance Analysis of Liquid Flat Plate Collectors: Performance variables, analysis and design. Photovoltaic Solar Energy Generation and integration, Description, principle of working and characteristics, Construction and working of solar cells and PV modules, different PV technologies, solar module sizing and design. Photovoltaic system components and different applications. Solar water Pumping, solar street lighting. ,
4. **Biomass and Biofuels:** Photosynthesis, photosynthetic oxygen production, energy plantation, bio gas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of bio-gas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages. **Hydrogen Energy:** Properties of Hydrogen with respected to its utilization as a renewable form of energy, sources of hydrogen, production of hydrogen, electrolysis of water, thermal decomposition of water, thermo chemical production bio-chemical production. Fuel Cells and its operation.

5. **Geothermal energy and Ocen Thermal Energy**, Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy. Ocean thermal energy conversion (OTEC): Principle of working, Rankine cycle, OTEC power stations in the world, problems associated with OTEC; Tidal energy: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations,
6. **Modern Energy Generation System:** Wave energy, Small scale hydro-electric energy, Flywheel Energy Storage and generation system, Peizoelectric energy generation, triboelectric Energy genenration, Plant dye based Solar module for Energy generation.

***References:***


1. B H Khan "Non-Convention Energy Resources" McGraw Hill Education (India) Pvt. Ltd. 3rd Edition
2. S.P. Sukhatme, Solar Energy: Principles of Thermal Collection And Storage, Tata Mcgraw-Hill, 2nd Edition, 1996.
3. Non-Conventional Energy Sources G.D RaiKhanna Publishers 2003
4. N.K.Bansal, Manfred Kleeman&MechaelMeliss "Renewable Energy Sources and Conversion Technology" Tata McGraw Hill. 2004
5. Ramesh R & Kumar K U "Renewable Energy Technologies" Narosa Publishing House New Delhi
6. Ashok V Desai "Non-Conventional Energy" Wiley Eastern Ltd, New Delhi 2003
7. John Twidell , Tony Weir , 'Renewable Energy Resources', Taylor & Francis; 2nd edition, 2005
8. Duffie, J. A. & W. A. Beckman, 'Solar Engineering of Thermal Processes', 3rd ed. John Wiley & Sons, Inc., 2006
9. C. S. Solanki, 'Solar Photovoltaics: Fundamental Applications and Technologies, Prentice Hall of India, 2009.
10. Michel A. Laughton "Renewable Energy Resources" Report 22.


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|---|---|---|---|
| Course Title | **Electrical Engineering Materials and Devices** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-I) | Semester | III |
| Prerequisite Knowledge | Basic concepts of Physics, chemistry, Electronics, magnetism, magnetic circuits, electrical circuits. | | |
| Course Aim | To understand the recent theories and analyze various types of Electrical Engineering materials and study the modern developments in materials and devices. | | |
| Course Outcomes (COs) | At the end of the course the students will be able to:<br>CO 1: have introductory idea and classification of different types of materials with basic performance measures of materials.<br>CO 2: have the idea about the electrical properties of conducting materials and their analysis.<br>CO 3: know about Electronic Properties of Semiconducting Materials.<br>CO 4: know about the theory of Superconductivity and analysis of Superconducting Materials.<br>CO 5: to have idea about dielectric properties of insulating materials.<br>CO6: to study about the magnetic properties and magnetic materials.<br>CO7: to have Idea about optical properties and optoelectronic materials.<br>CO8: to study about the recent advances in materials and their performance improvement. | | |

Mapping of COs with POs

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | M | M | H | L | L | L | L | L | L | L | M | M | M | M | M |
| **CO2** | M | M | H | L | L | L | L | L | L | L | M | M | M | M | M |
| **CO3** | M | M | H | M | M | L | L | L | L | L | M | M | M | M | M |
| **CO4** | M | M | H | M | M | L | L | L | L | L | M | M | M | H | H |
| **CO5** | M | M | H | M | M | M | L | L | L | L | M | H | H | H | H |
| **CO6** | M | M | H | M | M | M | L | L | L | L | M | H | H | H | H |
| **CO7** | M | M | H | M | M | M | L | L | L | L | M | H | H | H | H |
| **CO8** | H | H | H | H | H | M | L | M | M | M | M | H | H | H | H |

**UNIT 1:Introduction**-Classification of materials on the basis of energy gap, conductors, semiconductors, dielectrics, superconductors, ferroelectrics, pyroelectrics, piezoelectrics, perovskites (titanates, zirconates, hafnates) etc. 2(L)

**UNIT 2:Electrical Properties and Conducting Materials**-Mechanism of electrical conduction, electron theories of solids, free electron theory, Factors affecting electrical conductivity, Wiedemana-Franz law, Lorentz number, thermoelectric properties, characteristics, properties and examples of high voltage conducting materials, high and low resistance materials. Contact fuse and filament materials. Conductors, cable & wire materials. Solder, sheathing, and sealing materials. Electrical properties of these materials. Related calculations. 4(L)

**UNIT 3:Electronic Properties and Semiconducting Materials**-Energy band theory, Brillouin zone theory, Fermi energy level, effective mass, concept of doping, energy diagrams, types of semiconductors, semiconductor compounds and alloys and their properties. structures of semiconductors, amorphous semiconductor, Junction properties, materials for different devices. Related calculations. 4(L)

**UNIT 4**: **Superconductivity and Superconducting Materials**-Concept of superconductivity, Phenomenon, properties of superconductors, Meissner effect, Critical magnetic field & critical temperature. Types of superconducting materials. Type I & II superconductors, Silsbee rule. Mechanism of superconduction. BCS theory, Debye temperature. London's &Glag theories, High temperature ceramic superconductors, applications: NMR, Maglev, MHO etc., recent advances. Related calculations.
5(L)

**UNIT 5:Dielectric Properties and Insulating Materials**-Dielectric constant, dielectric strength and dielectric loss. Polarizability, mechanism of polarization, factors affecting polarization, polarization curve and hysteresis loop, types of dielectric materials-solid, liquid and gaseous types; natural and synthetic types. Characteristic, properties, and applications of different types of mica, transformation oil, vacuum etc. Behavior of polarization under impulse and frequency switching. Ferroelectrics, piezoelectric, pyroelectrics, electrostriction effect. Clausius -Mosotti equation. Related calculations. 5(L)

**UNIT 6:Magnetic Properties and Magnetic Materials**-Origin of magnetism, basic terms and properties. Types of magnetic materials. Introduction to dia, para, ferro, antiferro and ferrimagnetic materials, Curie temperature. Laws of magnetic materials. Domain theory, Domain growth and domain wall rotation, Magnetic anisotropy. Magnetostriction & its mechanism. Ferrites, spinels& garnets. Ferromagnetic domains, magnetic hystersis. Magnetoplumbite, hexaferrite. Magnetic hysteresis loop, hysteresis loss. Hard and soft magnetic materials. Textured magnetic materials, Oxide magnetic materials. Magnetic tape, Magnetic bubble, Magnetic glasses, Colossal magneto- resistance. High energy hard magnetic materials, Commercial magnetic materials such as Supermalloy, Alnico, Cunife, Cunico etc., Conventional and non-conventional applications, characterisation of magnetic materials, Recent developments. Related calculations. 8(L)

**UNIT 7:Optical and Optoelectronic Materials**-Optical properties, Solar cell, Principles of photoconductivity. simple models, effect of impurities. Principles of luminescence, types; semiconductor lasers; LED materials, binary, ternary photo-electronic materials, effect of composition on band gap, crystal structure and properties. LCD materials, photo detectors, application of photoelectronic materials, introduction to optical fibers, light propagation, electro-optic effect, Kerr effect, Pockel's effect. 5(L)

**UNIT 8:Recent Advances.** Developments and Researches-Spintronics: materials and devices, Diamond semiconductors, Ferromagnetic semiconductors, Giant magneto-resistance (GMR), Left handed materials, Left and right handed (LH & RH) composite materials, Diluted magnetic semiconductor etc. Fabrication of Electronic and Opto-electronic Devices-Methods of crystal growth, zone refining. Term Paper-On application/recent advances based on literature survey and/or lab/industry visit(s) 7(L)

**Text/ Reference Books:**


1. L. Solymar, D. Walsh, 'Electrical Properties of Materials', Oxford University Press, USA, 2004. ,
2. David C. Jiles, 'Introduction to the Electronic Properties of Materials', Taylor and Francis, 200 I.
3. D.C. Jiles, 'Introduction to Magnetism and Magnetic Materials', Springer, 1990.
4. Manijeh Razeghi, 'Optoelectronic Materials and Device Concepts', SPIE-International Society for Optical Engine, 1991.
5. Rose R.M., Shepard L.A., Wulff J., 'Structure and Properties of Materials', Volume IV, 'Electronic Properties', 4th Edition, 1984.
6. K.M. Gupta, 'Electrical Engineering Materials', 3rd Edition, Umesh Publication, Delhi, 2005.
7. B.D. Cullity, 'Introduction to Magnetic Materials', Addison-Wesley publishing company, California, London, 1972.
8. Goldman, 'Modem Ferrite Technology', Van Nostrand, New York, 1990.
9. J.P. Jakubovics, 'Magnetism and Magnetic Materials', Institute of Materials, London, 1994.
10. Tareev B., 'Physics of Dielectric Materials', MIR, 1975.
11. Rolf E. Hummel, 'Electronic Properties of Materials', Springer, 2004.
12. Safa O. Kasap, 'Principles of Electronic Materials and Devices', McGraw-Hili, 2005.
13. Irene, 'Electronic Materials Science', Wiley-Interscience, 2006.
14. Jasprit Singh, 'Smart electronic materials: Fundamentals and Applications', Cambridge University Press, 2005.
15. M.E. Lines, A.M. Glass, 'Principles and Applications of Ferroelectrics and Related Materials', Oxford University Press, USA, 200 I.
16. Dekker A.J., 'Solid State Physics', Macmillan India, 1995.
17. Robert C., O' Handley, 'Modem Magnetic Materials: Principles and Applications', Wiley-Interscience,1999.
18. G. K. Mithal , “Electrical Engineering Materials”, Khanna Publisher, New Delhi.

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|---|---|---|---|
| Course Title | **Modern Computation Languages** | | |
| Course Code | EEXXXXX | Credit | 4 |
| Core/ Elective | Elective | Semester | 3 |
| Prerequisite Knowledge | None | | |
| Course Aim | To teach the modern programming language such as Python for application development in Electrical Engg. | | |
| Course Outcomes (COs) | At the end of the course students will (Number may vary)<br>**CO 1.** To get an adequate grasp over the rudimentary concepts of Python.<br>**CO 2.** To grasp the concepts of functions, be able to handle exceptions and numerous file types.<br>**CO 3.** To understand numerical data operations and data visualisation by utlising various libraries.<br>**CO 4.** To be able to apply various other modern programming language in Electrical Engg. Applications | | |

Mapping of COs with POs

| **CO** | **PO** | | | | | | | | | | | | **PSO** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | **1** | **2** | **3** |
| **1** | H | H | H | H | M | H | M | L | M | L | L | L | H | M | M |
| **2** | H | H | M | H | M | M | M | M | L | H | H | M | H | M | M |
| **3** | H | M | H | H | M | L | L | L | M | M | M | M | H | M | H |
| **4** | H | H | H | H | M | L | L | L | L | L | L | L | H | H | H |

L=Low, M=Medium, H=High

**UNIT 1 –INTRODUCTION OF MODERN COMPUTATIONAL LANGUAGES**
Various programming languages for development of applications such as C, $C^{++}$, Python, Java etc.

**UNIT 2 –INTRODUCTION TO PYTHON**
Fundamental Concepts of Python, Variables and Data types, Explicit and Implicit Type Casting, Operators, Lists, Tuples, Sets, Dictionaries, Conditional Statements, Loops and Iterators.

**UNIT 3 –FUNCTIONS, EXCEPTION HANDLING AND FILE HANDLING**
Creation and execution of functions. Arguments: arbitrary, keyword and arbitrary keyword arguments. Pass Statement, Recursion. Lambda functions, Passing functions as arguments.

Exception Handling: try block, except block, else block, finally block. Assert keyword. Raising an exception. Various exception names.

File Handling: read files, write files, delete files, create files. "with" statement.

**UNIT 4 – INTRODUCTION TO NUMPY AND PANDAS**
Introduction to Numpy Arrays, Array Dimensions and Reshaping, Indexing, Slicing and array broadcasting, Numpy Functions; Introduction to Pandas: series and data frames, handling and creating CSV and XLXX files, Handle Missing Data, Group By functions, Pandas Functions.

**UNIT 5 – INTRODUCTION TO DATA VISUALIZATION**
Introduction to Matplotlib and Seaborn, Basic plotting with Matplotlib, Line Plots, Histograms, Bar charts, Pie Charts, Box Plots, Scatter Plots, Word Clouds.

**UNIT 6 – APPLICATIONS**
Examples in various Electrical Engineering application development

**Text / Reference books**

1. Zed A. Shaw, "Learn Python3 the hard way, Pearson Education (US), 1st edition. 2017
2. Eric Matthes, "Python Crash Course", No Starch Press; 2nd edition, India, 2019.
3. Paul Barry, "Head First Python", Shroff/O'Reilly, 2nd edition, India, 2016.

| Course Title | **Electrical Machines-I** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | IV |
| Prerequisite Knowledge | Basic Electrical Engineering, Engineering physics, Engineering mathematics Electrical/Magnetic Circuits and Network, EM Theory | | |
| Course Aim | To make the students familiar with construction, operating principle of static and rotating machines, viz., transformer, DC machines and poly-phase induction machines along with their with different speed control methods and testing. | | |
| Course Outcomes (COs) | At the end of the course students will be<br>**CO1:** able to understand the concepts related to electromechanical energy conversion. Working principle, construction and behaviour of transformer.<br>**CO2:** able to represent transformer and electrical machines in its equivalent electrical circuit/ model and do the analysis and computations.<br>**CO3:** able to know the performance parameters related to transformers, rotating machine and its suitability for different applications.<br>**CO4:** able to get the comprehensive idea of DC machine, working principle of poly-phase induction motor, its construction, operation and speed control<br>**CO5:** able to develop a team spirit acquire real time working knowledge during lab sessions | | |

Mapping of COs with POs and PSOs

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PS O1 | PS O2 | PS O3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | H | M | M | M | H | L | M | L | M | M | L | H | H | H | H |
| **CO 2** | H | H | H | H | M | L | L | L | M | M | M | M | H | H | M |
| **CO 3** | H | H | M | M | H | L | M | L | M | H | L | H | H | H | H |
| **CO 4** | H | M | H | L | M | L | H | L | M | M | M | H | H | H | M |
| **CO 5** | H | H | H | M | H | L | M | M | H | H | H | H | M | H | M |

**H**- High (3), **M**- Medium (2), **L**- Low (1)

**UNIT 1 – TRANSFORMER: (10)**

Equivalent circuits (Exact and approximate), OC & SC test, Voltage regulation, Separation of hysteresis and eddy current losses, All-day efficiency, Parallel operation (conditions, equal and unequal voltage turn ratio), Division of load between parallel transformers, Polarity test, Sumpner's test., Three-phase transformers: Connections

**UNIT 2 – ELECTROMECHANICAL ENERGY CONVERSION: (4)**

Principles of electromechanical energy conversion, Singly- and multiply-excited systems- Energy, co-energy, Determination of Torque/Forces from energy/co-energy

**UNIT 3 – BASICS OF ROTATING MACHINES: (6)**

Introduction to AC machine- Stator & rotor (cylindrical and salient), DC machines- Field &Armature, Flux lines due to field and stator excitation, Windings layout, connections, Armature windings- Simplex-Lap and wave types.

**UNIT 4 – DC MACHINES: (10)**

Construction details, Speed and voltage expression, Torque production in D.C. machines, Types according to excitation (with circuit representation and equations), Magnetization curve- effect of field resistance and speed, Series, shunt and compound machines: DC generator & DC motor-Characteristics, Speed control and starting methods, Efficiency, Armature reaction: reduction and compensation, Commutation action, Testing of DC machines: Hopkinson's test, Swinburne's test

**UNIT 5– POLY PHASE INDUCTION MACHINE: (10)**

Construction features, Production of rotating magnetic field, Phasor diagram, Equivalent circuit, Torque and power characteristics, Torque – slip characteristics, No-load and blocked Rotor Test, Power flow, losses and efficiency Starting and speed control (With and without EMF injection in the rotor circuit), Deep bar and double cage induction motors, Cogging and crawling

**Text/ Reference Books:**


1. E. Fitzgerald, Charles Kingsle, and Jr. Stephen D. Umans, "Electric Machinery," Tata McGraw Hill, 7th Edition, 2013.
2. Stephen J Chapman, "Electrical Machinery and Power System Fundamentals,"McGraw-Hill Higher Education, 1st Edition, 2001.
3. P.S. Bhimbhra, "Generalized Theory of Electrical Machines," Khanna Publications, New Delhi, 5th Edition, 2014.
4. J. Nagrath, D. P. Kothari, "Electric Machines," TMH Publications, New Delhi, 4th Edition, 2010
5. G. K. Dubey, "Fundamental of Electrical Drives," Narosa Publishing House, New Delhi, 2nd Edition, 2011.


| Course Title | **CONTROL SYSTEM - I** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | IV |
| Prerequisite Knowledge | Mathematics I & II | | |
| Course Aim | To understand concepts of the mathematical modelling, system behaviour, feedback control and stability analysis in time and frequency domains. | | |
| Course Outcomes (COs) | At the end of the course the student will be able to:<br>**CO1:** Develop mathematical model of physical systems.<br>**CO2:** Determine Transient and Steady State behaviour of systems.<br>**CO3:**Analyze linear systems for steady state errors, absolute stability and relative stability.<br>**CO4:**Analytically quantify the time and frequency domain behaviour of dynamic systems.<br>**CO5:** Design a control system satisfying the design specifications. | | |

**UNIT 1 – INTRODUCTION TO CONTROL SYSTEM:**

Introduction, Closed-loop control versus open-loop control

**UNIT 2 – MATHEMATICAL MODELLING OF CONTROL SYSTEMS:**

Control hardware and their models, various physical system modeling, Block diagram reduction, Signal flow graph, Basic characteristics of Feedback, Modes of feedback control: proportional, integral and derivative, PID, The performance of Feedback systems

**UNIT 3 – TRANSIENT RESPONSE ANALYSIS:**

Time response analysis, Concepts of Stability and Routh's Stability Criteria, Steady-state error analysis

**UNIT 4 –ROOT-LOCUS ANALYSIS& THE FREQUENCY-RESPONSE METHOD:**

Root-locus plots, Rules of constructing Root Loci, Root-locus analysis of control systems

**UNIT 5 – FREQUENCY RESPONSE ANALYSIS:**

Bode plots, Polar plots, The Nyquist Stability Criterion and Stability Margins, Closed loop frequency response (M & N circles)

**UNIT 6 –DESIGN AND COMPENSATION TECHNIQUES:**

Design considerations, Lag Compensation, Lead Compensation, Lag-lead Compensation, Compensator Design Using Root-locus and Frequency Response methods

**Text/ Reference Books:**


1. B.C Kuo., "Automatic Control System," Wiley, 9th edition, 2009.
2. K.Ogata, "Modern Control Engineering," Prentice Hall, 5th edition, 2010.
3. I. J. Nagrath&M. Gopal, "Modern Control Engineering," New Ages International, 5th edition, 2007.
4. R.T Stephani., "Design of Feedback Control Systems," Oxford University Press, 4th edition, 2001.


| **Course Title** | **Power System - I** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | IV |
| Prerequisite Knowledge | Basic Electrical Engineering | | |
| Course Aim | To gain adequate knowledge on various aspects, issues related to power systems and identifying suitable solution methods to solve practical power system problems. | | |
| Course Outcomes (COs) | At the end of the course students will be able to | | |

| | |
|---|---|
| | **CO1:** Explain past, present and future trends in electric power systems, Recall basic concepts, interpret terminology/ notation, and explain components of the power system.<br><br>**CO2:** Evaluate the transmission line parameters; and assess the performance, line loadability, line compensation techniques *(for improving voltage regulation and line loadings closer to the thermal limit)*. Classify overhead line insulators and evaluation of string efficiency and its improvement.<br><br>**CO3:** Acquire knowledge of underground cables: construction, methods of laying, grading, and determination of fault location.<br><br>**CO4:** Investigate the concept of Corona, with factors affecting corona losses, and its reduction methods.<br><br>**CO5:** Formulate power flow problems,and apply solution methods, Explain the sparsity techniques, the dc power flow,<br><br>**CO6:** Explain grounding with its necessity; and illustrate methods of grounding. |

Mapping of course outcomes with program outcomes:

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | H | H | M | M | H | H | L | M | -- | L | -- | -- | H | H | M |
| CO2 | H | M | H | H | M | M | H | H | -- | L | -- | L | H | M | H |
| CO3 | M | M | H | L | L | H | M | H | -- | M | -- | M | H | M | L |
| CO4 | M | L | M | L | M | H | M | L | -- | L | -- | -- | H | L | M |
| CO5 | H | H | H | H | M | -- | M | -- | -- | L | -- | -- | H | H | H |
| CO6 | H | H | H | M | H | -- | L | L | -- | L | -- | -- | H | H | M |

**UNIT 1 – INTRODUCTION TO POWER SYSTEM: (08 Hours)**

**Electric Power Systems: (02 hours)**

History, Present and Future Trends, Electric Utility Industry Structure.

Brief Description of Power system elements

**Fundamentals: (02 hours)**

Phasors, Instantaneous Power, Complex Power, Network Equations, Power in Single-Phase Systems & Balanced Three-Phase Circuits

**Power system generation & Economics: (02 hours)**

Conventional/ renewable energy sources of electrical energy, Power plant economics, operating costs, load factor, demand factor, diversity factor, plant factor, tariffs,

**Distribution and Transmission:** **(02 hours)**

Different kinds of supply system and their comparison; Choice of transmission voltage, advantages of high voltage transmission, conductor size, Kelvin's law, Standard voltages, Comparison of D.C. and A.C. transmission, methods of voltage control.

**UNIT 2 –TRANSMISSION LINE: (16 hours)**

Parameters, Resistance, Conductance, Inductance, Capacitance, Admittance, Design Considerations, Composite Conductors, Bundled Conductors, Stranded Conductors, Shunt Admittances: Lines with Neutral Conductors and Earth Return, Electric Field Strength at Conductor Surfaces and at Ground Level.

Transmission Lines Modelling (short, medium, and long lines), Steady-State Operation, ABCD parameters, receiving- and sending-end voltage, performance (regulation and efficiency). Ferranti effect, Lossless Lines, Maximum Power Flow, Line Loadability, Compensation Techniques.

Mechanical Design: Main components of overhead line, line supports, sag, stringing chart, vibrations Insulators: types, material, potential distribution, string efficiency, methods of improvement of string efficiency, causes of failure, testing of insulators.

Corona: formation, critical disruptive voltage, visual disruptive voltage, power losses, factors affecting corona, reduction methods.

**UNIT 3 – CABLES: (04 hours)**

Types and construction of cables, insulation resistance of a cable, capacitance and grading in cables, current rating of power cable, dielectric stress, overhead lines versus underground cables, Potential distribution; Equalizing the potential, Insulation Resistance, Capacitance of single phase and three phase cables, Dielectric Loss.

**UNIT 4 - LOAD FLOW ANALYSIS: (10 hours)**

Per unit (p.u.) system and their application to power system network, Single line diagram of power system, Y bus and Z bus formulation,

Direct Solutions to Linear Algebraic Equations: Gauss Elimination

Iterative Solutions to Linear Algebraic Equations: Jacobi and Gauss-Seidel

Iterative Solutions to Nonlinear Algebraic Equations: Newton-Raphson

Classification of buses, Power Flow Problem, Power Flow Solution by Gauss-Seidel, Power Flow Solution by Newton-Raphson, Control of Power Flow, Sparsity Techniques, Fast Decoupled Power Flow.

**UNIT 5 –GROUNDING: (2 hours)**

| |
|---|
| Grounded & Ungrounded System, Resonant Grounding, Necessity and methods of neutral grounding, Grounding Practices.<br>***References:***<br>1. C. L. Wadhwa, "Electric Power System," New Age International Ltd., 8th Edition, 2022, ISBN: 978-93-93159-17-5.<br>2. SINGH, S. N., "Electric Power Generation, Transmission and Distribution," PHI Learning, Second Edition, 2011, ISBN : 97881203356082.<br>3. D. P. Kothari, I. J. Nagrath, R K Saket, "Modern Power System Analysis" Tata McGraw-Hill Publishing Company Limited, New Delhi, 5th Edition, 2022 ISBN: 9789354600968.<br>4. J. Duncan Glover, Mulukuta S. Sarma, and Thomas J. Overbye, "Power System Analysis and Design", Cengage Learning, 6th Edition, **2017**, ISBN: 9789353502089<br>5. Hadi Sadat, "Power System analysis," McGraw-Hill, 2nd Edition, 2002.<br>6. Stephen J. Chapman, "Electric Machinery and Power System Fundamentals," McGraw Hill, New York, 2002.<br>7. John J. Grainger, William D. Stevenson, Gary W. Chang, "Power System analysis," McGraw-Hill Education, 2016, ISBN: 9781259008351.<br>8. TuranGonen, "Electric Power Distribution Engineering", CRC Press, 3rd Edition, 2014. |

| Course Title | **COMPUTER ORGANIZATION & MICROCONTROLLER** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CES | Semester | IV |
| Prerequisite Knowledge | Microprocessor & Computer Organization | | |
| Course Aim | To understand the basics of microcontrollers and microprocessors, interfaces, IDEs, design etc. with their applications. | | |
| Course Outcomes (COs) | At the end of the course the students will be able to:<br>**CO1:** Understand the basic concept of microprocessors & microcontrollers in general and their architecture and working in detail.<br>**CO2:** Learn the assembly language programming /C-Programming /IDE Concepts and apply the same for solving real life problems.<br>**CO3:** Learn about the different peripherals used with microprocessor /microcontrollers and will be able to use them for real life problems /projects.<br>**CO4:** Learn about the different microcontrollers available and their programming. The students will be able to use them for different applications.<br>**CO5:** Apply the knowledge gained to use microcontrollers or microprocessors in making real time controllers for various applications. | | |

**UNIT 1 −MICROCONTROLLER BASICS:**

8-Bit and 16-bit Microcontroller Internal Block Diagram, CPU, ALU, address bus, data bus, control signals, Working Registers, SFRs, Clock and Reset circuits, Stack and use of Stack Pointer, Program Counter. I/O Ports, Memory structure, Data Memory, Program Memory, and Execution of Program. Power saving modes and its operation, Timing diagram for execution cycle. Different Addressing Modes, Interrupts priority, interrupt handling, housekeeping during power on and power off situations, self-check and recoveries.

**UNIT 2−ON CHIP PERIPHERAL INTERFACES:**

Interfacing concept and design rule , Interfacing of digital input and output pin PWM, ADC, I/O Pins, Timers, counters, Interrupts, UART, I2C, SPI, ICSP, DATA E2RAM, FLASH RAM

**UNIT 3−EXTERNAL INTERFACES:**

A to D, D to A, LCD, LED & keyboard interfacing, I/O expansion techniques, Memory expansion techniques, RS232, RS485 transceivers. Stepper motor interfacing, DC Motor interfacing, sensor interfacing, CAN Protocol and its interfacing, USB protocol and its interfacing, Blue-tooth, Zig-bee protocol and its interfacing

**UNIT 4− INTEGRATED DEVELOPMENT ENVIRONMENT (IDE) FOR MICROCONTROLLERS:**

(Specific examples of ATMEL 89C51 with Kiel IDE or PIC micro controllers with MPLAB IDE) Study of datasheets, programming using assembly language and "C" Cross compiler, programming tools such as simulator, **Assembler**, "C" cross compiler, emulator and debugger. Illustrative applications and programming techniques, Tutorial programs should include programming using: Arithmetic instructions, Jump, Loop and Call instructions, I/O programming, Logic instructions, Single bit instructions, Timer/Counter Programming, UART programming, Interrupt Programming.

**UNIT 5− ANALYSIS OF ANY REFERENCE DESIGN:**

Application examples: Any reference circuit schematic with specification application and firmware analysis can be taken.

**Text/ Reference Books:**

1. Kenneth J. Ayala, "The 8051 microcontroller," Penram International, 3rd edition, 2014.
2. M. A. Mazidi, "8051 Microcontroller and embedded systems," Pearson Higher Education, 2$^{nd}$ Edition, 2011.
3. M.Predko, "Programming and customizing the 8051 microcontroller,"Tata McGraw Hill 1$^{st}$Edition, 2011.
4. Ramesh S. Gaonkar, "Microprocessor Architecture, Programming and Application with the 8085 – Microprocessor & Interfacing," Prentice Hall, 4$^{th}$Edition, 1998.


| | | | |
|---|---|---|---|
| Course Title | **Utilization of Electrical Energy** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-II / Elective-III) | Semester | IV |
| Prerequisite Knowledge | Basic concepts of different laws on Electrostatic and Electromagnetism (Faraday's Law, Fleming's Rule), Basic knowledge on Electric Machine (DC Series Motor, Induction Motor) | | |
| Course Aim | • To present the basic concepts on utilization of electrical energy on various applications.<br>• To understand the basic principles of heating, welding, light control and electrolysis process. | | |
| Course Outcomes (COs) | **CO1:**To acquaint with the different types of heating and welding techniques.<br>**CO2:**To study the basic principles of illumination and its measurement.<br>**CO3:**Illustrate the fundamentals on electrolytic processes.. | | |
| Mapping of COs with POs and PSOs | (see table below) | | |

| | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PSO** | **PSO** | **PSO** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **CO1** | H | M | H | M | H | H | M | M | H | M | M | H | H | H | H |
| **CO2** | H | M | M | M | M | M | M | M | M | M | M | H | M | M | M |
| **CO3** | H | H | M | M | H | H | H | M | H | M | M | H | H | M | M |

**UNIT 1. ELECTRIC HEATING (CO1)**

- Advantages and methods of electric heating,
- Resistance heating – direct and indirect resistance heating, electric ovens, their temperature range, properties of resistance heating elements, domestic water heaters and other heating appliances, thermostat control circuit
- Induction heating; principle of core type and coreless induction furnace, their construction and applications
- Electric arc heating; direct and indirect arc heating, construction, working and applications of arc furnace
- Dielectric heating, applications in various industrial fields
- Infra-red heating and its applications (construction and working of two appliances)
- Microwave heating and its applications (construction and working of two appliances)
- Solar Heating
- Calculation of resistance heating elements (simple problems)

**UNIT 2. ELECTRIC WELDING (CO1)**

- Advantages of electric welding, Welding methods
- Principles of resistance welding, types – spot, projection, seam and butt welding, welding equipment
- Principle of arc production, electric arc welding, characteristics of arc; carbon arc, metal arc, hydrogen arc welding method and their applications. comparison between AC and DC arc welding, welding control circuits,welding of aluminum and copper

**UNIT 3. ILLUMINATION (CO2)**

- Introduction, terms used in illumination, laws of illumination, polar curves, photometry, integrating sphere, sources of light. Discharge lamps, comparison between tungsten filament lamps and fluorescent tubes.

**UNIT 4. ELECTROLYSIS PROCESS (CO3)**

- Electrolytic Process: Principle of electro deposition, Factors affecting electro-depositionlaws of electrolysis, Principles of anodizing and its applications, Electroplating of non-conducting materials, applications of electrolysis.

**Text / Reference books**

1. “Utilization of electrical energy” by E.O.Taylor.

2. “Electrical Drives: Concept and applications” by VedamSubrahmanyam” THM.

3. A course in Utilization of Electrical Energy, *G. Garg*

4. A course in Electrical Drives, *S. K. Pillai*

| | | | |
|---|---|---|---|
| Course Title | **ANALOG AND DIGITAL COMMUNICATION** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL | Semester | IV |
| Prerequisite Knowledge | **1.** Analog Electronics<br>**2.** Digital Electronics<br>**3.** Fourier series/Transform | | |
| Course Aim | **1.** Understanding Analog communications systems with design and analysis of various basic modulation systems.<br>**2.** Understanding Digital communications systems with design and analysis of various basic Digital modulation systems. | | |
| Course Outcomes (COs) | **After completion of the course students shall be able to:**<br>CO 1: Understand the Basics of Analog and Digital Communication Systems and Modulation as well as Transmission Techniques.<br>CO 2: Analyse the various Analog and Digital Modulation and Transmission Techniques.<br>CO 3 Implement the Analog and Digital Communication Systems. | | |

Mapping of COs with POs

| | CO 1 | CO 2 | CO 3 | CO 4 | CO 5 |
|---|---|---|---|---|---|
| **PO 1** | High | High | High | Low | Low |
| **PO 2** | High | High | High | Medium | Low |
| **PO 3** | High | Low | High | High | High |
| **PO 4** | Medium | High | Low | High | Medium |
| **PO 5** | High | High | Low | High | Medium |
| **PO 6** | High | Medium | Medium | Low | Low |
| **PO 7** | High | Medium | Medium | Low | Medium |
| **PO 8** | Low | Low | Medium | Low | Low |
| **PO 9** | Medium | Low | Low | Medium | Low |
| **PO 10** | Medium | Medium | Low | Medium | Medium |
| **PO 11** | Low | Medium | Medium | Low | Low |
| **PO 12** | Low | Medium | Medium | Low | Low |

**Unit 1: Introduction To Communication System**

Analog and Digital Messages, Channel Effect, Signal-to Noise ration and capacity, Modulation and Detection, History of Communications. (Revision of Signal Transmission through a linear system, Signal distortion over a communication channel, Signal Energy and Energy spectra density, Signal power and power density).

**Unit 2: Amplitude modulation And Demodulations**

Single and Double sideband Amplitude modulation, Amplitude modulation, Bandwidth-efficient Amplitude modulation, VSB, Local Carrier synchronization, FDM, PLL.

**Unit 3: Angle Modulation and demodulation**

Nonlinear Modulation, Bandwidth of Angle-modulated Waves,, Generating FM waves, Demodulation of FM signals, Nonlinear distortion and interference, Superheterodyne Receivers, FM broadcasting System.

**Unit 4: Sampling and Analog to digital Conversion**

Sampling theorem, Sampling and signal reconstruction, Aliasing, Types of sampling, Quantization, PCM, Companding, DPCM, ADPCM, Delta modulation, Adaptive delta modulation, T1 carrier system.

**Unit 5: Digital Data Transmission**

Components of digital communication system, line coding, pulse shaping, Scrambling, Regenerative Repeater, Eye Diagram, Timing Extraction, Detection Error Probability, M-ary communication, Digital Carrier Systems.

**Unit 6: Introduction to Digital Modulation-Demodulation Techniques**
Modulation techniques for ASK,FSK, PSK, MSK, BPSK, QPSK, GMSK

Text Books / Reference Books / Online Resources:

*1.* Digital and analog communication system by B.P.Lathi .Zhi Ding 4th edition.
*2.* Communication Systems by Simon Haykins.
*3.* Electronic Communications Systems by Wayne Tomasi.

| | | | |
|---|---|---|---|
| Course Title | Modelling & Simulation | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-II / Elective-III) | Semester | IV |
| Prerequisite Knowledge | Probability distributions and random variables, Object Oriented Modeling Concepts, Operation research. | | |
| Course Aim | Analysis of Simulation models using input analyzer, and output analyser. Explain Verification and Validation of modelling and simulation. | | |
| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:** Describe the role of important elements of discrete event simulation and modeling paradigm.<br>**CO2:**Conceptualize real world situations related to systems development decisions, originating from source requirements and goals.<br>**CO3:**Develop skills to apply simulation software to construct and execute goal-driven system models.<br>**CO4:**Interpret the model and apply the results to resolve critical issues in a real world environment. | | |
| Program Specific Outcome (PSOs) | **PSO1:**Implement and maintain enterprise solutions using latest technologies.<br>**PSO2:**Develop and simulate wired and wireless network protocols for various network applications using modern tools.<br>**PSO3:**Apply the knowledge of Information technology and software testing to maintain legacy systems. | | |

Mapping of COs with POs and PSOs

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | H | M | L | M | M | M | M | M | M | M | L | H | H | H | H |
| CO2 | H | M | M | M | H | M | M | M | H | M | L | H | M | H | H |
| CO3 | M | M | H | M | H | H | M | M | H | M | M | H | M | M | H |
| CO4 | M | M | H | M | H | H | M | M | H | H | M | H | L | M | M |

**Unit- I: Introduction to Simulation:** Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study.
**Simulation Examples:** Simulation of Queuing systems, Simulation of Inventory System, Other simulation examples.

**Unit – II: General Principles:** Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling.
**Random Numbers:** Properties, Generations methods, Tests for Random number- Frequency test, Runs test, Autocorrelation test.

**Unit – III: Random Variate Generation:** Inverse Transform Technique- Exponential, Uniform, Weibull, Triangular distributions, Direct transformation for Normal and log normal Distributions, convolution methods- Erlang distribution, Acceptance Rejection Technique.
**Optimisation Via Simulation:** Meaning, difficulty, Robust Heuristics, Random Search.

**Unit – IV: Analysis of Simulation Data- Input Modelling:** Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data, Multivariate and time series analysis.
**Verification and Validation of Model:** Model Building, Verification, Calibration and Validation of Models.

**Unit – V: Output Analysis:** Types of Simulations with Respect to Output Analysis, Stochastic Nature of output data, Measures of Performance and their estimation, Output analysis of terminating simulation, Output analysis of steady state simulations.
**Simulation Softwares:** Selection of Simulation Software, Simulation packages, Trend in Simulation Software**.**

**Text / Reference books**


1. Zeigler B.P. Praehofer. H. and Kim I.G. "Theory of modeling and simulation", 2 nd Edition. Academic press 2000.
2. Ogata K "Modern control Engineering" 3 rd edition. Prentice hall of India 2001.
3. Jang J.S.R. sun C.T and Mizutani E., "Neuro-Fuzzy and soft Computing ", 3 rd edition, Prentice hall of India 2002.
4. Shannon, R. E., “System Simulation: the Art and Science”, Prentice Hall Inc. 1990.
5. Pratab.R "Getting started with MATLAB" Oxford university Press 2009.

| | | | |
|---|---|---|---|
| Course Title | **ADVANCED INSTRUMENTATION** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-II / Elective-III) | Semester | IV |
| Prerequisite Knowledge | Electrical Measurement and Measuring Instruments, Instrumentation | | |
| Course Aim | To aware the students about the concepts of advanced instrumentation systems. | | |
| Course Outcomes (COs) | After the course, the student should be able to:<br>**CO1:** Acquire knowledge about the fundamental concepts of transducers and smart sensors.<br>**CO2:** Acquire knowledge about the advanced instrumentation devices.<br>**CO3:** Study and analysis of hardware design techniques<br>**CO4:** Effectively communicate ideas, explain procedures and interpret results and solutions in written and electronic forms. | | |

Mapping of COs with POs

| | **CO1** | **CO2** | **CO3** | **CO4** |
|---|---|---|---|---|
| **PO1** | H | H | H | M |
| **PO2** | H | H | H | H |
| **PO3** | M | H | H | H |
| **PO4** | L | M | H | H |
| **PO5** | H | L | H | H |
| **PO6** | M | L | H | M |
| **PO7** | M | L | M | M |
| **PO8** | L | L | M | L |
| **PO9** | H | L | M | M |
| **PO10** | L | M | L | L |
| **PO11** | L | L | L | L |
| **PO12** | M | M | M | M |

Mapping of COs with PSOs

| | **CO1** | **CO2** | **CO3** | **CO4** |
|---|---|---|---|---|
| PSO1 | H | H | H | H |
| PSO2 | H | H | H | H |
| PSO3 | M | M | M | M |

**UNIT 1 –INTRODUCTION:**

Introduction to embedded systems and architecture, system design using specification and modelling tools

**UNIT 2 −COMPUTING PLATFORMS:**

Overview of embedded computing platforms; microprocessors, microcontrollers, DSPs and SoCs, hardware – software design and partitioning

**UNIT 3 − DESIGNS AND TRADE-OFFS:**

Design issues, consideration and trade-offs: performance memory, power, timing, cost, and development time. Memory hierarchy, system interfaces and communication with peripheral units, timers-counters, introduction to real-time system and real-time scheduling.

**UNIT 4 − RTOS:**

Real-time software development: high level languages and programming issues, systems performance: networked embedded systems.

**Text/ Reference Books:**

1. J.W. S. Liu, "Real-time systems," Pearson, 1st edition,2000.

| Course Title | **Modern Power Station Practice** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-II / Elective-III) | Semester | **IV** |
| Prerequisite Knowledge | Basic understanding of different types energy and types of power plant. | | |
| Course Aim | To provide basic understating of power plant structure, their types, applications and economics | | |
| Course Outcomes (COs) | **CO1:**An understanding of basic abstractions of electrical power generations from conventional and nonconventional sources of energy.<br>**CO2:**The capability to use abstractions to comprehend and analyse the impact of various system on environments and economics aspects of energy generation.<br>**CO3:**Knowledge for learning advanced topics in electrical power system<br>**CO4:**The capability to incorporate the knowledge of electrical power generation in other field of science, engineering and economics. | | |

Mapping of COs with POs and PSOs

| | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PSO** | **PSO** | **PSO** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **CO1** | H | H | M | M | M | M | H | M | M | M | M | M | M | M | M |
| **CO2** | H | H | M | H | H | H | M | H | H | M | H | M | M | H | M |
| **CO3** | H | H | H | H | H | H | H | H | H | H | H | H | H | H | H |
| **CO4** | H | H | M | M | M | M | M | M | M | M | M | M | M | M | M |

**UNIT 1. Sources of energy: (CO1)**

Types and choice of power generation, amount of generation of electric power from conventional and non-conventional sources of energy in UP and India and some developed countries of the world.

**UNIT 2. Steam power station: (CO1), (CO2)**

Main parts, layout and working of a steam station, characteristics of steam turbines and turbo generator; advantages and disadvantages, choice of site, efficiency of steam power station; environmental aspects for selecting the sites and locations of thermal power stations. Numerical.

**UNIT 3. Hydro and Nuclear power station: (CO1), (CO2)**

Hydro power station: Main parts, layout and working of a hydro station, characteristics of hydro turbines and generator; advantages and disadvantages, choice of site, efficiency of hydro power station; environmental aspects for selecting the sites and locations of hydro power stations. Numerical.
Nuclear power station: Schematic arrangement, advantages and disadvantages, selection of site, types of reactors, Hazards, Environmental aspects for selecting the sites and locations of nuclear power stations

**UNIT 4. Power Generation by Non-Conventional Energy Sources:(CO3)**

Need of Renewable energy, Concept of Distributed energy resources (DER) and distributed generation (DG), Photovoltaic Power Conversion systems: Solar radiation spectrum, Radiation measurement, Solar Photovoltaic (SPV) systems, Applications, Green Building, Present Status of PV in India, Governmental incentives.
Wind Power Conversion System: Principles of wind energy conversion, Basic components of wind energy conversion systems, Classifications of wind power plants (WPPs), Comparison/ advantages and disadvantages of WECS. Site selection considerations.

**UNIT 5. Economics Aspects:(CO4)**

Introduction. Diversity factor, load factor, plant capacity factor, plant use factor, plant utilization factor and loss factor, load duration curve. Cost of generating station, factors influencing the rate of tariff designing, tariff, and types of tariff. Power factor improvement Numerical.

**UNIT 6. Substation and Neutral Earthing: (CO4)**

Classification of Substations, substation equipment, Specification and selection of equipment, Site selection of substation. Bus bar arrangement schemes, Interconnection of power stations.
Neutral Earthing: Introduction, isolated neutral, earth neutral systems-solid, resistance, reactance. Arc suppression coil, voltage transformer and earthing, transformer, earthing systems. Numerical.

**Text / Reference books**

1. B.R. Gupta, "Generation of Electrical Energy", S. Chand Publication.
2. Soni, Gupta &Bhatnagar, "A text book on Power System Engg.", DhanpatRai& Co.
3. 'Modern Power Station Practice", Volume B, British Electricity International Ltd., Central Electricity Generating Board, Pergamon Press, Oxford, 1991
4. P.S.R. Murthy, "Operation and control of Power System" BS Publications, Hyderabad. Reference Books:
4. W. D. Stevenson, "Elements of Power System Analysis", McGraw Hill.
5. S. L. Uppal, "Electrical Power", Khanna Publishers.

| Course Title | **Power plant engineering** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-II / Elective-III) | Semester | IV |
| Prerequisite Knowledge | Power System I | | |
| Course Aim | To develop the comprehensive understanding about various power plants and analyze their applications in modern systems. | | |
| Course Outcomes (COs) | At the end of this course students will be able to:<br>**CO1:** Ability in understanding various power plants and identify mal operations in power plant.<br>**CO2:** Proficiency in designing thermal and hydro turbine blades and steam boiler surfaces.<br>**CO3:** Competence in selecting motor and generator ratings in power plants.<br>**CO4:** Ability in calculation of resent worth depreciation and cost of various power plants and | | |

| | |
|---|---|
| | Estimate the cost of producing power per kW. |

Mapping of COs with POs and PSOs

| | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PO | PSO | PSO | PSO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **CO1** | H | M | M | M | H | M | H | M | M | M | M | H | M | H | H |
| **CO2** | H | H | H | H | H | H | M | M | M | M | H | H | H | M | M |
| **CO3** | H | H | M | H | H | H | M | M | M | H | M | H | M | H | M |
| **CO4** | H | H | H | H | M | H | H | H | H | H | H | H | H | H | H |

**UNIT 1 −INTRODUCTION TO POWER PLANTS:**
Conventional power plant- Thermal, Hydro, Nuclear, Combined cycle, etc, Non-conventional power plant-Small hydro, wind (on shore/off-shore), fuel cell, PV etc, their layout, Load duration curves, Switchyard.

**UNIT 2 −THERMAL POWER PLANT (STEAM BASED):**
Study on different sections- fuel and ash handling, Furnace and mechanical strokers, Pulverizers, Steam boiler types and cycles (including fluidized bed), Turbo-generators, Excitation system, Draught, Electrostatic precipitator, Cooling towers

**UNIT 3 − NUCLEAR POWER PLANT:**
Nuclear energy-Fission and fusion reaction, Types of reactors, pressurized water reactor, waste disposal.

**UNIT 4 −HYDRO POWER PLANT:**
Different layout- Dam and run-of-river, Main sections- Intake, Tunnel, Surge tank, Penstock, Tail race, Turbine types, Hydro generators, Governors.

**UNIT 5 −DIESEL AND GAS TURBINE POWER PLANT:**
Types of diesel power plant, components, Selection of engine type, Gas turbines, Open and closed cycles, reheating, Regeneration, Inter-cooling.

**UNIT 6 −ECONOMICS OF POWER PLANTS:**
Cost of electrical energy- Fixed and operating cost, Tariff rates, Economics of load sharing, Comparison of cost from different power plants, Power plant instrumentation and major Electrical Equipment, Pollution and its control.

**Text/ Reference Books:**
1. P.K. Nag, "Power plant engineering," Tata McGraw-Hill Education, 2nd edition, 2002
2. M.M.EI-Wakil , "Power plant Technology," Tata McGraw-Hill Education, 1984
3. Frederick Tracy Morse, "Power plant engineering and design," D. Van Nostrand company, inc.,1932.
4. F. Beach, "Modern Power Station Practice: Electrical Systems and Equipment," 3rd Edition, Pergamon 1992.
5. Joel Weisman and Roy Eckart , "Modern Power Plant Engineering," Prentice-Hall, 1985

R.K. Rajput, "A Textbook of Power Plant Engineering,"Laxmi; 4 edition, 2007.

| | | | |
|---|---|---|---|
| Course Title | **Network Synthesis** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-II / Elective-III) | Semester | IV |
| Prerequisite Knowledge | Network & System | | |

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|---|---|
| Course Aim | To get the idea about network synthesis, filter design, biquad circuit, ladders, capacitor filters etc. and their applications in real life problems. |
| Course Outcomes (COs) | At the end of the course the students will be able to:<br>**CO 1:** Understand the basic concept of synthesizing the circuit with resistance, inductance and capacitance and apply it to solve real problems.<br>**CO 2:** Learn the various filter design technology which is useful to filter out the unwanted signals and apply the same for solving real life problems.<br>**CO 3:** Learn about the transfer function of network to know the behaviour of network which will be very useful for solving real life problems /projects.<br>**CO 4:** Understand the basics of biquad circuits. Also learn about behavior of ladder networks by simulating them. . the knowledge gained to solve the realistic problems |
| Mapping of COs with POs and PSOs | (see table below) |

| | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PSO** | **PSO** | **PSO** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **CO1** | H | H | H | H | L | H | H | M | M | L | M | H | H | M | M |
| **CO2** | H | M | H | M | M | H | M | H | M | H | H | H | H | H | H |
| **CO3** | M | H | M | M | M | H | M | M | H | H | H | H | H | H | H |
| **CO4** | M | M | L | H | M | M | H | H | H | H | H | M | M | H | H |

**NETWORK SYNTHESIS**

**UNIT 1– ELEMENTS OF NETWORK SYNTHESIS:**
Synthesis of L-C Driving–point immitances, synthesis of R-C Impedances or R-L Admittances , Synthesis of certain R-L -C Functions.

**UNIT 2–ELEMENTS OF TRANSFER FUNCTION SYNTHESIS:**
Properties of Transfer function, Synthesis of Y21 Z 21 with 1-Ω termination, Synthesis of Constant Resistance Networks.

**UNIT 3 –FILTER DESIGN:**
Filter design problem, Low Pass Filter Approximations, Synthesis of Low Pass Filter, Magnitude and Frequency Normalization, Frequency Transformations.

**UNIT 4 – BIQUAD CIRCUITS:**
Biquad Circuits, Four Op-Amp Biquad Circuit, Frequency and Phase Response of BiquadCircuit .Butterworth Low Pass filter, Chebyshev, Bessel Thomson Filter.

**UNIT 5 – LEAPFROG SIMULATION OF LADDERS**
Ladder Simulation, Band pass Leapfrog Filters, Active Resonators, Band pass Leapfrog Design, Girling-good form of leapfrog.

**UNIT 6 – SWITCHED CAPACITOR FILTERS**
Switched Capacitor, Analog Operations , Range of Circuit elements Sizes, Bandpass Switched –Capacitor Filters. OP Amp Oscillators: Loop gain, Conditions for Third –Order Circuit Oscillations Amplitude Stabilization

**Text/ Reference Books:**


1. Franklin F. Kuo, “Network Analysis and Synthesis”, Wiley India Pvt Ltd, 2nd Edition, 2010.
2. M. E.Valkenberg, “Analog Filter Design, “Oxford University Press, 2008.
3. A. S.Sedra and P O Brackett, “Filter Theory and design: Active and Passive”, Matrix Publishers, 1977.

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|---|---|---|---|
| Course Title | **Electrical Machines-II** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | V |
| Prerequisite Knowledge | Electrical machines-I, Electromagnetic theory, Circuit theory | | |
| Course Aim | To make the students aware about the concepts of synchronous and asynchronous machines and analyze their performance | | |
| Course Outcomes (COs) | At the end of the course students will be able to:<br>**CO1:**Draw the constructional details and explain the performance and application of salient and non-salient type synchronous machines.<br>**CO2:**Draw and explain the principle of operation and performance of precision motors.<br>**CO3:**Draw and describe the construction, principle of operation and performance of reluctance motors, BLDC motors and induction generators<br>**CO4:**Solve the critical engineering problems in the area of rotating A.C.. electrical machines.<br>**CO5:**Design, develop and formulate the problems in the area of electrical machines which they can apply in the final year B. Tech project and in future life. | | |

Mapping of COs with POs and PSOs

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PS O1 | PS O2 | PS O3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | H | M | M | M | H | L | M | L | M | M | L | H | H | H | H |
| CO 2 | H | H | H | H | M | L | L | L | M | M | M | M | H | H | M |
| CO 3 | H | H | M | M | H | L | M | L | M | H | L | H | H | H | H |
| CO 4 | H | M | H | L | M | L | H | L | M | M | M | H | H | H | M |
| CO 5 | H | H | H | M | H | L | M | M | H | H | H | H | M | H | M |

**H**- High (3), **M**- Medium (2), **L**- Low (1)

**UNIT 1 –SYNCHRONOUS MACHINES: (8)**

Constructional Features, EMF Equation, Winding Co-efficient, Harmonics in the induced EMF, Equivalent circuit, Power expression for cylindrical and salient pole machines, Losses and efficiency, Synchronous generator characteristics, Active and reactive power control, Single and parallel operation, Performance characteristics, Capability curve, Synchronous Motor, Principle of operation, Starting methods, Speed control

**UNIT 2 –PERMANENT MAGNET SYNCHRONOUS MOTORS: (6)**

Principle of operation, EMF and torque equations, reactance phasor diagram, Torque speed characteristics, Steady state and dynamic modelling, Field weakening operation, Operation as 120 deg mode.

**UNIT 3 –PRECISION MOTORS: (8)**

Stepper motors-constructional features, principle of operation, variable reluctance stepper motor, hybrid stepper motor, single and multi-stack configurations, characteristics, drive circuits, applications in control, AC Servomotors-Construction-principle of operation-performance characteristics, (Speed torque) -damped AC servomotors-Drag cup servomotor-applications-DC servomotors-field and armature controlled DC servomotors- permanent magnet armature controlled.

**UNIT 4 –RELUCTANCE MOTORS and Generators: (6)**

Synchronous**-** constructional features, types, axial and radial air gap motors, operating principle, reluctance phasor diagram, characteristics, comparison between induction and synchronous motor in terms of output torque,SwitchedReluctance Motors -constructional features, principle of operation, torque production, Relationship between inductance and rotor position, equivalent circuit,

**UNIT 5 –PERMANENT MAGNET BRUSHLESS D.C. MOTORS: (6)**

Principle of operation, Types– trapezoidal type-sinusoidal type, Magnetic circuit analysis, EMF and torque equations, Power controllers, Motor characteristics and control.

**UNIT 6 –INDUCTION GENERATORS: (6)**

Working principle, Power balance relations, Power flow in sub synchronous/super synchronous operation, Equivalent circuit, Application in Wind system for power generation, Steady state analysis of DFIG

**Text/Reference Books**

1. P.S. Bimhra, “Electrical Machinery,” Khanna publishers, 2003.
2. T.J.E. Miller, “Brushless Permanent Magnet and Reluctance Motor Drives,” Oxford University Press, 1989.
3. P. P. Acarnley, “Stepping Motors – A Guide to Motor Theory and Practice,” Institution Of Engineering And Technology, 4th Edition, 2002.

4. T. Kenjo and S. Nagamori, "Permanent Magnet and Brushless DC Motors," Oxford University Press, 1985.
5. Kenjo& A. Sugawara, "Stepping Motors and Their Microprocessor Controls,"Clarendon Press, 2nd Edition, 1994.
6. J. Nagrath& D.P. Kothari, "Electrical Machines," TMH Publication, New Delhi, 25th Edition, 2010.
7. P.S. Bimbhra, "Generalized theory of Electrical Machine," Khanna publishers, New Delhi, 5th Edition, 1995.
8. Gopal K. Dubey, "Fundamental of Electrical Drives," Narosa Publishing House, New Delhi, 2nd Edition, 2011.
9. Thomas A Lipo, "Introduction to AC Machine Design, First Edition," Wiley Online Library.

| Course Title | **CONTROL SYSTEM-II** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | V |
| Prerequisite Knowledge | Control System-I | | |
| Course Aim | To get the comprehensive knowledge about digital control devices & systems, deign digital control algorithms, system stability analysis etc. | | |
| Course Outcomes (COs) | At the end of the course the students will be able to:<br>**CO 1:** Understand the detail about basics of signal operations.<br>**CO 2:** Study the detail about basics of mathematical modelling and deign controllers in discrete time domain to get desired response.<br>**CO 3:** Understand about stability of the systems by using various methods.<br>**CO 4:** Express and solve system equations in state-variable form (state variable models). | | |

**UNIT 1 −INTRODUCTION-SIGNAL PROCESSING IN DIGITAL CONTROL:**

Introduction to digital control systems, Principles of signal conversion, Sampling and reconstruction, Principles of discretization, Impulse andstep invariance, Finite difference approximation, Bilinear transformation

**UNIT 2 – MODELS OF DIGITAL CONTROL DEVICES AND SYSTEMS:**

Mathematical models discrete time signalsand systems, Transfer function and system response, Stability on the z-domain, Closed loop digitalcontrol systems, System with dead time, Commonly used digital devices, Examples of industrial controlsystems

**UNIT 3 −DESIGN OF DIGITAL CONTROL ALGORITHMS:**

Transform design of digital controllers, Root locusmethods and frequency domain method

**UNIT 4 − CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS:**

State variable representation ofcontinuous and discrete time systems, Conversions state variable models to transfer function models,Conversion of transfer function to canonical models, Eigen values and eigenvectors, Solution of stateequations, Sampled continuous-time systems, Controllability and Observability properties

**UNIT 5 −DESIGN OF CONTROL SYSTEMS BY STATE VARIABLE METHODS:**

Pole-placement design, Observer design, Lyapunov Stability analysis

**Text/ Reference Books:**

1. M.Gopal, "Digital Control and State Variable Methods," Mcgraw Hill Education, 4th edition, 2012.
2. Katsuhiko Ogata, "Discrete-Time Control Systems," PHI Learning Pvt Ltd, 2nd Edition, 2009.
3. B.C.Kuo, "Digital Control System," Oxford University Press, 2nd Edition, 2012.

| | | | |
|---|---|---|---|
| Course Title | POWER SYSTEM-II | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | V |
| Prerequisite Knowledge | POWER SYSTEM -I | | |
| Course Aim | To gain adequate knowledge on issues related to power systems and identifying suitable solution methods to solve practical power system problems. | | |
| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:** Recall per unit (p.u.) quantities, bus impedance matrix, and superposition principle to apply in short-circuit current calculation; and classify fault current components.<br>**CO2:** Explain the concept of symmetrical components and sequence networks; and solve balanced and unsymmetrical three-phase fault calculations.<br>**CO3:** Model the power system components for stability considerations, explain transient stability issues, swing equation, equal-area criterion, and recommend methods for stability improvement.<br>**CO4:** Explain, apply and analyze the methods of economic dispatch and unit commitment in the power system.<br>CO4:Evaluate the condition of economic scheduling of thermal power plants including transmission losses and explain the load frequency control.<br>**CO5:** Compare the configurations and characteristics of distribution systems; and assess the role of related modern concepts. | | |

Mapping of course outcomes with program outcomes:

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | H | H | M | M | H | H | L | M | H | -- | -- | L | H | H | M |
| CO2 | H | M | H | H | L | L | H | -- | -- | L | M | H | H | M | H |
| CO3 | M | M | H | L | L | H | M | -- | L | M | H | H | H | M | H |
| CO4 | H | M | M | L | M | H | M | -- | -- | -- | H | L | H | L | M |
| CO5 | H | H | H | M | H | M | L | -- | -- | -- | -- | H | H | H | H |

**UNIT 1 – FAULT ANALYSIS: (10 hours)**

Application of Per unit (p.u.) system to power system network, Single line diagram of power system, Y bus and Z bus formulation. Series R–L Circuit Transients, Three-Phase Short Circuits,

Symmetrical Components, Sequence Networks of - Impedance Loads, Series Impedances, Three-Phase Lines, Rotating Machines, Per-Unit Sequence Models of Three-Phase Transformers, Power in Sequence Networks.

System Representation: Single Line-to-Ground Fault, Line-to-Line Fault, Double Line-to-Ground Fault, Sequence Bus Impedance Matrices.

**UNIT 2 – POWER SYSTEM STABILITY ANALYSIS: (16 hours)**

Power Flow, Swing Equation, Steady-state, Dynamic, and Transient Stability, Simplified Synchronous Machine Model and System Equivalents.

Steady-state Stability Power Limit, Transfer Reactance, Synchronizing Power Coefficient, Power Angle Curve.

Equal Area Criterion and its application, Critical Clearing Angle, Two Finite Machines, Point-by-point Method, Factors Affecting Transient Stability.

Multi-machine Stability, Two-Axis Synchronous Machine Model.

Methods to improve Stability, Application of Auto Reclosing and Fast Operating Circuit Breakers, Design Methods for Transient Stability Improvement.

**UNIT 3– ECONOMIC LOAD DISPATCH (08 hours)**

System Constraints, Economic Load Dispatch (with and without considering transmission losses), Derivation of Loss Formula, Optimization of continuous functions and their application to optimal dispatch of generation.

Unit commitment, Spinning Reserve, Thermal Unit Constraints, Unit Commitment Solution Methods.

Load frequency control.

**UNIT 4 − POWER DISTRIBUTION: (6 hours)**

Introduction to Primary and Secondary Distribution, Transformers and Shunt Capacitors in Distribution Systems, Distribution Softwares, Distribution Reliability, Distribution Automation, Distributed generation, Energy Storage Systems for Utility, Concept of Power quality, Smart Grids, Microgrids, Asset management.

**References:**

1. C. L. Wadhwa, "Electric Power System," New Age International Ltd., 8th Edition, **2022**, ISBN: 978-93-93159-17-5.
2. SINGH, S. N., "Electric Power Generation, Transmission and Distribution," PHI Learning, Second Edition, 2011, ISBN : 97881203356082.
3. D. P. Kothari, I. J. Nagrath, R K Saket, "Modern Power System Analysis" Tata McGraw-Hill Publishing Company Limited, New Delhi, 5th Edition, 2022 ISBN: 9789354600968.
4. J. Duncan Glover, Mulukuta S. Sarma, and Thomas J. Overbye, "Power System Analysis and Design", Cengage Learning, 6th Edition, **2017**, ISBN: 9789353502089
5. Hadi Sadat, "Power System analysis," McGraw-Hill, 2nd Edition, 2002.
6. John J. Grainger, William D. Stevenson, Gary W. Chang, "Power System analysis," McGraw-Hill Education, 2016, ISBN: 9781259008351.
7. TuranGonen, "Electric Power Distribution Engineering", CRC Press, 3rd Edition, 2014.
8. PrabhaKundur, "Power system stability and control," McGraw Hill Education, 2006.
9. Olle. I. Elgerd, "Electric Energy Systems Theory - An Introduction," McGraw Hill Education, 2nd Edition, 2001.


| Course Title | **POWER ELECTRONICS** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | V |
| Prerequisite Knowledge | Basics of Semiconductor Physics, Circuit theory, Steady-state and transient operation of electrical circuits, Electrical Machine, Power System, Digital Electronics | | |
| Course Aim | To make the students aware about various power semiconductor devices their operations applications and limitations. Students to be familiar with different power converter circuits, their analysis design and real time applications,. | | |
| Course Outcomes (COs) | After successfully completing this course students will become aware of followings:<br>**CO-1:** Power Electronics Systems, Roles and objective of Power Electronics in the field of electric power control.<br>**CO-2:** Various Power Semiconductor Devices used in different Power Electronics applications, their characteristics, power ratings, switching frequency, about their protection and applications.<br>**CO-3:** Various configurations of power converters used for AC-DC, DC-DC, DC-AC and AC-AC power conversion, their working principle, various operating modes with some of the control schemes and their limitations.<br>**CO-4:** Application of Power Electronics converters for different domestic, commercial and industrial applications. | | |

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|---|---|
| | **CO-5:** Design and develop a new converter system for improving the performance or for novel application. |

Mapping of COs with POs and PSOs

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PS O1 | PS O2 | PS O3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | H | H | M | H | L | M | H | M | M | L | H | H | H | H | H |
| **CO2** | H | M | M | H | M | L | M | L | L | M | M | H | H | M | H |
| **CO3** | H | H | H | H | M | M | H | L | M | H | M | H | H | H | H |
| **CO4** | H | H | H | H | M | H | H | M | H | M | H | H | H | M | H |
| **CO5** | H | H | H | M | H | M | H | L | H | H | M | H | H | H | H |

**H**- High (3), **M**- Medium (2), **L**- Low (1)

**UNIT 1 – INTRODUCTION: (2)**

Introduction to Power Electronics, Power Electronics Systems, Role of Power Electronics in the field of electric power control.

**UNIT 2 − POWER ELECTRONIC DEVICES: (8)**

A Brief Survey of Power Semiconductor Devices: Power Diodes, Thyristor, Diac, Triac, UJT, GTO etc. Construction characteristics and their applications, methods of triggering a SCR. Different firing (R, RC and UJT) circuits, commutation of SCR, converter grade and inverter grade SCRs, series parallel operation of SCRs, Protection of SCR and GTO thyristorand triggering of GTO thyristor.

**UNIT 3 −OTHER POWER ELECTRONICS DEVICES: (5)**

Characteristics, operation, constructional details and application of Power Transistor (BJT), MOSFET, IGBT and MCT.

**UNIT 4 − CONTROLLED RECTIFIERS: (8)**

Phase controlled Rectifiers operation on resistive and inductive loads, use of free-wheeling diode, Single -Phase and Three phase controlled and Fully controlled bridge rectifiers, Semi-converters, Dual converters, Effect of source impedance on converter, Line commuted inverters

**UNIT 5 − CHOPPERS: (6)**

Principle of operation and control technique of chopper, classification of Choppers, current and voltage waveforms for resistive, inductive and motor loads, Power Transistor and MOSFET based chopper circuits, step up chopper and its application.

**UNIT 6 − INVERTERS: (6)**

Single-phase and Three-phase (six-step) inverters, voltage and current waveforms, Bridge Inverter, voltage control & PWM strategies of VSI., Series and parallel inverters, Methods of voltage control, and various techniques of phase width modulation. Comparisons of voltage source, current source inverters and their applications.

**UNIT 7 −CYCLOCONVERTER: (3)**

Single-phase and three-phase Step-up and Step down cycloconverter, full bridge and half bridge configurations.

**UNIT 8 − APPLICATIONS: (2)**

Static circuit breakers, UPS, Static frequency converter, Power factor control.

**Text/ Reference Books:**


1. M. H. Rashid, "Power Electronics: Circuits, Devices and Applications," Pearson, 4rd Edition, 2018.
2. G. K. Dubey, S. R. Doradla, A. Joshi & V. P. Sinha, "Thyristorised Power Controllers," New Age International, 2nd Edition, 2012.
3. Krishna Kant and VineetaAgrawal "Power Electronics," BPB Publications, 2008.
4. P. C. Sen, "Power Electronics," Mcgraw Hill Education, 1stEdition, 2001.
5. P. S. Bimbhra, "Power Electronics," Khanna Publishers, 2012.
6. Cyril W. Lander, "Power Electronics," McGraw-Hill, 3rd Edition, 1993.
7. Ned Mohan, T. M. Undeland& W. P. Robbin"Power Electronics: Converter, Applications & Design," Wiley India Pvt Ltd, 3rd Edition, 2010.


| | | | |
|---|---|---|---|
| Course Title | Electrical System Design | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-IV) | Semester | V |
| Prerequisite Knowledge | Circuit Theory, Basics of Machines | | |

| | |
|---|---|
| Course Aim | • To instruct the basic Rules and regulations in electrical installations.<br>• To instruct to prepare the design procedure, selection of materials and estimate for different electrical installations |
| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:** Gain the knowledge of acts and rules used for regulating the electrical supply in our country<br>**CO2:** Understand the various lightning and its design procedures.<br>**CO3:** Do the electrical installations in domestic and industrial buildings<br>**CO4:** Choose the materials for cables and sizing it<br>**CO5:** Design to improve the power quality by various techniques<br>**CO6:** Understand the Energy Economics in system design |

Mapping of COs with POs

| | **PO** | | | | | | | | | | | | **PSO** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** | **3** |
| **CO1** | M | M | M | M | M | M | M | L | L | L | M | L | M | L | L |
| **CO2** | H | H | H | H | H | M | H | L | M | L | L | L | H | L | M |
| **CO3** | H | H | H | H | H | M | H | L | M | L | L | H | H | L | M |
| **CO4** | H | H | H | H | H | M | H | L | M | L | L | M | H | L | L |
| **CO5** | H | H | H | H | H | M | H | L | M | L | L | M | H | L | L |
| **CO6** | H | H | H | H | H | M | H | L | M | L | L | H | H | L | H |

**UNIT 1 Role of statuses in Electrical Systems Design [4 hours]**

The Electricity Act, 2003 - Indian Electricity Rules, 1956 - National Electrical Code, 1985 - International Electrotechnical Commission (IEC) - Standard Values of Voltages - Voltage Limits for Alternating - Current Systems - Safety Aspects of Electrical System Design

**UNIT 2 Principles of Lightning [7 hours]**

Lightning Design: Light Sources, Lightning Calculations, Point by Point Method, Average Lumen Method, Lumen, Light Loss Factor, Quality of Lightning, Design Procedures

Exterior Lightning: Introduction, General considerations, Road Lighting, Area Lighting and High Mast Lighting

**UNIT 3 Electrical Installations [10 hours]**

Domestic Buildings: Classification, Estimation of Load Requirements, Selection of Types of Wiring, Special Features Applicable for High-Rise Apartment Buildings, Pre-commissioning tests.

Industrial Buildings: Introduction, Classification, General Characteristics, selection of distribution architecture, transformer substations and drives.

**UNIT 4 Cable Sizing and Voltage Drop Calculations [3 hours]**

Introduction, Voltage Designation, Choice of Materials used in Cables

**UNIT 5 Power Factor Improvement** **[7 hours]**

Nature of Reactive Energy, Power Factor, how to improve the Power Factor, Location of Capacitors, Optimal Compensation, Power Factor Correction of Induction Motors

**UNIT 6 Energy Economics in System Design** **[7 hours]**

Introduction, Time Value of Money, Singe payment compound amount model, uniform series compound amount model, uniform series present worth model, depreciation, tax considerations

**Text / Reference books**


1) M.K.Giridharan, Electrical Systems Design, , M/s I K International Publishers, New Delhi, 2nd edition, 2016
2) Bosela, Theodore R.. Electrical system design. United Kingdom, Prentice Hall, 2002.
3) B. Gupta, A Course in Electrical Installation Estimating and Costing, S.K. Kataria& Sons; Reprint 2013 edition (2013).
4) K. B. Raina, S. K. Bhattacharya, Electrical Design Estimating Costing, NEW AGE; Reprint edition (2010).
5) National Electric Code, Bureau of Indian Standards publications, 1986.
6) Relevant Indian Standard – specifications (IS – 732, IS – 746, IS – 3043, IS – 900), etc.


| Course Title | Digital Signal Processing | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-IV) | Semester | V |
| Prerequisite Knowledge | Basic Signal and system and Fourier analysis. | | |
| Course Aim | To understand the basic concepts and techniques for digital signal processing, familiarization with DSP concepts by studying the design of different digital filters and transform-domain processing. | | |
| Course Outcomes (COs) | At the end of the course students will be able to<br><br>**CO1:** Analyze the signals in time and frequency domain.<br>**CO2:** Apply the transformation tools on signals and systems and analyze their significance and applications.<br>**CO3:** Design the structures of different types of digital filters.<br>**CO4:** Design various digital filters and analyze their frequency response. | | |

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| Program Specific Outcome (PSOs) | **PSO1:** Students will acquire technical skill for developing different types of digital filtersfor industrial applications.<br>**PSO2:** Can develop strong technical knowledge about z-transform and fourier transform.<br>**PSO3:** Students can acquire job as technician / Supervisor / Manager / Engineer in instrumentation based industries. |

Mapping of COs with POs and PSOs

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | H | M | H | M | M | M | L | L | M | L | M | H | H | L |
| CO2 | M | H | M | H | M | M | M | L | L | M | L | M | H | H | L |
| CO3 | H | M | H | M | M | H | H | M | M | M | L | H | H | M | M |
| CO4 | H | M | H | M | M | H | H | M | M | M | M | H | H | M | H |

**UNIT- I:Introduction:** Review of Discrete Time Signals and Systems and z-Transforms, Solution of Difference Equations Using One-sided z-Transform, Frequency domain Characteristics of LTI Systems, LTI Systems as Frequency-Selective Filters.

**UNIT- II:Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT):** Discrete Fourier Transform and its Properties, Divide and Conquer Approach, Decimation in Time and Decimation in Frequency FFT Algorithms.

**UNIT- III:Digital Filter Structure:** Describing Equation of digital filter, Structures for FIR Systems: Direct Form Structure, Cascade Form Structure, Structure for IIR Systems: Direct Form Structures, Cascade Form Structure, Parallel Form Structure and Lattice Structure.

**UNIT- IV:Design of Digital Filters:** Causality and its Implications, Difference between analog filters and digital filters, FIR filter design using windows, Design of IIR filters from analog filters using: Approximation of Derivatives, Impulse Invariance and Bilinear Transformation, Frequency transformations.

**Text books**

6. Oppenheim A V and Sehafer R W, “Discrete Time Signal Processing”, Prentice Hall (1989).
7. Proakis J G and Manolakis D G, “Digital Signal Processing”, Pearson Education India.

**References books:**

1. Oppenheim A V, WillskyA S and Young I T, “Signal & Systems”, Prentice Hall, (1983).
2. Ifeachor and Jervis, “Digital Signal Processing”, Pearson Education India.
3. DeFatta D J, Lucas J G and Hodgkiss W S, “Digital Signal Processing”, J Wiley and Sons, Singapore, 1988
4. Sanjit K Mitra “Digital Signal Processing” TMH

| | | | |
|---|---|---|---|
| Course Title | **Microprocessor & Applications** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-IV) | Semester | V |
| Prerequisite Knowledge | Basic concepts of Memory, Digital Electronics and Data Conversion. | | |
| Course Aim | To understand the basics of microprocessors &its applications and study about assembly language programming, peripheral devices and their applications in real life problems. | | |
| Course Outcomes (COs) | At the end of the course the students will be able to:<br>**CO 1:** Understand the basic concept of microprocessors &its structure and details<br>**CO 2:**to study about the designing of Memory, memory interfacing, operations and Direct memory access controllers for Memory interfacing, Interrupts and its controller.<br>**CO 3:**to study the instructions related to data transfer, logical, arithmetic and memory operation and their addressing modes, timing diagrams etc.<br>**CO 4:** to study about the interfacing schemes of displays, keyboards, peripheral interface, and data converters.<br>**CO 5**: to study about different applications of the microprocessors. | | |

Mapping of COs with POs

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | L | L | M | L | L | L | L | L | L | L | L | M | L | L | L |
| CO2 | M | M | H | L | M | L | L | L | L | L | L | H | M | M | M |
| CO3 | H | H | H | H | M | L | L | L | L | L | L | H | H | H | H |
| CO4 | M | M | H | L | L | M | H | L | L | L | L | H | H | H | H |
| CO5 | L | M | H | L | L | L | L | L | L | L | L | H | H | H | H |

**UNIT 1:** Introduction to Microprocessor, Basic Computer Model, Working Principle, and Microprocessor, Organization of Intel 8085 Micro-Processor, Hardware Architecture, pin-out diagram. **(4Hrs)**

**UNIT 2:** Main Memory Organization, Memory interfacing, Memory Operations, Timing diagram, I/O ports and data transfer concepts Timing Diagram. Direct Memory Access (DMA) and 8237 Direct Memory Access (DMA) Controller, block diagram, pin diagram, process of DMA, Interrupt structure, 8259 Programmable Interrupt controller**(10 Hours)**

**UNIT 3:** Instruction set of Intel 8085 Micro-Processor & Assembly programming, Instruction format and addressing modes - Assembly language format - Data transfer, data manipulation & control instructions - Programming: Loop structure with counting & Indexing - Look up table, Stack and Subroutine instructions.**(10 hours)**

**UNIT 4:** Introduction to Peripherals, Study of Architecture and programming of ICs: 8255 PPI, 8251 USART, 8279 Key board display controller and 8253, Timer/ Counter - Interfacing with 8085 , A/D and D/A converter interfacing. **(8 hours)**

**UNIT 5:** Application of Microprocessor, Data Transfer, Manipulation, Control & I/O instructions - Simple programming exercises, key board and display interface, Single board Microcomputer, Closed loop control of servo motor speed control system, stepper motor speed control ,Washing Machine Control, Microprocessor based Temperature Control, Traffic Light Control System.**(8 hours)**

Text/Reference Books


1. R.S. Gaonkar, "Microprocessor Architecture and Programming and Applications with the 8085,"PrenticeHall; 5 edition , 2002
2. M. A. Mazidi, J. G. Mazidi and R. D. McKinlay ,"The 8051 Microcontroller and Embedded systems," Prentice Hall; 2 edition, 2005
3. A. NagoorKani,"Microprocessor (8085)AnditsApplications", Third Edition, McGrawHill.


| Course Title | **Finite Element Methods for Electrical Engineers** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/ RS | HR/RS (Course-1) | Semester | V |
| Prerequisite Knowledge | **3.** Mathematics<br>**4.** Electromagnetic field theory | | |
| Course Aim | This course focuses on the fundamentals concepts and formulation of the finite element methods for solving electric and magnetic field computation problems. | | |
| Course Outcomes (COs) | **After completion of the course students shall be able to:**<br>CO 1. understand the basic concept behind the formulation of finite element methods (FEMs).<br>CO 2. analyze electric and magnetic elements using FEMs.<br>CO 3. perform modeling and analysis of electrical apparatus in the laboratory/simulation platform. | | |

Mapping of COs with POs

| | **CO 1** | **CO 2** | **CO 3** |
|---|---|---|---|
| **PO 1** | High | High | High |
| **PO 2** | Medium | High | High |
| **PO 3** | Medium | High | High |
| **PO 4** | Medium | High | High |
| **PO 5** | Medium | High | High |
| **PO 6** | Low | Low | Low |
| **PO 7** | Low | Low | Low |
| **PO 8** | Low | Low | Low |
| **PO 9** | Low | Low | Low |
| **PO 10** | Low | Low | Low |
| **PO 11** | Low | Low | Low |
| **PO 12** | Low | Low | Medium |

Electromagnetic Field Theory Review: Maxwell Equations, Constitutive Relations, Electrostatic, Magnetostatic and Magnetodynamic fields.

Analytical Solution and Numerical Solution, Basic methods: Finite Element Method using electrostatic fields, Galerkin's method of weighted residuals, Minimum energy principle, Calculation of capacitance, electric field, electric forces from the potential solutions.

Finite Element Basics: Reduction of 3D problem to 2D, One Dimensional and Two-dimensional Finite Element Analysis. Pre-processing, shape functions, isoperimetric elements, meshing, solvers, post-processing.

Finite Element Modeling: Conductive media, steady currents; Magnetostatic fields, Permanent Magnets, scalar and vector potentials; Electromagnetic fields, eddy current problems, movement modeling for moving parts i.e. Electrical machines; modeling of electrical circuits.

| References: |
|---|
| **4.** Matthew N. O. Sadiku, Numerical Techniques in Electromagnetics with MATLAB, Third Edition, CRC press, 2009, chapter 6.<br>**5.** Electrical machine Analysis using Finite Elements-Nicola Bianchi (CRC press-Taylor & Francis)<br>**6.** S. J. Salon, Finite element analysis of electrical machines, Springer India.<br>**7.** Field solution on Computers, S J Humphries, CRC press, 1998.<br>**8.** Finite elements in electric and magnetic field problems, Chari and Silvester, Wiley, 1980.<br>**9.** Electromagnetic modeling by finite element methods, J P ABastos, Marcel-Dekker 2003.<br>**10.** Computer-aided analysis and design of electromagnetic devices, S R H Hoole, Elsevier, 1989.<br>**11.** Computational electromagnetics, A Bondeson, T Rylander and P Ingelstroem. Springer, 2000.<br>**12.** Recent conference and journal publications.<br>**13.** Instructor Provided notes. |

| Course Title | **Virtual Instrumentation** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/ HR | HR/RS (Course-1) | Semester | V |
| Prerequisite Knowledge | EMMI, Control System | | |

Introduction, Virtual instrumentation (VI) advantages, Graphical programming techniques, Data flow programming , VI's and sub VI's, Structures, Arrays and Clusters, Data acquisition methods, File I/O, DAQ hardware, PC hardware: operating systems, Instrumentation buses, ISA, PCI, USB, PXI, Instrument control, Data communication standards, RS-232C, GPIB, Real time operating systems, Reconfigurable I/O, FPGA.

***Reference Books:***

1. JovithaJerome,*Virtual Instrumentation Using Lab VIEW*, PHI Learning Pvt. Ltd, New Delhi, 2009.
2. S. Gupta and J. John, *Virtual Instrumentation Using Lab VIEW, Tata McGraw-Hill,* New Delhi, 2005.
3. R.H. Bishop, *Lab VIEW 7 Express Student Edition,* Prentice Hall, 2003.
4. National Instruments, *Lab VIEW User Manual, USA, 2003.*
5. National Instruments, *Lab VIEW Real Time User Manual, USA, 2001.*

| Course Title | **Neural Network & Deep Learning** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR | HR/RS (Course-1) | Semester | V |
| Prerequisite Knowledge | Coding Skills, Linear Algebra | | |

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|---|---|
| Course Aim | To teach the students to obtain basic knowledge on Neural Network & Deep Learning |
| Course Outcomes (COs) | At the end of the course, students will be able<br>**CO 1:** To Model Neuron and Neural Network, and to analyze ANN learning, and its applications.<br>**CO 2:** To perform Pattern Recognition, Linear classification.<br>**CO 3:** To develop different single layer/multiple layer Perception learning algorithms<br>**CO 4:** To design of another class of layered networks using deep learning principles. |

**Introduction to Neural Networks:** Neural Network, Human Brain, Models of Neuron, Neural networks viewed as directed graphs, Biological Neural Network, Artificial neuron, Artificial Neural Network architecture, ANN learning, analysis and applications, Historical notes.

**Learning Processes:** Introduction, Error correction learning, Memory-based learning, Hebbian learning, Competitive learning, Boltzmann learning, credit assignment problem, Learning with and without teacher, learning tasks, Memory and Adaptation.

**Single layer Perception:** Introduction, Pattern Recognition, Linear classifier, Simple perception, Perception learning algorithm, Modified Perception learning algorithm, Adaptive linear combiner, Continuous perception, Learning in continuous perception. Limitation of Perception.

**Multi-Layer Perceptron Networks:** Introduction, MLP with 2 hidden layers, Simple layer of a MLP, Delta learning rule of the output layer, Multilayer feed forward neural network with continuous perceptions, Generalized delta learning rule, Back propagation algorithm.

**Introduction to Deep learning:**Neuro architectures as necessary building blocks for the DL techniques, Deep Learning &Neocognitron, Deep Convolutional Neural Networks, Recurrent Neural Networks (RNN), feature extraction, Deep Belief Networks, Restricted Boltzman Machines, Autoencoders, Training of Deep neural Networks, Applications and examples(Google, image/speech recognition)

**References:**


1) Simon Haykins, "Neural Network- A Comprehensive Foundation", Pearson Prentice Hall, 2nd Edition, 1999. ISBN-13: 978-0-13-147139-9/ISBN-10: 0-13-147139-2
2) Zurada and Jacek M, "Introduction to Artificial Neural Systems", West Publishing Company, 1992, ISBN: 9780534954604
3) Vojislav Kecman,"Learning& Soft Computing", Pearson Education, 1st Edition, 2004, ISBN:0-262-11255-8.
4) M T Hagan, H B Demoth, M Beale, "Neural Networks Design", Thomson Learning, 2002. ISBN-10: 0-9717321-1-6/ ISBN-13: 978-0-9717321-1-7.
5) Charu C. Aggarwal, "Neural Networks and Deep Learning: A Textbook", Springer Publisher; 1st ed. 2018 edition
6) François Chollet, "Deep Learning with Python", Manning Publisher; 1st edition, 2017


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|---|---|
| Course Title | **Artificial Intelligence in Engineering** |

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|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/ HR | HR/RS (Course-1) | Semester | V |
| Prerequisite Knowledge | Control System | | |
| Course Aim | To teach the various intelligent techniques applied for electrical engineering | | |

**Basic Principles:** Introduction, Experimental Evaluation: Over-fitting, Cross-Validation. Sample complexity. VC-dimension, Regularization, Theory of generalization, Bias-Variance trade off, Reinforcement Learning.

**Supervised Learning:** Linear and Logistic Regression, Decision Tree Learning, k-NN classification, SVMs, Ensemble learning: boosting, bagging.

**Neural Network:** Artificial Neural Networks: Perceptron, Multilayer networks and back propagation. Radial Basis function NN , Applications in electricalengineering

**Probabilistic Models:** Maximum Likelihood Estimation, MAP (Maximum a-posteriori), Bayes Classifiers, Naive Bayes. Markov Networks, Bayesian Networks, Factor Graphs, Inference in Graphical Models. Applications of probabilistic models

**Unsupervised Learning:** K-means and Hierarchical Clustering, Gaussian Mixture Models, PAC learning. EM algorithm, Hidden Markov Models. Applications in electrical Domain

**Reference Books:**

1. Tom Mitchell, Machine Learning, McGraw Hill, 1997.

2. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer 2006.

3. Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, John Wiley & Sons, 2006.

4. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer 2009.

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|---|---|---|---|
| Course Title | **Expert System** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/ HR | HR/RS (Course-1) | Semester | V |
| Prerequisite Knowledge | Power electronics, Electrical Machines | | |
| Course Aim | To teach several mathematical tools for intelligent operation of electrical System | | |
| Course Outcomes (COs) | CO1 To use basic concepts of expert systems<br>CO2: Implement a rule-based expert system and Evaluate Expert System tools<br>CO3: Apply knowledge representation and Design a knowledge base<br>CO4: To Use and apply fuzzy logic in various control applications | | |
| Introduction, Expertise and Heuristic knowledge, knowledge based systems, Structure of knowledge based systems, Logic and automated reasoning, Predicate logic, logical inference, Resolution, Truth maintenance systems, Rule based reasoning, Forward chaining , Backward chaining, Rule based architectures, conflict resolution schemes, Associative networks, Frames and Objects, uncertainty management, Baynesian approaches, Certainty factors, Dempeter-Shefer theory of Evidence, Fuzzy sets and Fuzzy logic, knowledge Acquisition search strategies and matching techniques.<br>Inference based knowledge generation | | | |

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|---|---|---|---|
| Course Title | **Embedded Systems** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/ HR | HR/RS (Course-1) | Semester | V |
| Prerequisite Knowledge | Control System | | |

| Course Aim | To teach different Embedded System |
|---|---|

Introduction to an Embedded systems design: Introduction to Embedded system (ES), Embedded system project management, ESD and co-design issues in system development process, design cycle in the development phase for an embedded system, use of target system or its emulator and in-circuit emulator, use of software tools for development of an ES.

**RTOS & its overview:** Real time operating system: Task and task states, tasks and data, semaphores and shared data operating system, services, message queues, timer function, events, memory management, interrupt routines in an RTOS environment, basic design using RTOS.

**Microcontroller:** Role of processor selection in embedded system (Microprocessor vs Microcontroller), 8051 Microcontroller**:** architecture, basic assembly language programming concepts, instruction set, addressing modes, logical operation, arithmetic operations, subroutine, interrupt handling, timing subroutines, serial data transmission, serial data communication.

**Embedded System Development:** Embedded system evolution trends. Round - Robin, robin with interrupts, function-one-scheduling architecture, algorithms. Introduction to assembler compiler-cross compilers and Integrated Development Environment (IDE). object oriented interfacing, recursion, debugging strategies, simulators.

**Networks for Embedded Systems:** The I2C Bus, The CAN bus, SHARC link ports, Ethernet, Myrinet, Internet, Introduction to Bluetooth: specification, core protocol, cable replacement protocol. IEEE 1149.1 (JTAG) Testability: boundary scan architecture.

**Reference Books:**


1. Raj Kamal, Embedded Systems, TMH
2. K.J. Ayala, The 8051 Microcontroller, Penram International
3. J B Peatman, Design with PIC Microcontrollers, Prentice Hall
4. David E. Simon,An Embedded Software Primer, Pearson Education
5. John Catsoulis, Designing Embedded Hardware,O'reilly,
6. Frank Vahid, Tony Givargis, Embedded System Design, John Wiley & Sons, Inc
7. KarimYaghmour,Building Embedded Linux Systems, O'reilly
8. Michael Barr, Programming Embedded Systems,O'reilly
9. Alan C. Shaw, Real-time systems & software, John Wiley & sons, Inc

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|---|---|---|---|
| Course Title | **ELECTRIC DRIVES** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | VI |
| Prerequisite Knowledge | Power Electronics and Electrical Machines | | |
| Course Aim | To aware the students about the requirement of different type of drives along with their application in various industries. | | |
| Course Outcomes (COs) | At the end of the course students will be able to:<br>**CO1:** Understand the basic principles of power electronics in drives using switch-mode converters and pulse width modulation to synthesize the voltages in dc and ac motor drives.<br>**CO2:** Apply the knowledge about the operation of d.c motor and a.c motor speed control using converters and choppers.<br>**CO3:** To understand the modes of operation of a drive in various applications.<br>CO4: Design torque, speed and position controller of motor drives.<br>**CO5:** understand the starting and breaking methods of both a.c. and d.c. drives.<br>**CO6:** Review and Describe the structure of electric drive systems and their role in various applications such as flexible production systems, energy conservation, renewable energy, transportation etc. | | |

**UNIT 1**: Introduction of Drives-Concept of Electrical Drive, Classification of Drives, Block Diagram of an Electrical Drive, power modulators, Sources, Control Unit , Choice of Electrical Drive, Status of DC and AC Drive, Load Characteristics, Load With Rotational Motion and Transnational Motion, Classification of Load Torques, Load Torques function of Speed, Time, Path or Position Taken by the Load during Motion and Quadrant Operation

**UNIT 2:** Dynamics of Electrical Drive-Electric motor speed torque characteristics, Joint Speed-Torque Characteristic of an Electric Motor and Driven Unit, Stability of Drive System, Determination of Moment Of Inertia, Load Equalization, Concept of Transient Stability, Selection of motor under Continuous Duty, for Continuous variable Duty, for Short Duty Load, and intermittent Duty Load, Effect of Load Inertia, Environmental Factors

**UNIT 3:** Starting and Braking of DC Drives-Effect of staring on power supply, motor and load, Types of starters, Different methods of starting of a motor, Starting Circuit as a Function of Motor Speed, Function of Current and Function of Time, Thyristors and the resistance starter, Thyristor starting without resistance, Braking of DC Drives, Type of Braking, Friction Braking and Electrical

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| **UNIT 4:** Speed Control of DC Drives-Performance parameters for Power Controller Fed DC Drives, Classify various power electronics controller fed DC drives, Types of controlled rectifier fed DC drives, Performance of Controlled Rectifier Fed DC Shunt Motor and Series Motor, Performance of Chopper fed DC drives<br>**UNIT 5:** Starting and Braking of AC Drives-Need of using starters for AC Drives, Two (Star-Delta and Auto-transformer) types of starters used for Squirrel cage Induction motor, Starter using additional resistance in rotor circuit, for Wound rotor (Slip-ring), Starting of Synchronous Motor, Principle of electric braking for AC drives, Types of braking of AC drives<br>**UNIT 6:** Speed Control of AC Drives-Different methods of speed control of induction motor, Advantage of low frequency starting of induction motor, Sources of Variable frequency generation, Variation of supply voltage, Injection of voltage in rotor circuit, static ScherbiusDrive, Static Kramer Drives, Rotor resistance control Speed Control of Synchronous Motor Drives, Traction Motor drive<br>**Text/ Reference Books:**<br>1. G.K.Dubey, "Fundamental of electric drives," Narosa Publishing House, 2nd Edition, 2015.<br>2. VineetaAgarwal, "Fundamental of electric drives," Agarwal Publications, Ist Edition, 2013.<br>3. S. K. Pillai, "A First Course on Electrical Drives," New Age International Publishers, 3rdEdition, 2015.<br>4. P.C.Sen, "Thyristor DC drives,"John Wiley & Sons Inc., 1981.<br>5. B.K. Bose, "Modern Power Electronics and AC Drives," Prentice Hall, 1st Edition, 2001.<br>6. V. Subramanayam, "Thyristor control of electric drives," Tata McGraw Hill Publication, 1st Edition, 1988. |

| | | | |
|---|---|---|---|
| Course Title | **RENEWABLE ENERGY SOURCES AND DISTRIBUTED GENERATION** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | VI |
| Prerequisite Knowledge | Power System and Electrical Machines I & II | | |
| Course Aim | To impart the knowledge about various distributed generation resources, solar, wind generation systems and their appropriate integration in the utility grid. | | |
| Course Outcomes (COs) | At the end of this course, students will be able to:<br>**CO1:** Have a good understanding of the characteristics of solar PV system, wind energy system and other DG technologies for their suitable applications in real life. | | |

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|---|---|
| | **CO2:** Develop a conceptual understanding of grid-connected energy storage schemes & hybrid energy systems.<br>**CO3:** Idea about modern electrical loads as well as energy storage technologies and the impact of increased penetration of such technologies in distribution systems.<br>**CO4:** Understand the power management aspects of smart and micro-grids etc. |

**UNIT 1−DISTRIBUTED GENERATION RESOURCES**:

Installed capacities of electrical power system, Renewable energy sources (RES) types solar, wind, small-hydro, diesel generator , marine, fuel cells, current break up of installed capacities and growth of RES, distributed generation technologies, standalone, hybrid and grid connected, renewable energy system planning.

**UNIT 2− POWER ELECTRONICS IN DG:**

AC/DC, DC/DC and DC/AC converters in DG, Fully rated and partially rated converters, Battery charging, maximum power point tracking (MPPT) methods, Inverter topologies for solar and wind, reactive power, voltage, current and frequency control, intelligent power inverters.

**UNIT 3− SOLAR PV SYSTEM:**

Solar photovoltaic (PV) cell technologies, Modules and Arrays, Solar radiation: irradiance, capturing and orientation, I-V and P-V characteristics, Series and parallel connection and characteristics, bypass diodes, Solar PV components: Batteries, Power conditioning units charge controllers, DC cables, protection and safety devices, etc., Utility, Commercial and Residential PVs, PV system design.

**UNIT 4− WIND ELECTRICAL SYSTEM:**

Wind Turbines, Wind sites, Fixed speed and Variable speed wind turbines, Synchronous generator, PMSG, Induction generator , doubly fed synchronous generator, Generation schemes, Land vs. offshore wind turbines, wind turbine characteristics, Hybrid energy systems.

**UNIT 5− OTHER DG TECHNOLOGIES:**

Energy Storage, Batteries, Capacitors, Ultra-Capacitors, flywheel, Thermal Storage , Fuel Cells and its characteristics.

**UNIT 6− GRID INTEGRATION:**

Grid synchronization, Standards for grid connection, Power Quality, Eigen Analysis, optimal location of DG, Islanding issues, Solar and Wind power park, Smart grid, VSC-HVDC, Smart Inverter, Low voltage ride through capability (LVRT)

**Text Books:**


1. Chetan Singh Solanki, *Solar Photovoltaics: Fundamental, Technologies and Applications*, 2nd ed. PHI Learning Pvt. Ltd., 2011.
2. Chetan Singh Solanki, *Solar Photovoltaics: Technology and Systems: A manual for Technicians, Trainers and Engineers*, PHI Learning Pvt. Ltd., 2014.
3. S. N. Bhandra, D. Kastha and S. Banerjee, Wind Electrical Systems, Oxford University Press, 2005.
4. N. Mohan, T. M. Undeland and W. P. Robbins, *Power Electronics, Converters, Applications and Design*, Singapore, John Wiley & Sons. (Asia), 2003.
5. M. H. Rashid (ed), *Power Electronics Handbook*, Academic Press, Florida, 2001.
6. Brendan Fox, Leslie Bryans, Damian Flynn, Nick Jenkins, David Milborrow, Mark O'Malley, Richard Watson, and Olimpo Anaya-Lara, “Wind Power Integration: Connection and System Operational Aspects”, The Institution of Engineering and Technology, London, U.K., 2007.
7. Bin Wu, Yongqiang Lang, NavidZargari, and Samir Kouro, “Power Conversion and Control of Wind Energy Conversion System”, The Institution of Electrical and Electronics Engg. Inc., John Wiley &Sons.Inc., New Jersy, USA, 2011.
8. Mukund R. Patel, *Wind and Solar Power Systems*, CRC Press LLC, 1999.


**References:**


9. Michael Boxwell, Solar Electricity Handbook, Greanstream Publishing Ltd., U.K., 2017.
10. R. A. Messenger and J. Ventre, *Photovoltaic Systems Engineering*, “CRC Press, 3rd ed. 2010.
11. A. Ghosh and G. Ledwich, *Power Quality Enhancement using Custom Power Devices*, Kluwer Academic Publisher, Boston, MA, 2002.


| Course Title | **Advance Power Electronics** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEE | Semester | VI |
| Prerequisite Knowledge | Power Electronics | | |
| Course Aim | To make the students aware about various power electronics converters used in common low and medium power applications. Students to be familiar with different power converter circuits, modulation methods, modeling and analysis. Emphasis is on to know | | |

the students various applications like charging devices, power supplies, UPS, grid connected converters, renewable energy etc.

**Course Outcomes (COs)**

After successfully completing this course students will become aware of followings:

**CO1:** To introduce basic switched converters involving both non-isolated and isolated DC-DC converter, its steady state and dynamic analysis.

**CO2:** To present switched DC-AC inverter and various modulation techniques for both single and three-phase applications.

**CO3:** To provide understanding of soft switching operation through resonant circuits in order to minimise switching losses.

**CO4:** To present PWM and switch-mode AC-DC rectifiers in order to improve power factor and total harmonic distortions on AC side and controlled DC output voltage.

**CO5:** To introduce various advanced power electronics converters and its applications in power utility, distribution system and renewable energy systems.

**Mapping of COs with POs and PSOs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | H | H | M | H | L | M | H | M | L | L | H | M | H | M | H |
| CO2 | H | M | H | H | M | H | M | M | M | M | M | H | H | H | H |
| CO3 | M | M | H | H | M | M | H | H | M | H | H | M | M | H | H |
| CO4 | M | M | H | H | M | M | H | M | H | M | H | H | H | H | H |
| CO5 | M | H | H | H | H | H | H | M | H | M | H | M | M | H | H |

**H**- High (3), **M**- Medium (2), **L**- Low (1)

**Unit 1: DC-DC converters and Control( 6 Hrs)**

Review of switching devices, Semi-controlled and fully controlled switches, Characteristics of controlled switches and power loss calculations, Switched DC-DC converter circuits. Buck, Boost, Buck-boost, Cuk converters; Steady state characteristics of DC-DC converters, continuous and discontinuous conduction mode, Dynamics of converters; state-space averaging, voltage and current mode of control.

**Unit 2: PWM and other DC-DC Converters/Power Supplies( 6 Hrs)**

Parasitic effects: non-ideal switches and circuit elements in DC-DC converters, voltage transfer characteristics and efficiency calculation, Full bridge converter, Pulse width modulation (PWM) with unipolar and bi-polar switching, Isolated DC-DC converters: Unidirectional and bidirectional core excitation, Flyback, Forward and Push-Pull, Half-Bridge and Full-Bridge converters.

**Unit 3: DC-AC Inverters( 6 Hrs)**

Voltage source and current source inverters, Half-bridge, full-bridge and three-phase inverter circuits, Square wave and PWM modulation, Sinusoidal pulse-width modulation (SPWM), Space vector modulation (SVM)

**Unit 4: Resonant converters( 4Hrs)**

Hard switched and Soft Switched Converter, Classification of resonant converters, hard switched buck converter, Resonant-Switch converters, Zero-current switched (ZCS) DC-DC buck converter, Zero-voltage switched (ZVS) DC-DC buck converter.

**Unit 5:AC-DC switched Rectifiers ( 5Hrs)**

Power and harmonics in non-sinusoidal AC systems, Modeling, analysis, and control of low-harmonic rectifiers, various topologies of an ac-dc controlled rectifiers, Pulse-width modulated full-bridge rectifiers, Switched mode rectifiers.

**Unit 6: Other converter topologies and Applications( 5Hrs)**

Introduction to multi-level and Z-source inverters, Matrix-converters, Applications: Current controlled voltage source inverters (CCVSI), Active power filters (APF), Uninterrupted power supplies (UPS), Power conditioning units (PCU), Battery charging, monitoring of components.

**Textbook:**

1. N. Mohan, T. M. Undeland and W. P. Robbins, *Power Electronics, Converters, Applications and Design*, Singapore, John Wiley & Sons. (Asia), 2003.
2. M. H. Rashid (ed), *Power Electronics Handbook*, Academic Press, Florida, 2001.
3. V. Ramanarayanan, *Course Material on Switched Mode Power Conversion*, 2nd ed. IISc Bangalore, India, 2006.
4. J. G. Kassakian, M. F. Schlecht& G. C. Verghese, Principles of Power Electronics, Addison Wesley, 1991.
5. R. W. Erickson, Fundamentals of Power Electronics, Kluwer Academic Publications, 1997.
6. D. W. Hart, Introduction to Power Electronics, Prentice Hall International, 1997.
7. Erickson andMaksimovic, Fundamentals of Power Electronics, 2nd edition, Springer Science Business (2000)

| **Course Title** | **Power Systems Dynamics & Control** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-V/VI) | Semester | VI |
| Prerequisite Knowledge | Electrical Machines, Electric Power System | | |
| Course Aim | • To explain the power system stability problem.<br>• To model the dynamics of the electrical system components<br>• To understand the behavior of synchronous machine during disturbance.<br>• To employ mathematical tools for power system stability analysis. | | |
| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:** Understand the basics of power system stability<br>**CO2:** Do the dynamic modelling of the electrical system components<br>**CO3:** Investigate the system response for small and large disturbance<br>**CO4:** Ability to interpret results coming from the simulation of differential - algebraic systems.<br>**CO5:** Develop essential measures to enhance the power system stability | | |

Mapping of COs with POs

| | **PO** | | | | | | | | | | | | **PSO** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** | **3** |
| **CO1** | H | H | H | H | L | L | L | L | M | L | L | L | H | L | L |
| **CO2** | H | H | H | H | L | L | L | L | M | L | L | L | H | L | L |
| **CO3** | H | H | H | H | L | L | L | L | M | L | L | L | H | L | L |
| **CO4** | H | H | H | H | L | L | L | L | M | L | L | L | H | L | L |
| **CO5** | H | H | H | H | L | L | L | L | M | L | L | L | H | L | L |

**UNIT 1** **[10 hours]**

Introduction to Power System Stability. [3 hours]

Power System Operation and Control. Stability Problems faced by Power Systems. Impact on Power System Operation and Control.

Analysis of Dynamical Systems [7 hours]

Concept of Equilibria, Small and Large Disturbance Stability. Example: Single Machine Infinite Bus System. Modal Analysis of Linear Systems. Analysis using Numerical Integration Techniques. Issues in Modeling: Slow and Fast Transients, Stiff Systems.

**UNIT 2** **[10 hours]**

Modeling of Synchronous Machines

Physical Characteristics, Rotor Position Dependent model, D-Q Transformation, Model with Standard Parameters, Steady State Analysis of Synchronous Machine, Short Circuit Transient Analysis of a Synchronous Machine, Synchronous Machine Connected to Infinite Bus.

**UNIT 3** **[8 hours]**

Modeling of Excitation and Prime Mover Systems [4 hours]

Physical Characteristics and Models, Control system components, Excitation System Controllers, Prime Mover Control Systems.

Modeling of Transmission Lines and Loads [4 hours]

Transmission Line Physical Characteristics, Transmission Line Modeling, Load Models - induction machine model, Other Subsystems - HVDC, protection systems.

**UNIT 4** **[8 hours]**

Stability Issues in Interconnected Power Systems

Single Machine Infinite Bus System, Multi-machine Systems, Stability of Relative Motion, Frequency Stability: Centre of Inertia Motion, Concept of Load Sharing: Governors, Single Machine Load Bus System: Voltage Stability, Torsional Oscillations.

**UNIT 5** **[4 hours]**

Enhancement of Power System Stability

Planning Measures, Stabilizing Controllers (Power System Stabilizers), Operational Measures- Preventive Control, Emergency Control.

**Text / Reference books**


1) P.Kundur, Power System Stability and Control, McGraw Hill Inc, New York, 1995.
2) P.Sauer&M.A.Pai, Power System Dynamics & Stability, Prentice Hall, 1997.
3) K.R.Padiyar Power System Dynamics, Stability & Control, Interline Publishers, Bangalore, 1996.
4) E. W. Kimbark, Power System Stability, Vol I, II, III, Wiley Publication, 2007.
5) P. M. Anderson, 'A A Fouad, 'Power System Control and Stability', John Wiley & Sons, 1st Edition, 2008


| | | | |
|---|---|---|---|
| Course Title | **Distribution System Engineering** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-V/VI) | Semester | VI |
| Prerequisite | Basic knowledge of power system operation, analysis and protection | | |

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|---|---|
| Knowledge | |
| Course Aim | The objective of the course is to provide students with the skills to understand the analytical and design methods and modern tools for solution of problems associated with electric distribution system engineering.<br>To learn the basic concepts of reliability models, approaches and distribution system planning. |
| Course Outcomes (COs) | **CO1:** Study the need of load forecasting and different methods of load forecasting.<br>**CO2:**Study distribution system elements, planning, expansion methodologies and control. Ofdistribution system.<br>**CO3:**Study the scheme of subtransmission, substation, and primary, secondary feeder design of distribution systems.<br>**CO4:**Studythe performance of distribution system and operation. |
| Mapping of COs with POs and PSOs | |

| | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PO** | **PSO** | **PSO** | **PSO** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **CO1** | H | M | M | L | M | M | H | M | M | M | M | M | M | M | M |
| **CO2** | H | H | H | M | M | H | H | M | H | M | M | H | H | M | M |
| **CO3** | H | M | M | H | H | H | H | H | M | H | H | H | H | H | H |
| **CO4** | H | H | H | M | M | M | H | M | H | M | M | M | H | M | M |

**UNIT 1. LOAD CHARACTERISTICS AND LOAD FORECAST (CO1)**
**6hours**

Basic definitions- load definitions, load factor definitions, diversity principle in distribution systems - Load Forecast- factors affecting load forecasting methods, small areas load forecasting, spatial load forecasting methods, simulation, trending and mixed load forecasting methods

**UNIT 2**. **DISTRIBUTION SYSTEM PLANNING, AUTOMATION AND CONTROL(CO2)9 hours**

Short term planning - Long term planning - Dynamic planning - Structure of distribution automation - Essential component of distribution automation - Automation of distribution system components - Load management

**UNIT 3.SUB-TRANSMISSION AND SUBSTATION DESIGN (CO3) 6hours**

Sub-transmission networks configurations - Substation bus schemes - Distribution substations ratings - Service areas calculations - Substation application curves.

**UNIT 4.PRIMARY AND SECONDARY SYSTEM DESIGN CONSIDERATIONS (CO3) 6hours**

Primary circuit configurations - Primary feeder loading - Secondary networks design - Economic design of secondary - Unbalance loads and voltage considerations

**UNIT 5. DISTRIBUTION SYSTEM PERFORMANCE AND OPERATION (CO4) 9hours**

Voltage drop calculation for distribution networks - Power loss Calculation - Application of capacitors to distribution systems - Application of voltage regulators to distribution systems

**Text / Reference books**


1.Electric Power Distribution System Engineering, T. Gonen, 2 nd edition, CRC, 2007, ISBN 978-1-4200-6200-7

2. Distribution System Modeling and Analysis, W. H. Kersting, 3rd edition, CRC, 2012

3. Electric Power Distribution Handbook, Thomas Allen Short, CRC Press

3. Power distribution engineering: fundamentals and applications, James J. Burke, M. Dekker, New York, 1994.

4. Electrical power distribution and transmission, Luces M. Faulkenberry, Prentice Hall, 1996.


| | | | |
|---|---|---|---|
| Course Title | **Advanced Semiconductor Devices** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-V/VI) | Semester | VI |
| Prerequisite Knowledge | Power Electronics, Electrical Machines, Control system | | |
| Course Aim | To teach the different semiconductor devices used for power electronics. | | |

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|---|---|
| Course Outcomes (COs) | **CO1:** To introduce basic EMI due to switching.<br>**CO2:** To understand the operation of the different current and voltage-controlled devices.<br>**CO3:** To understand the different firing and protection circuits.<br>**CO4:** To study the different thermal protection techniques of thedevices |
| | **Power switching devices overview**: Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics and ratings<br>**Current controlled and voltage controlled devices:** Review of power electronics devices: Power BJT, Power MOSFET, IGBT, GTO, etc. – Construction, Principle of voltage controlled devices, types, static and switching characteristics, steady state and dynamic models, Negative temperature co-efficient and secondary breakdown, Other emerging devices GTO, MCT, SiC, FCT, RCT, IGCT etc.<br>**Firing and protecting circuits:** Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubber.<br>**Thermal protection :**Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour, phase cooling; Guidance for hear sink selection – Thermal resistance and impedance, Electrical analogy of thermal components, heat sink types and design – Mounting types, Packaging and power modules.<br>**Reference Books:**<br>1. B.W Williams, *Power Electronics, Devices, Drivers and Applications,* Wiley, New York, 1987.<br>**2.** M. H. Rashid, *Power Electronics Circuits, Devices and Applications*, Prentice Hall India, Third Edition, New Delhi,2004**.**<br>3. VineetaAgarwal and Krishna Kant, *Power Electronics,* BPB Publications, New Delhi 2008.<br>4. M. D. Singh and K.B Khanchandani, *Power Electronics*, Tata McGraw-Hill, New |

| | |
|---|---|
| | Delhi 2003.<br>**5.** N. Mohan, T. M. Undeland and W. P. Robbins, *Power Electronics, Converters, Applications and Design*, Wiley |

| **Course Title** | **Digital Design & VHDL** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-V/VI) | Semester | VI |
| Prerequisite Knowledge | Basic Instrumentation. | | |
| Course Aim | To gain an in-depth understanding of VHDL and to realize different circuits using it both sequential and combinational. | | |
| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:** Understand the basic concepts of Digital Design.<br>**CO2:** Implement various Combinational and sequential circuits using VHDL descriptions. Write simple VHDL programs in different styles.<br>**CO3:** Design and verify the functionality of digital circuits (PLA, PAL, PLD) and ArithmeticOperations.<br>**CO4:** Identify the suitable Abstraction level for a particular digital design.<br>**CO5:** Write the programs more effectively using Verilog tasks and directives. Perform timing and delay Simulation. | | |
| Program Specific Outcome (PSOs) | **PSO1:**Recognize the engineering problems and develop solutions in the area of digital systems.<br>**PSO2:** Gain proficiency with VHDL software package and utilize software package to solve problems on a wide range of digital logic circuits. | | |

Mapping of COs with POs and PSOs

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | M | M | M | L | L | L | L | L | M | M | M | L | L | M |
| CO2 | H | M | H | H | H | M | L | L | H | M | H | H | M | H |
| CO3 | H | H | H | H | M | M | L | L | H | M | H | M | M | H |
| CO4 | H | H | H | H | M | M | M | M | M | L | M | L | H | H |
| CO5 | H | M | M | H | M | M | M | M | M | M | H | M | H | H |

**UNIT-1: Introduction**

VHDL description of combinational networks, Modeling flip-flops using VHDL, VHDL models for a multiplexer, Compilation and simulation of VHDL code, Modeling a sequential machine, Variables, Signals and constants, Arrays, VHDL operators, VHDL functions, VHDL procedures, Packages and libraries, VHDL model for a counter.

**UNIT-2: Designing With Programmable Logic Devices**

Read-only memories, Programmable logic arrays (PLAs), Programmable array logic (PLAs), Other sequential programmable logic devices (PLDs), Design of a keypad scanner.

**UNIT-3: Design Of Networks For Arithmetic Operations**

Design of a serial adder with accumulator, State graphs for control networks, Design of a binary multiplier, Multiplication of signed binary numbers, Design of a binary divider.

**UNIT-4: Digital Design with SM Charts**

State machine charts, Derivation of SM charts, Realization of SM charts. Implementation of the dice game, Alternative realization for SM charts using microprogramming, Linked state machines.

**UNIT-5: Designing With Programmable Gate Arrays And Complex Programmable Logic Devices**

Xlinx 3000 series FPGAs, Designing with FPGAs, Xlinx 4000 series FPGAs, using a one-hot state assignment, Altera complex programmable logic devices (CPLDs), Altera FELX 10K series COLDs.

**UNIT-6: Floating - Point Arithmetic**

Representation of floating-point numbers, Floating-point multiplication, Other floating-point operations.

**UNIT-7: Additional Topics in VHDL**

Attributes, Transport and Inertial delays, Operator overloading, Multi-valued logic and signal resolution, IEEE-1164 standard logic, Generics, Generate statements, Synthesis of VHDL code, Synthesis examples, Files and Text IO.

**UNIT-8: VHDL Models for Memories and Buses**

Static RAM, A simplified 486 bus model, Interfacing memory to a microprocessor bus.

**Text / Reference books**

1. Stephen Brown and ZvonkoVranesic," Fundamentals of Digital Logic with VHDL Design" , Mc-Graw-Hill (2nd edition).ISBN-10: 0077211642
2. Peter J. Ashenden, "Designers guide to VHDL ",Morgan Kaufman Publishers. 3rd edition, ISBN-10: 0120887851.

| **Course Title** | **Optimization Techniques** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-V/VI) | Semester | VI |
| Prerequisite Knowledge | Basic calculus; calculation of maximum and minimum of any function. | | |
| Course Aim | To understand basics of optimization techniques and its different characteristics. To know working principle of different optimization techniques and their applications. | | |
| Course Outcomes (COs) | At the end of the course students will be able<br>**CO1:**To know the basics of optimization problems and concepts of local and global minima.<br>**CO2:**To know the concepts of linear programming of optimization<br>**CO3:**To obtain the solution of unconstrained optimization problems.<br>**CO4:**To obtain the solution of constrained optimization problems.<br>**CO5:**To apply the Evolutionary algorithms in their future works. | | |
| Program Specific Outcome (PSOs) | **PSO1:** Students will acquire technical knowledge about the optimization problems.<br>**PSO2:** Can develop strong skill to apply different optimization techniques inindustrial automation systems.<br>**PSO3:** Students can acquire chance for higher education as well as job in a roll of researcher/ technician / Supervisor / Manager / Engineer in different sectors. | | |
| Mapping of COs with POs and PSOs | (see table below) | | |

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | H | H | M | M | M | M | M | M | M | L | L | L | H | M | M |
| CO2 | H | H | M | M | M | M | M | M | M | L | L | H | H | M | M |
| CO3 | H | H | H | H | M | M | M | M | M | M | L | H | H | H | M |
| CO4 | H | H | H | H | M | M | M | M | H | M | L | H | H | H | M |
| CO5 | H | M | H | M | H | H | M | H | H | H | M | H | H | H | H |

**UNIT 1:** Classical optimization techniques: Introduction to Optimization, Engineering application of Optimization, Statement of an Optimization problem, Optimal Problem formulation,Classification of Optimization problem. Optimum design concepts, Definition of Global and Local optima, Optimality criteria, Review of basic calculus concepts, Global optimality

**UNIT 2:** Linear programming (LP): Two variable problems, graphical solutions, Duality, Duality and Primal Dual algorithm. Simplex algorithms.

**UNIT 3:**Non-linearprogramming (NLP): Optimization algorithms for solving unconstrained optimization problems, Gradient based method such as Cauchy's steepest descent method, Newton's method, Conjugate gradient method.

**UNIT 4:**Non-linearprogramming (NLP): Optimization algorithms for solving constrained optimization problems such as direct methods, penalty function methods, steepest descent method, Engineering applications of constrained and unconstrained algorithms.

**UNIT 5:** Evolutionary algorithms (EA): Genetic algorithm, particle swarm optimisation, Tabusearch,simulated annealing and ant colony optimization, Multi objective optimization using EA, Paretosolutions.

**Text / Reference books**


1. S.S. Rao, Engineering Optimization: Theory and Practice. New York: Wiley. 2009.
2. K. Deb, Multi-objective Optimization using Evolutionary Algorithms. New York; Wiley. 2002.
3. A. D. Belegundu, and T. R. Chandrupatla, Optimization Concepts and Applications inEngineering: Pearson Education (Singapore). 2003.
4. A. Schirisieer, Theory of linear and integer programming, John Wiley and Sons, 1986.
5. D. Leunberger, Linear and Nonlinear programming, Add. Wesley, 1984.


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| | | | |
|---|---|---|---|
| Course Title | **INTRODUCTION TO ELECTRICITY MARKETS** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-V/VI) | Semester | VI |
| Prerequisite Knowledge | Power System-I, Power System-II | | |
| Course Aim | This course provides a comprehensive introduction to electricity markets, including power system economics, market models, and market design. | | |

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|---|---|
| Course Outcomes (COs) | At the end of the course students will be able to:<br>**CO1:**Familiarize the needs,concepts, challenges and structures of deregulated power systems.<br>**CO2:**Distinguish the components of restructured power system and conventional power system and their applications.<br>**CO3:**Describe the development and latest trends in electricity market design and analyzeits connection to operation and planning of power system.<br>**CO4:**Analyze and reflect upon different models and methods for electricity market design, planning and operation.<br>**CO5:**Impart the knowledge of power market developments in India and across the world. |

Mapping of COs with POs& PSOs

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | - | - | - | 1 | 1 | - | - | - | - | - | 1 | - | 1 |
| **CO2** | 3 | 2 | - | 1 | - | 1 | 1 | - | - | - | - | - | 1 | - | 1 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 2 | 2 | - | - | - | - | - | 3 | 3 | 2 |
| **CO4** | 3 | 3 | 3 | 2 | 2 | 2 | 2 | - | - | - | - | - | 3 | 3 | 2 |
| **CO5** | 3 | 2 | - | 1 | - | 1 | 2 | - | - | - | - | - | 1 | - | 1 |

**UNIT 1 – INTRODUCTION TO ELECTRICITY MARKETS: (7 Hours)**

Traditional Power Industry Structure, Introduction to the Electric Power Grid, Basics of Electric Power Flow, Economics of Power Generation, Motivations & need for restructuring & deregulation, Fundamentals of restructured & deregulated power system, Components of restructured & Deregulated power systems, Technical, economic & regulatory issues involved in deregulation of power industry, Privatization, Competition in the electricity sector, conditions, barriers, different types, benefits and challenges.

**UNIT 2 – COMPONENTS OF RESTRUCTURED SYSTEMS: (9 Hours)**

Different structure model like Monopoly model, Purchasing agency model, wholesale competition model, Retail competition model. Functions and responsibilities, Functions and responsibilities of key market entities- ISO, TSO, GENCO, TRANSCO, DISCO, RETAILCO, Trading arrangements: Pool, bilateral & multilateral, Open Access Transmission& Distribution Systems, Power system operation and control: Old vs. New, IT applications in restructured markets.

**UNIT 3 – OPERATION OF RESTRUCTURED POWER MARKETS: (9 Hours)**

Transmission Congestion management, Locational Marginal Prices (LMP), Ancillary Service Management, Day-ahead and Real-time Energy Markets, Financial Transmission Rights and Hedging, Market Power.

**UNIT 4 – TRANSMISSION PRICING METHODS AND LOSS ALLOCATION: (7 Hours)**

Models of transmission pricing, Different transmission services, Network cost evaluation methods, Cost allocation methods, loss allocation algorithms, Wheeling transactions.

**UNIT 5 – POWER SECTOR REFORMS IN INDIA AND WORLD: (8 Hours)**

Introduction to Indian electricity markets, electricity market provisions in Electricity Act 2003 and subsequent amendments, Introduction to various institutions in Indian Power sector: e.g. Ministry of Power, Planning Commission, CEA, central and state utilities, PGCIL, Power Finance Corporation Limited (PFC), REC, CERC & SERCs, traders, LDCs, Power Exchanges, and their roles.

Experience of world's electricity reforms and key electricity markets: e.g. UK, South American markets (Argentina, Brazil, Chile, Uruguay), US (California, New York, PJM, ERCOT, New England, Midwest), Scandinavian market (Norway, Denmark, Sweden, Finland), Canada, Australia, China, Japan, Germany, New Zealand, France.

**Text / Reference books**


1. Loi Lei Lai, "Power System Restructuring and Deregulation", John Wiley & Sons Ltd, England, 2001.
2. Mohammad Shahidehpour, MuwaffaqAlomoush, "Restructured Electric Power Systems: Operation, Trading and Volatility", Marcel Dekker, Inc., 2001.
3. D. Kirschen, G. Strbac, "Fundamentals of Power System Economics", 2$^{nd}$Edition, John Wiley, 2018
4. Sioshansi, "Competitive Electricity Markets: Design, Implementation, Performance", Elsevier, 2008
5. Geoffrey Rothwell, Tomas Gomez (Eds.), "Electricity Economics Regulation and Deregulation", IEEE Press Power Engineering Series, John Wiley & Sons, 2003.
6. Steven Stoft, "Power System Economics: designing markets for electricity", Wiley Interscience, 2002.
7. Richard J. Gilbert, Edward P. Khan, "International Comparisons of Electricity Regulation", Cambridge University Press, 2002.
8. A. R. Abhyankar, S. A. Khaparde, NPTEL Web Course: Restructured Power System, Available: https://nptel.ac.in/courses/108/101/108101005/
9. Lorrin Philipson, H. Lee Willis, "Understanding Electric Utilities and Deregulation", Taylor & Francis, New York, 2nd Edition, 2006.


| **Course Title** | **Industrial Instrumentation & Control** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-V/VI) | Semester | VI |
| Prerequisite Knowledge | Basic instrumentation and control system | | |
| Course Aim | To understand construction and working principle of different industrial measurement systems. To understand new trends in industrial process control. | | |
| Course Outcomes (COs) | At the end of the course students will be able<br>**CO1:** To know the working principle and uses of Transducer systems.<br>**CO2:** To implement PID controller, Overriding controller, Split range controller etc.<br>**CO3:** To realize PLCs and Relay Ladder Logic Sequence Control.<br>**CO4:** To understand the working principles of Control valves and actuators.<br>**CO5:** To do Motor control in real life. | | |
| Program Specific Outcome (PSOs) | **PSO1:** Students will acquire technical skill for developing embedded based industrial automation and control circuit.<br>**PSO2:** Can develop strong technical knowledge for establishing instrumentation-based automation system in various industries. | | |

<table>
<tr><td></td><td>PSO3: Students can acquire job as calibration, Instruments, PLC, Virtual Instruments and embedded technician / Supervisor / Manager / Engineer.</td></tr>
<tr><td>Mapping of COs with POs</td><td>
<table>
<tr><th></th><th>PO1</th><th>PO2</th><th>PO3</th><th>PO4</th><th>PO5</th><th>PO6</th><th>PO7</th><th>PO8</th><th>PO9</th><th>PO 10</th><th>PO 11</th><th>PO 12</th><th>PSO1</th><th>PSO2</th><th>PSO3</th></tr>
<tr><td>CO1</td><td>H</td><td>H</td><td>M</td><td>M</td><td>L</td><td>L</td><td>L</td><td>M</td><td>M</td><td>M</td><td>L</td><td>H</td><td>H</td><td>M</td><td>M</td></tr>
<tr><td>CO2</td><td>H</td><td>H</td><td>M</td><td>M</td><td>L</td><td>M</td><td>M</td><td>M</td><td>M</td><td>M</td><td>L</td><td>H</td><td>M</td><td>M</td><td>H</td></tr>
<tr><td>CO3</td><td>M</td><td>M</td><td>H</td><td>L</td><td>H</td><td>H</td><td>H</td><td>M</td><td>M</td><td>M</td><td>H</td><td>H</td><td>H</td><td>M</td><td>H</td></tr>
<tr><td>CO4</td><td>H</td><td>M</td><td>L</td><td>L</td><td>H</td><td>M</td><td>M</td><td>M</td><td>M</td><td>M</td><td>M</td><td>M</td><td>M</td><td>M</td><td>L</td></tr>
<tr><td>CO5</td><td>H</td><td>M</td><td>H</td><td>H</td><td>M</td><td>H</td><td>H</td><td>H</td><td>M</td><td>M</td><td>H</td><td>M</td><td>H</td><td>M</td><td>M</td></tr>
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**UNIT 1:** Introduction to Industrial Instrumentation and Control, Architecture of Industrial Automation Systems.

**UNIT 2:** Specifications of Measuring Instruments, Measurement of Temperature, Pressure and Force Measurement, Measurement of Displacement and Speed, Flow Measurement, Measurement of Level, Signal Conditioning Circuits, Errors and Calibration.

**UNIT 3:** Introduction to Process Control, PID Control, Controller Tuning, Implementation of PID Controllers, Special Control Structures: Feed forward and Ratio Control, Predictive Control, Control of Systems with Inverse Response, Cascade Control, Overriding Control, Selective Control, Split Range Control.

**UNIT 4:** Introduction to Sequence Control, PLCs and Relay Ladder Logic Sequence Control.

**UNIT 5:** Control Valves, Hydraulic Actuation Systems - I: Principles and Components, Directional Control Valves, Switches and Gauges, Practical Hydraulic Circuits, Pneumatic Control Components, Pneumatic Control Systems.

**Module 7:** Electrical Motor control, Motor operation, Motor ratings, Motor control applications, Motor protection.

**Text / Reference books**

8. S. Mukhopadhay, S. Sen, and A. K. Deb, Industrial Instrumentation Control and Automation, JAICO, 2015.
9. Singh S K, ―Industrial Instrumentation and Control, Tata McGraw Hill, New Delhi, 2004.
10. Krishna Kant, Computer-Based Industrial Control, Prentice Hall of India, 1997.
11. David Bailey, E. Wright, Practical SCADA for Industry, Newnes, 2003.
12. W. Dunn, Fundamentals of Industrial instrumentation and control system, McGraw-Hill, 2005.

| | |
|---|---|
| Course Title | **Modern Electrical Machines** |

| Course Code | | Credit | 4 |
|---|---|---|---|
| Core/ Elective | CEL (Elective-V/VI) | Semester | VI |
| Prerequisite Knowledge | Basic electrical machine principles, conventional machine theories. | | |
| Course Aim | The aim of this course is to provide the knowledge of modern advancements in machines and construction, theory and operation of modern electrical machine. | | |
| Course Outcomes (COs) | At the end of the course students will (Number may vary)<br>**CO1:** the students will learn the construction, operation and control of some non-conventional electrical machines<br>**CO2:** students will have an idea how the materials affect the motor performance and their characterization for selection.<br>**CO3:** the students will be able to study construction, operation and control of high speed and high power density motors<br>**CO4:** the students will be able to learn modern advanced electrical machines for various special purposes such as navy, aircrafts, vehicles and medical.<br>**CO5:** the students will be able to deal with and understand the Modern design tools and software based analysis of motors their optimization and analysis. | | |
| Mapping of COs with POs | (see table below) | | |

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | H | H | L | L | L | H | L | M | L | L | L | H | H | H | L |
| CO2 | H | L | L | L | L | H | M | H | L | L | L | H | H | H | H |
| CO3 | H | H | L | L | L | H | H | L | L | L | L | H | M | H | H |
| CO4 | M | L | L | L | L | M | H | L | L | L | L | H | M | H | M |
| CO5 | H | H | H | H | H | H | M | M | L | M | L | H | H | H | H |

**UNIT-1 (8 hours)**

Basic Principles of Electrical Machines, Basic Electrical Machines, Construction, Governing equation, Equivalent circuit, analysis and control, Universal motors (AC/DC series motors), Welding Generators, Single Phase IM, Split Phase, Capacitor start and run motors, revolving field theory and cross field theory, Equivalent circuit and speed control, Schrage Motor, Linear Induction Motor, Magnetic Levitation and Levitating train Principle. Hysteresis Motor, Reluctance Motor, Switched reluctance Motors, Synchronous Reluctance motors, Double Rotor Synchronous Reluctance motor, converter operation for Switched Reluctance motor, High Speed switched reluctance generator, Servo Motor, single stack and multi-stack Stepper Motors.

**UNIT-2 (6 hours)**

**Material characterization for Advanced Machines**, Amorphous ferromagnetic materials, High saturation ferromagnetic alloys, laminated silicon steels; high saturation alloys; amorphous ferromagnetic alloys; soft magnetic powder composites; Permanent Magnet materials; high temperature wires; insulating materials; high temperature superconductors (HTS); nanostructured materials.

**UNIT-3 (10 hours)**

**High power density and High Speed machines,** High Speed Spindle motors, Hard disc drive motors, High speed turbogenerators machine requirements, cooling techniques for high speed machines, BLDC motor, Permanent Magnet Synchronous Motors (PMSM), Surface-mounted permanent magnet (SPM) machine, flux switching permanent magnet (FSPM) machine, Modern Converters for, Speed and torque control, Sensorless control, Field oriented control (FOC), direct torque control (DTC) control, Space Vector PWM control, Rotating transformer, Resonant IPT based Contactless field power to rotor, Contactless Field Power controlled BLDC and BLAC motors, slottless BLDC and PMSM motors, Coreless BLDCM and PMSM, Magnetic Bearings, Bearingless Motors, Governing Equations, analysis and control of Converters for High Speed BLDCM and PMSM.

**UNIT-4 Special Application Electric Machines (10 hours)**

**Aircraft generators system**, High speed multimegawatt generators for Directed energy weapons (DEW), High-power microwave (HPM) weapons, Lazer weapons and particle beam (PB), recyclable electric machines, **Electric motors for medical and clinical applications**, micro engine driven PM generator, **Generators for portable power Applications**, Coreless stator disc type microgenerators, **Superconducting motors,** High Temperature Superconducting (HTS) Motor, Low speed and high Speed HTS motor, Superconducting (HTS) Synchronous Generator, Dynamic Synchronous Condensor, HTS induction motor, high Speed HTS generators, Motors and Generator for Naval applications, Electric Ship Propulsion system, Integrated motor-propeller, Axial Flux Disc type PM motor, Large IM and PM, Transverse Flux Motor (TFM), HTS motor for Ship Propulsion, Integrated Starter generator (ISG) for Vehicles, Integrated and PCB motors, Magnetic Braking, Thruster motors for braking in cranes, Written pole motor, Piezoelectric or ultrasonic motors.

**UNIT-5 (6 hours)**

**Analysis tools for Machines, FEA and FEM**, Different Platforms for FEA, Altair FluxMotor, Ansys Maxwell, RMxpert, MotorAnalysis, MotorXP, Motor-CAD Software, SimcenterMotorsolve, Optimization and thermal Analysis method and steps.

**Text/Reference Books**


1. Jacek F. Gieras “Advancements in Electric Machines”, Springer
2. P.S. Bimbhra “Generalized Thoery of Electrical Machines”
3. P.S. Bimbhra “Electrical Machinery”
4. Vincent Del Toro “Basic Electrical Machines”
5. Asfaq Hussain “Electric Machines”
6. M. H. Rashid “Power Electronics Handbook”, third Edition, 2011, Butterworth-Heinemann, Elsevier.


| Course Title | **Special Topics in Control System** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Control System) | Semester | VI |
| Prerequisite Knowledge | 1. Control System<br>2. Mathematics | | |

| | |
|---|---|
| Course Aim | To discuss different control strategies. |
| Course Outcomes (COs) | After completion of the course students shall be able to:<br>**CO1:** Importance of Model Order Reduction: Time domain techniques and frequency domain techniques.<br>**CO2:** Concept of variable-structure controller and sliding control and application of switching control laws to practical systems.<br>**CO3:** To develop understanding of fuzzy logic systems and familiarity with Mamdani and TSK fuzzy logic controllers.<br>**CO4:** Developing analytical skills to design microcontroller, DSP controller and Embedded controller for specific requirement and to analyze its performance. |

Model Order Reduction: Importance of reduced order models, Time domain Techniques,Frequency Domain Classical techniques, Optimal Hankel Norm Approximation. Sliding modecontrol: Concept of variable-structure controller and sliding control, reaching condition andhigher order sliding mode, reaching mode, implementation of switching control laws. Reductionof chattering in sliding and steady state mode. Fuzzy Logic: Fuzzy arithmetic and fuzzy relations,Fuzzy logic controller, Adaptive fuzzy control, Stabilization using fuzzy models Microcontrollerand DSP control.

**Reference Books:**


1. G. Obinata and B.D.O. Anderson, "Model reduction for control system design," Springer-Verlag, London, 2001.
2. M. Jamshid, "Large-Scale Systems: Modeling, Control and Fuzzy Logic," Prentice Hall; 1stedition, 1996.
3. J. .I. E. Siotine, "Applied nonlinear control," Prentice Hall Englewood Cliffs, New Jersey.1991.
4. M. Chidambaran, "Computer Control of Processes," Alpha Science International Ltd, 2002.
5. V. I. Utkin, "Sliding modes in control and optimization," Springer- Verlag, 1992.
6. W. Pedrycz,"Fuzzy control and fuzzy systems," Research Studies Press, 1993.


| | | | |
|---|---|---|---|
| Course Title | **Cyber Security** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Control System) | Semester | VI |
| Prerequisite Knowledge | Power system, Distribution Automation | | |
| Course Aim | To understand the different Cyber attacks and their prevention techniques | | |
| Course Outcomes (COs) | CO1: Understand the core principles behind CPS<br>CO2: Identify safety specifications and critical properties<br>CO3: Understand abstraction in system design<br>CO4: Learn techniques for attack detection and attack mitigation. | | |

**Unit 1: Dynamical Systems Modeling**

i. Cyber-Physical Systems (CPS) in the real world
ii. Dynamical Systems : stability and performance
iii. Different notions of stability
iv. Controller Design techniques
v. Sensors and Actuators for Physical Processes

**Unit 2: CPS Compute/Scheduling**

i. Real time scheduling theory
ii. CAN bus scheduling
iii. Packet drops and their effects on stability/performance
iv. Delay/Deadline-miss aware control design

**Unit 3: Secure CPS**

i. Distributed CPS
ii. Attack Models
iii. Attack detection techniques in CPS
iv. Attack mitigation in CPS

**Unit4:**

Smart Grid Security and Privacy : Automated Generation Control attack mitigation

***References***:


1. E. A. Lee and S. A. Seshia , Introduction to Embedded Systems - A Cyber-Physical Systems Approach, 2014.
2. Rajeev Alur, Principles of Cyber-Physical Systems, MIT Press, 2015.
3. J. J. E. Slotine, Applied nonlinear control, Prentice-Hall,1991

Brown, P., Sensors and Actuators: Technology and Applications, Library Press, 2016


| Course Title | **Adaptive Control** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Control System) | Semester | VI |
| Prerequisite Knowledge | 1. Control System<br>2. Optimal Control | | |
| Course Aim | To discuss the design of adaptive control systems. | | |
| Course Outcomes (COs) | After completion of the course students shall be able to:<br>**CO1:** explain self-tuning, adaptive, predictive and robust adaptive control systems.<br>**CO2:** explain self-tuning, adaptive, predictive and robust adaptive control systems.<br>**CO3:** understand adaptive control systems, their development and properties.<br>**CO4:** understand methods and tools for stability analysis of adaptive and learning systems. | | |

Introduction: Linear feedback, effects of process variations, adaptive schemes, adaptive controlproblem.

Real-Time Parameter Estimation: Least squares and regression models, estimating parameters indynamical systems, simulation of recursive estimation.

Self-tuning Regulators (STR): Pole placement design, indirect STR, direct STR, stochastic and predictive STR, applications.

Model-reference Adaptive Control (MRAC): The MIT rule, determination of adaptive gain,design of MRAS' using Lyapunov theory, BlBO stability, output feedback, relation between MRAS and STR, applications.

Gain Scheduling: The principles, design of gain scheduling controllers, nonlinear transformations, applications.

Robust adaptive control scheme, averaging-based analysis, adaptive control of nonlinear systems. Practical issues and implementation, commercial products and applications.

**Reference Books :**


1. K. J. Astrom, B. Wittenmark, "Adaptive Control, Prentice Hail," 2 edition, 1994 .
2. P. A. Ioannou, J. Sun, "Robust Adaptive Control, Dover Publication," 2 edition, 2012.
3. H. K. Khalil, "Nonlinear Systems," Prentice Hall; 3 edition, 2001.
4. K. S. Narandra, A. M. Annaswamy, "Stable Adaptive Systems," Prentice Hall, EnglewoodClis, NJ, 1989.
5. S. Sastry, M. Bodson, "Adaptive Control: Stability, Convergence and Robustness," DoverPublications, 2011.


| Course Title | **Stochastic Control and Optimization** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Control System) | Semester | VI |
| Prerequisite Knowledge | Advanced Mathematics<br>Control theory<br>Probability and random processes | | |
| Course Aim | This course introduces basic theories and methodologies for analysis and design of stochastic controlsystems.It provides a comprehensive introduction to stochastic control, with applications | | |
| Course Outcomes (COs) | **After the successful completion of this course, students are able to:**<br>CO1: Understand basic principles of probability theory and stochastic dynamical systems including Markov chains.<br>CO2: Rigorously formulate stochastic control problems as Markov Decision Process (MDP) problems.<br>CO3: Solve Linear Quadratic stochastic control problems.<br>CO4: apply solve constraint optimization problems by applying hybrid optimization techniques. | | |

| Mapping of COs with POs | | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|---|---|---|---|---|---|---|---|
| | CO 1 | High | High | High | Medium | Medium | Low |
| | CO 2 | High | High | High | Medium | Low | Low |
| | CO 3 | High | High | High | Medium | Low | Medium |
| | CO 4 | High | High | Medium | Medium | Low | Medium |

**Module 1:**

Introduction to stochastic control, Shortest path example, Probability and Monte Carlo, Markov chains, Structure of Markov chains, Markov decision processes,Dynamic programming, Approximate dynamic programming,The Bellman-Ford algorithm, Linear quadratic stochastic control, Linear exponential quadratic regulator, Model predictive control, Hidden Markov models, Risk averse control, nonlinear filtering.

**Module 2:**

Multi-valued optimization, hybrid optimization, meta-heuristic algorithms.

***References***:


1. K.J. Astron, Introduction to Stochastic Control Theory, Dover Pub.
2. J. Spall, Introduction to Stochastic Search and Optimization, Wiley-Interscience, New York, 2003.
3. Sheldon Ross, Introduction to Stochastic Dynamic Programming, Academic Press, New York, 1995.
4. S. Asmussen and P. W. Glynn, Stochastic Simulation, Springer Verlag, New York, 2007.


| Course Title | **Modern Digital and Embedded Controllers** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Control System/ Power Electronics) | Semester | VI |
| Prerequisite Knowledge | Digital Electronics and Micro processors | | |
| Course Aim | To teach internal structure, operation and application of the various controllers | | |
| Course Outcomes (COs) | CO1: To explain the various micro controller available and study the structure.<br>CO 2 To understand the basic I/O of FPGA and DSP based controllers<br>CO 3: To understand the serial and parallel operation in DSP and FPGA controllers<br>CO 4 To understand the operation of the PLC controllers. | | |

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|---|
| **UNIT 1:** Microcontroller Basics-8-Bit and 16-bit Microcontroller Internal Block Diagram, CPU, ALU, address bus, data bus, control signals, Working Registers, SFRs, Clock and Reset circuits, Stack and use of Stack Pointer, Chip Peripheral Interfaces-Interfacing concept and design rule<br><br>**UNIT 2**: FPGA based controller: Architecture, logic for different operations, parallel operation, Set of inputs, FPGAs-Resource Sharing, Implementation technology – PLD's, Custom Chips, Standard Cell and Gate arrays – FPGA Architectures – SRAM based FPGAs – Permanently programmed FPGAs –FPGA logic cells, I/O block architecture: Input and Output cell characteristics, clock input, Timing. FPGA applications to power electronic systems, Gating Pulse generation for AC-AC converter, AC-DC converter, PWM generation for Buck Converter, SPWM generation<br>- Main design rules of an FPGA-based controller: Control algorithm refinement (design of a time continuous controller, internal delay issues, digital re-design, sampling issues, quantization issues). Architecture refinement (algorithm architecture matching, IP-modules reusability, Hardware-In-the-Loop (HIL) validation<br><br>**UNIT 3**: DSP based controllers: Architecture, logic for different operations, parallel operation, Set of inutps, Dspace based controller<br><br>**UNIT 4**:Atmel AVR ATMEGA 8 Micro-controller: Introduction, Major features, Architecture, Application and programming, PLC for various control application, ladder logic.<br>Reference Books:<br>1. The 8051 Microcontroller and Embedded systems-using assembly and C, Muhammad Ali Mazidi and Janice Gillespie Mazidi and Rollin D. McKinaly,PHI,2006/pearson,2006<br>2. Embedded Systems Design using the TI MSP430 series, Cris Nagy, Newnes, Elsevier. |

| Course Title | **System Identification and Estimation** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/H R/RS | HR/RS Course-2 (Control System) | Semester | VI |
| Prerequisite Knowledge | Control System<br>Probability theory | | |
| Course Aim | This course aims to demonstrate the methodologies of system identification and estimation. | | |
| Course Outcomes (COs) | After completion of the course students shall be able to:<br><br>**CO1:** Apply basics of probability theory in system identification and system state estimation.<br>**CO2:** Methods for non-parametric system identification and model validation.<br>**CO3:** Estimation of parametric models and validation of the obtained system models.<br>**CO4:** Design state estimator for linear deterministic and stochastic systems.<br>**CO5:** Apply Kalman filter in various variants for system state and parameter estimations. | | |

| | |
|---|---|
| Mapping of COs with POs | see table below |

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | High | Medium | High | Medium | Low | Medium |
| CO2 | High | Medium | Medium | Low | Low | Low |
| CO3 | High | Medium | Medium | Low | Low | Low |
| CO4 | High | High | High | High | Low | Medium |
| CO5 | High | High | High | High | Low | Medium |

System Identification - Motivation and Overview, random variables and stochastic processes, stochastic static models, Disturbance models - random processes, representation of stationary processes, white-noise process, auto-covariance function (ACF), ARMA models. Parametric model structures - ARX, ARMAX etc.

The identification problem, classical methods of identification of transfer functions models,Linear Regression - Least Squares estimates, Statistical properties of LS Estimates. Weighted Least Squares, Recursive Least Squares, Maximum Likelihood Estimation. Minimum variance algorithm, stochastic approximation. Estimation of non-parametric models - impulse, step, response coefficients, frequency response models. Estimation of parametric models - notions of prediction and simulation, predictors for parametric models, prediction-error methods, Instrumental Variable method. Kalman-filters for state estimation Gauss Markov, Model for vector random processes. Model Structure Selection and Diagnostics - estimation of delay and order, residual checks, properties of parameter estimates, model validation.

***References:***

1. Pieter Eykhoff , "Trends and progress in system identification," Pergamon, 1981.
2. Raman K. Mehra, "System identification advanced and case studies," Elsevier Science; edition, 1976.
3. Jason L. Speyer, Walter H. Chung, "Stochastic processes, estimation and control," Society for Industrial and Applied Mathematics, 2008.
4. Gregory F. Lawler, "Introduction to stochastic processes," Chapman' and Hall/CRC; 2 edition, 2006.

| Course Title | **POWER SYSTEM DESIGN** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Power System) | Semester | VI |
| Prerequisite Knowledge | Power System-I, Power System-II | | |
| Course Aim | This course provides a comprehensive introduction to design aspects of power transmission and distribution systems considering the smart cities, renewable energy penetrations and future extensions. | | |

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|---|---|
| Course Outcomes (COs) | At the end of the course students will be able to:<br>**CO1:**Familiarize the fundamentals of designing aspects of transmission & distribution systems.<br>**CO2:**Design of distribution systems networks with the help of softwaresfor smart city applications.<br>**CO3:**Analyze substation layout planning criteria and capacity evaluations.<br>**CO4:**Design the EHV transmission networks for future expansions.<br>**CO5**Developthegeneralized simulation package in GUI framework and illustrate various case studies. |
| Mapping of COs with POs& PSOs | (see table below) |

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | 1 | 2 | 2 | - | - | - | - | 2 | 2 | 1 | 2 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 3 | 2 | 3 |
| **CO3** | 3 | 3 | 2 | 3 | 2 | 2 | 2 | - | - | - | - | 2 | 3 | 1 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | - | - | - | - | 3 | 3 | 2 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | - | - | - | - | 3 | 2 | 2 | 3 |

**UNIT 1 – FUNDAMENTALS OF POWER SYSTEM DESIGN: (7 Hours)**

Fundamental Concept of Distribution Network design, Design aspects of EHV transmission systems: Transmission system planning criterion for 132 kV, 220 kV, 400 kV and 765kV & 1200 kV Transmission network, Design/selection of conductor and Selection of Insulator for given Power Transfer Capacity, calculation of RI and Sag & tension. Performance of Transmission systems including Voltage Regulation.

**UNIT 2 – DESIGN OF DISTRIBUTION NETWORK WITH SOFTWARE FOR GIVEN LOCALITY/UPCOMING METROPOLITAN CITIES/SMART CITIES: (7 Hours)**

Conceptualization of Load assessment and developing entire distribution system such as selection of transformer based on peak load/upcoming loads looking into future expansion.

**UNIT 3 – DISTRIBUTION SUBSTATION LAYOUT PLANNING CRITERION AND CAPACITY EVALUATION OF EXISTING SUBSTATION:(6 Hours)**

Planning criterion of GIS underground/surface mounted. Comparison of AIS and GIS in terms of loading capacity addition and safety standards.

**UNIT 4 – DESIGN ISSUES OF SUBSTATION COMPONENTS& ITS LOCATION:(6 Hours)**

Transformer, Circuit Breaker, Relay setting, switchyard under upcoming Renewable Energy Penetration specially Solar Roof Top and Land base plants. Location of Substation: Centre-of-gravity method and voltage regulation criterion.

**UNIT 5 – DESIGN OF EHV TRANSMISSION NETWORK:(9 Hours)**

Selection of operating voltage and conductor rating, calculation of voltage gradient, corona loss, tower design, computation of efficiency.

***Development of Generalized Simulation Package in GUI framework and case studies.***

**Text / Reference books**

1. J. Duncan Glover, Thomas J.Overbye, "Power System Analysis and Design", Cengage Learning International Edition, 5th Edition, 2012.
2. Mohammad E. El-Hawary, "Electrical Power Systems: Design and Analysis", Wiley-IEEE Press, 1995.
3. JurgenSchlabbach, Karl-Heinz Rofalski, "Power System Engineering: Planning, Design, and Operation of Power Systems and Equipment", Wiley-VCH Verlag GMBH & Co., 2nd Edition.
4. Gary D. Price, "Power Systems and Renewable Energy: A Textbook for Design, Operation, and Analysis of Interconnected and Stand-Alone Renewable Energy Systems", Momemtum Press.
5. Other online and offline software tools for power system design.

| Course Title | **Distribution Automation** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Power System) | Semester | VI |
| Prerequisite Knowledge | Power System, Power system Protection, Electrical Machines. | | |
| Course Aim | To teach the automation in the Power System | | |
| Course Outcomes (COs) | At the end of the course, students will be able<br>**CO 1.** To study Automation of Distribution System.<br>**CO 2.** To study different Control Techniques.<br>**CO 3.** To understand the issues with Automated System.<br>**CO 4.** To understand the Cost benefit Analysis. | | |

**SUBSTATION AUTOMATION:** Tools for distribution system planning and design. Substation Automation – Data acquisition from field devices and supervisory control of field devices, Substation Automation-Data acquisition from field devices and supervisory control of field devices, Different techniques of service restoration, substation reactive power control, Procedure to determine the best capacitor location, Asset Management.

**FEEDER AUTOMATION:** Feeder level Automation-Modern devices at Feeder level, Data acquisition from Field devices at feeder level, supervisory control of field devices, Fault location, Fault isolation, Feeder reconfiguration, feeder reactive power control. Coordinated Control of ALL devices.

**CUSTOMER LEVEL AUTOMATION:** Customer level Automation-automatic meter reading, Remote programming of time-of-use (TOU) meters, Remote service connect / disconnect, Automated customer claims analysis. Demand Side management, Energy Audit for energy conservation. Remote LOAD control.Home management system, Home area network

**DIFFERENT CONTROL UNITS AND THEIR ISSUES:** Automatic meter reading, Remote programming of time-of-use (TOU) meters, Remote service connect / disconnect Control hierarchy and control center architecture-RTU's, IEDs, PLCs, Use of GPS and GIS systems for Asset/Facilities management. Cyber Security Issues with Automation. Resiliency improvement using Automation.

DSO role and its functions.

**COST BENEFIT ANALYSIS:** Cost benefit analysis of Distribution Automation Schemes-Review of distribution automation roadmaps of prominent utilities in Europe and US, Review of distribution automation in Indian utilities.

**Text/ Reference Books:**

| |
|---|
| 1. M. S. Nardone, "Direct Digital Control Systems: Application Commissioning," Kluwer, Springer US, 1 Edition, 1999.<br>2. K. Peter Brand and others Substation Automation Handbook<br>3. M.K. Khedkar, G.M. Dhole, "Electric Power Distribution Automation," University Science Press,2010.<br>4. A.S.Pabla, "Electric Power Distribution,"TMH,5th Edition, 2004 |

| | | | |
|---|---|---|---|
| Course Title | **Power System Planning** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Power System) | Semester | VI |
| Prerequisite Knowledge | Power System | | |
| Course Aim | To perform power system planning with load forecasting and uncertainties. | | |
| Course Outcomes (COs) | At the end of the course, students will be able to<br>**CO1:**Understand and analyze the need of power system planning in a detailed manner.<br>**CO2:**Learn and develop various optimization techniques for power system planning<br>**CO3:**Understand the concepts of load forecasting and apply load forecasting in power system planning.<br>**CO4:**Perform expansion planning, reactive power planning and plan the system with uncertainties | | |

**Introduction**: Basic principles, power system elements, structures, power system study in the perspective of various time horizon, various planning issues, role of renewable energy plants. Interconnected Systems, Research trends in PSP

**Economic aspects and Optimization methods**: Definition and various related terms, deregulation and constant tariff scheme, cash flow concept, economic analysis by present worth method, annual cost method, rate of return method. Importance of optimization, defining an optimization problem, problem modelling, constraints and limitations, conventional approaches: LP, dynamic programming, Newton's method, Gauss method, other conventional methods, heuristic approaches: nature inspired techniques, viz., SA, ACO, GA, PSO, etc.

**Load forecasting:** Relevance, various load characteristics, factors affecting the load, ISOs, Demand side management, spatial load forecasting, econometric models, time-series models, and heuristic models,

**Expansion planning (basic and advanced approaches for generation, sub-station and network expansion):** Basic definition, problem description, mathematical development, constraints, required data, solution algorithm for single and multi-bus generation planning.

**Reactive power planning:** Introduction, voltage profile, voltage stability, parameters affecting voltage profile, resources for static and dynamic reactive power. Problem description: static resource allocation and sizing, dynamic resource allocation and sizing, mathematical solution approaches.

**Uncertainties and deregulated electricity market:** Introduction, uncertainties due to regulated and deregulated environment, practical issues under deregulated environment, methods to deal uncertainties PSP: expected cost criterion, min-max regret criterion, Laplace criterion, VNM criterion, Hurwicz criterion.

Power System substation planning with large scale RE penetration

References:

1. HosseinSeifi, Mohammad SadeghSepasian, *Electric power system planning: Issues, Algorithms and solutions*, Springer-Verlag Berlin Heidelberg2011
2. James Momoh and LamineMili, *Economic Market Design and Planning for Electric Power Systems*, IEEE Press series on power engineering, M E Hawary (Ed.), A John Wiley &Sons, Inc., Publication,2010
3. FawwazElkarmi and Nazih Abu-Shikhah, *Power System Planning Technologies and Applications: Concepts, Solutions,and Management,* Engineering Science Reference, IGI Global, 2010
4. Sullivan, R.L., *Power System Planning*, Heber Hill,1987.

| Course Title | **Electrical Energy Conservation and Auditing** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Power System) | Semester | VI |
| Prerequisite Knowledge | Power System | | |
| Course Aim | To teach how to conserve the energy and different aspects of Audit | | |
| Course Outcomes (COs) | At the end of the course, students will be able to<br>**CO1:** Explain the basics of Energy audit.<br>**CO2:** To understand the Different equipment's used for energy Audit<br>**CO3:** To understand the requirement of the various economic analysis.<br>**CO4:** Computation of various economic aspect. | | |

Unit - I

Basic Principles of Energy Audit and management Energy audit – Definitions – Concept – Types of audit – Energy index – Cost index – Pie charts – Sankey diagrams – Load profiles – Energy conservation schemes and energy saving potential – Numerical problems – Principles of energy management – Initiating, planning, controlling, promoting, monitoring, reporting – Energy manager. Bureau of Energy Efficiency: Energy conservation building code,Accredited energy auditor.

Unit - II

Power Factor and energy instruments Power factor – Methods of improvement – Location of capacitors – Power factor with non linear loads – Effect of harmonics on Power factor – Numerical problems. Energy Instruments – Watt–hour meter – Data loggers – Thermocouples – Pyrometers – Lux meters – Tong testers – Power analyzer.

Unit - III

Space Heating and Ventilation – Air–Conditioning (HVAC) and Water Heating: Introduction – Heating of buildings – Transfer of Heat–Space heating methods – Ventilation and air–conditioning – Insulation– Cooling load – Electric water heating systems – Energy conservation methods

Unit - IV

Economic Aspects and Analysis Economics Analysis – Depreciation Methods – Time value of money – Rate of return – Present worth method – Replacement analysis – Life cycle costing analysis – Energy efficient motors (basic concepts). GREEN BUILDINGS: Barriers to green buildings, green building rating tools, material selection, operating energy, façade systems, ventilation systems, transportation, water treatment systems, water efficiency, building economics, Leed and IGBC codes

Unit - V

Computation of Economic Aspects Calculation of simple payback method – Net present worth method – Power factor correction – Lighting – Applications of life cycle costing analysis – Return on investment.

**Reference Books :**


1. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw hill publishing company Ltd. New Delhi.
2. Energy management by Paul o' Callaghan, Mc–Graw Hill Book company–1st edition, 1998.

3. Energy management hand book by W.C.Turner, John wiley and sons.
4. Energy management and conservation –k v Sharma and pvenkataseshaiah-I K International Publishing House pvt.ltd,2011.
5. http://www.energymanagertraining.com/download/Gazette_of_IndiaP artIISecI-37_25-08-2010.pdf
6. Energy management by W.R. Murphy & G. Mckay Butter worth, Elsevier publications. 2012
7. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd–2nd edition, 1995

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|---|---|---|---|
| Course Title | **Distributed Generation Systems** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Power System) | Semester | VI |
| Prerequisite Knowledge | Power Systems, Power Electronics | | |
| Course Aim | To aware the students about the status and perspectives of the distributed generation (DG) in modern power systems | | |
| Course Outcomes (COs) | At the end of the course, students will be able to<br>**CO1:** Perform preliminary evaluation of technical and economic potential of utilisation of renewable energy sources<br>**CO2:** Understand the basic operation, control and modelling of distributed energy sources<br>**CO3:** Understand and describe the impacts of distributed energy resources on the control and operation of electrical networks<br>**CO4:** Understand the operation and application of energy storage devices in renewable energy applications<br>**CO5:** Analyse the environmental and legal aspects of distributed energy sources for sustainable development | | |

**UNIT 1 – Introduction to DG systems: (6 Hours)**

Overview of DG based power systems, DG definition, distributed generation advantages and needs, basic models of DG systems, economic and financial Aspects of distributed generation, the regulatory environment and standards.

**UNIT 2 – Generation resources: (8 hours)**

Photovoltaic systems, Solar-thermal power generation, Wind power generation, Other renewables like geothermal, tidal, wave, etc.

**UNIT 3– Effects of DG on the grid: (6 hours)**

Stability, Supply guarantee and power quality, Issues related to bidirectional power flow on network; voltage control, system protection.

**UNIT 4 −Energy storage systems: (6 hours)**

Capacity evaluation storage for given distribution System Battery, Ultra capacitors, Flywheel, Compressed air,fuelcell.etc.

**UNIT 5 – Distributed Generation Protection: (5 hours)**

Islanding- Definition, detection approach, Protection approach, Protection schemes in DG based systems

**UNIT 6 – Smart grid: (4 hours)**

Concepts, Application of Information & Communication Technologies (ICT) in smart grid.

***References:***


1. A.J. Pansini, *Guide to Electrical Power Distribution Systems*, 2005, The Fairmont Press Inc.
2. Ann-Marie Borbely, Jan F. Kreider, *Distributed Generation*, 2001, CRC Press.
3. Felix A. Farret and M. Godoy Simoes, *Integration of Alternative Sources of Energy,* John Wiley and Sons, 2006.
4. Bollen, Hassan, Integration of Distributed Generation in the Power System, Wiley- IEEE Press, 2011.
5. H. Lee Willis, Walter G. Scott, *Distributed Power Generation, Planning & Evaluation*, CRC Press Taylor & Francis Group, 2000.


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|---|---|---|---|
| Course Title | **Smart Grid Technology** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Power System/ Power Electronics) | Semester | VI |
| Prerequisite Knowledge | Power System, Power system Analysis, Electrical Machines. | | |
| Course Aim | To teach the Smart technologies and their applications, challenges | | |
| Course Outcomes (COs) | At the end of the course students will (Number may vary)<br>**CO 1.** To study Smart Technologies.<br>**CO 2.** To study the communication techniques and advanced metering interface.<br>**CO 3.** To understand the application of WAMs for security Improvement.<br>**CO 4.** To Understand Cyber Security Issues. | | |

| Mapping of COs with POs | CO ↓ | PO → | | | | | | | | | | | | PSO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| | **1** | H | H | H | H | L | H | L | M | M | M | L | L | H | M | H |
| | **2** | H | H | M | H | M | M | M | M | L | H | H | M | H | M | M |
| | **3** | H | M | H | H | M | L | L | L | M | M | M | M | H | M | H |
| | **4** | H | H | H | H | M | M | L | M | M | L | L | L | M | H | H |

L=Low, M=Medium, H=High

UNIT 1: INTRODUCTION TO SMART GRID TECHNOLOGY: [12 HOURS]

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid. Technology Drivers, Smart energy resources

UNIT 2: SMART GRID TECHNOLOGIES: [8 HOURS]

Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/VAR control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency DistributionTransformers, Phase Shifting Transformers, Plugin Hybrid Electric Vehicles(PHEV);

UNIT 3: SMART GRID INFRASTRUCTURE: [10 HOURS]

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

UNIT 4: POWER QUALITY MANAGEMENT USING SMART GRID: [8 HOURS]

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit

UNIT 5: CYBER SECURITY FINANCIAL ASPECTS OF SMART GRID: [6 HOURS]

Energy and Reserve Markets o Market Power o Generation Firms o Locational Marginal Prices o Financial Transmission Rights,Local Area Network(LAN),House Area Network(HAN), Wide Area Network(WAN), Broad band over Power line(BPL),IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

**Text Book:**

**1** Stuart Borlase “Smart Grid: Infrastructure, Technology and Solutions”,CRCPress2012.

2. JanakaEkanayake,NickJenkins,KithsiriLiyanage,JianzhongWu,AkihikoYokoyama, “Smart Grid: TechnologyandApplications”,Wiley2012.

3. VehbiC. Güngör ,DilanSahin, Taskin Kocak, Salih Ergüt, ConcettinaBuccella, Carlo Cecati, and Gerhard P. Hancke, “Smart Grid Technologies: Communication Technologies and Standards” IEEE Transactions On Industrial Informatics, Vol.7,No.4, November2011.

4. Xi Fang, SatyajayantMisra, Guoliang Xue, and DejunYang“SmartGrid –The New and Improved Power Grid: A Survey” ,IEEE Transaction on Smart Grids,vol.14,2012.

5. James Momohe “Smart Grid: Fundamentals of Design and Analysis,”, Wiley-IEEE Press , 2012.

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|---|---|---|---|
| Course Title | **Active Power Conditioning** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/ HR/RS | HR/RS Course-2 (Power Electronics) | Semester | VI |
| Prerequisite Knowledge | Power Electronics, Power System | | |
| Course Aim | To teach improvement of power quality in power system | | |
| Course Outcomes (COs) | CO1: To introduce the wide application of power electronics in power system.<br><br>CO2: To convey the importance of power quality aspects in the distribution system and their characterization.<br><br>CO3: To discuss the conventional passive compensation methods including reactive power compensation and harmonics filter design.<br><br>CO4: To consider the various power system analytical methods useful for compensation and characterization, such as sequence components, reference frames and transformations, PQ theory etc.<br><br>CO5: To introduce the concept of power electronics based active power compensation in distribution system and design of power electronics converters. | | |

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**Introduction:** Distribution and Transmission system, Power Quality issues, Application of Power Electronics in Power Systems, Custom Power (CP) and FACTS devices.

**Power Quality Characterization and Analysis:** Load power factor, Harmonic distortion indices, Transients, Unbalancing and symmetrical components, Voltage sag/swell and flicker indices, Power acceptability curves, Harmonic distortions limits: IEEE 519, IEC standards

**ConventionalMethods of Compensation:** Load balancing, Capacitor banks design, higher pulse converter, Transformer connections, Harmonic filter design, Resonance effect

**Reference Current Generation:** Instantaneous PQ theory, Instantaneous symmetrical components, Moving average, Low pass and High pass filters, phase-locked loop (PLL)

**Active Power Filters:** Hybrid and Active Power Filters: Shunt, Series and Shunt-series active power filters, structure &control of APFs, Combination of active and passive hybrid power filters.

**Custom Power Devices**: Distribution static compensator (DSTATCOM), Dynamic voltage restorer (DVR), Unified power quality conditioner (UPQC):Structure, Modelling and Control

Reference Books:


1. A. Ghosh and G. Ledwich, Power Quality Enhancement using Custom Power Devices, Kluwer Academic Publisher, Boston, MA, 2002.
2. Bhim Singh, Ambarish Chandra, and Kamal Al-Haddad, Power Quality: Problems and Mitigation Techniques, Wiley, 2015.
3. G. J. Walkileh, Power Systems Harmonics, Springer Verlag, New York, 2001.
4. IEEE Standard 519-1992, IEEE recommended practices and requirements for harmonic control in electrical power systems, 1992.
5. R. C Dugan , S. Santoso, M. F. McGranaghan and H. W. Beaty, Electric Power System Quality, McGraw-Hill, New York, 2003. Page 27 of 29.
6. M. H. Rashid, Power Electronics Handbook, Elsevier, Third Edition, 2011.


| Course Title | **Electric Traction & Vehicles** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/ HR/RS | HR/RS Course-2 (Power Electronics) | Semester | VI |
| Prerequisite Knowledge | Power Electronics , Electrical Machines | | |
| Course Aim | To analyze the application of the various motors in electric traction | | |

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| Course Outcomes (COs) | **CO1:**Ability to develop the control techniques for traction DC and AC motors<br>**CO2:** Competence in selecting traction motor ratings suitable for various track conditions<br>**CO3**: Know how to hybridize the vehicles based on their power source<br>**CO4**: Proficiency in configuring electric vehicle system. |

Electric Traction Services, Nature of Traction Loads, Conventional and Modern Traction Drives, Traction Motors, Tractions Drives, Braking Systems, Semiconductor Converter Controlled drives, Induction and Synchronous motor drives, VSI/CSI drives, Polyphase ac motors for traction Drives, Diesel Electric traction, Energy Conservation, Interlocking and sequencing operations andprotection.

Introduction to Alternative Vehicles, Electric Vehicles, Hybrid Electric Vehicles, Electric and Hybrid, Vehicle Components, Vehicle Mass and Performance, Electric Motor and Engine Ratings, Well-to-Wheel Analysis, EV/ICEV Comparison, Electric Vehicle Market, Vehicle Mechanics, Roadway Fundamentals, Laws of Motion, Vehicle Kinetics, Dynamics of Vehicle Motion, Propulsion Power Velocity and Acceleration, Tire–Road Force Mechanics, Propulsion SystemDesign

Plug-In Hybrid Electric Vehicle, Power train Component Sizing, Mass Analysis and Packaging, Vehicle Simulation, Battery Energy Storage, Batteries in Electric and Hybrid Vehicles, Battery Modeling, Traction Batteries, Battery Pack Management, Alternative Energy Storage, Fuel Cells, Ultra capacitors, Compressed Air Storage, Flywheels Control of AC Machines.

Power train Components and Brakes, Cooling Systems, Vehicle Supervisory Controller, Mode Selection Strategy, Modal Control Strategies

Reference Books:

1. SandeepDhameja, Electric Vehicle Battery Systems, Elsevier, First Edition, 2002
2. John Fenton & Ron Hodkinson, Lightweight Electric/Hybrid Vehicle Design, Elsevier Oxford, 2000.
3. Seth Leitman, Bob Brant, Build Your Own Electric Vehicle, McGraw Hill, Third Edition, 2013.
4. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, Second Edition, 2010.

5. MehrdadEhsani, YiminGao, and Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, Second Edition 2009.

| Course Title | **Electro Magnetic Interference and Compatibility** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/ HR/RS | HR/RS Course-2 (Power Electronics) | Semester | VI |
| Prerequisite Knowledge | EM Waves & Transmission Lines , Wave Propagation, | | |
| Course Aim | To teach the Electromagnetic Interference and its disadvantages. | | |
| Course Outcomes (COs) | CO1: Explain the real world EMC design to reduce electromagnetic Interference.<br>CO 2 Comprehend design aspects of Electronic systems without interference and with compatibility. CO 3 Compute the radiated and conducted interference measurements.<br>CO 4 Analyze and design Grounding and Cabling aspects with reference to EMI/EMC standards.<br>CO 5 Design Components that meet EMI/EMC Standards. | | |

UNIT-I (11 Lectures) INTRODUCTION: History and concept of EMI, Definitions of EMI/EMC, Electromagnetic environment, Practical experiences and concerns, frequency spectrum conservation, mechanisms of EMI generation, EMI testing, Methods of elimination of EMI and Biological effects of EMI

UNIT-II (11 Lectures) SOURCES OF EMI/EMC: Sources of Electromagnetic noise, typical noise paths, modes of noise coupling, designing for EM compatibility, lightening discharge, electro static discharge (ESD), electromagnetic pulse (EMP). Electromagnetic emissions, noise form relays and switches, non-linearity in circuits, passive inter modulation, transients in power supply lines, EMI from power electronic equipment, EMI as combination of radiation and conduction. Open area test sites: OATS measurements, measurement precautions.

UNIT-III (10 Lectures) RADIATED/CONDUCTED INTERFERENCE MEASUREMENTS: Anechoic chamber, TEM cell, reverberating chamber, GTEM cell, comparison of test facilities, characterization of conduction currents / voltages, conducted EM noise and power line, conducted EMI from equipment, immunity to conducted EMI, characteristics of EMI filters and power line filter design.

Conducted Emissions , Conductive susceptibility , Radiated Emissions ,Radiated susceptibility

UNIT-IV (11 Lectures) GROUNDING AND CABLING: Safety and signal grounds, low and high frequency grounding methods, grounding of amplifiers and cable shields, isolation, neutralizing transformers, shield grounding at high frequencies, digital grounding, types of cables, mechanism of EMI emission coupling in cables. effectiveness of shielding, near and far fields / impedances, methods of analysis, total loss due to absorption and reflection effects, composite absorption and reflection losses for electric fields / magnetic fields, magnetic materials as a shield, shield discontinuities, slots and holes, seams and joints, conductive gaskets Electrical Bonding, Shape and Material for Bond straps, General Characteristics of good bonds. foremi/emc standards: Choice of capacitors, inductors, transformers and resistors, EMC design components National , military and civilian standards.

International EMC standards,

Reference Books:
1. Dr. V.P. Kodali, “Engineering Electromagnetic Compatibility”, IEEE Publication, S. Chand & Co. Ltd., New Delhi, 2000.
2. “Electromagnetic Interference and Compatibility”, IMPACT series, IIT-Delhi, Modules1-9.
3. C.R. Pal, “Introduction to Electromagnetic Compatibility”, Ny, John Wiley, 1992.

| Course Title | **HVDC Transmission** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-2 (Power Electronics) | Semester | VI |
| Prerequisite Knowledge | Power Systems, Power Electronics | | |
| Course Aim | To aware the students about the concepts of High Voltage Direct Current Transmission and analyze their performance | | |
| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:** Develop the knowledge of HVDC transmission and HVDC converters and the applicability and advantage of HVDC transmission over conventional AC transmission. | | |

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|---|---|
| | **CO2:** Formulate and solve mathematical problems related to rectifier and inverter control methods and learn about different control schemes as well as starting and stopping of DC links.<br>**CO3:** Develop harmonic models and use the knowledge of circuit theory to develop filters and assess the requirement and type of protection for the filters.<br>**CO4:** Study and understand the nature of faults happening on both the AC and DC sides of the converters and formulate protection schemes for the same.<br>**CO5:** Review the existing HVDC systems along with MTDC systems and their controls and recognize the need of HVDC transmission for sustainable development. |

**UNIT 1 – Introduction to HVDC Transmission: (5 hours)**

Growth and developments, Comparison of AC and DC transmission, Application of DC transmission, HVDC terminals and types; Description of DC transmission system, Substation layout, Planning for HVDC transmission, Modern trends in DC transmission

**UNIT 2 – HVDC converter and control characteristics: (10 hours)**

Analysis and waveforms of HVDC converters as rectifier and inverter, delay angle, overlap angle, Number of pulses, Choice of converter configuration, Simplified analysis of Graetz circuit, 6-pulse, 12-pulse groups and their voltage waveform, Power factor of converter, VSC-HVDC principle, Power flow in HVDC link, equivalent circuit, Compound converter control characteristics; constant extinction angle, constant current, constant ignition angle, positive current margin, negative current margin, Current margin control methods, Current control at rectifier, extinction angle control at inverter, Control hierarchy; bipole controller, pole controller, valve group controller.

**UNIT 3– Harmonics and filters: (6 hours)**

Introduction, Generation of harmonics, Characteristic ($2n\pm1$) and non-characteristic ($2n$) harmonics, Harmonic cancellation via transformer connection, Design of AC filters, DC filters and their characteristics, AC harmonics filter calculations; impedance circle and polygon methods.

**UNIT 4 −Multi-terminal HVDC (MTDC) systems: (5 hours)**

Configurations and applications, Future MTDC using VSC for wind-farm integration, Control methods in MTDC; slave and master, VSC-HVDC protection schemes, hand shaking method in MTDC.

**UNIT 4 −Fault and protection schemes in HVDC systems**: **(4 hours)**

Nature and types of faults, faults on AC side of the converter stations, converter faults, fault on DC side of the systems, protection against over currents and over voltages, protection of filter units.

***References:***

1. K. R. Padiyar, *HVDC Power Transmission System,* Wiley Eastern Limited, New Delhi. Second Edition, 1990.
2. Edward Wilson Kimbark, *Direct Current Transmission*, Vol.-I, Wiley Interscience, New York, London, Sydney, 1971
3. Colin Adamson and Hingorani N G, *High Voltage Direct Current Power Transmission*, Garraway Limited, London, 1960.

| **Course Title** | **Power System Protection & Switchgear** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-VII/VIII) | Semester | VII |
| Prerequisite Knowledge | Power System, Electrical Machines. | | |
| Course Aim | To provide a broad coverage on all types of protective relays, circuit breakers and provide a strong background for working in a practical power system protection. | | |
| Course Outcomes (COs) | At the end of the course students will (Number may vary)<br>**CO 5.** To study the conventional relaying Techniques.<br>**CO 6.** To study the Over current , distance and differential relay principle<br>**CO 7.** To understand the numerical protection techniques.<br>**CO 8.** To understand the issues in microgrid and WAMs based protection. | | |

Mapping of COs with POs

| CO ↓ | PO | | | | | | | | | | | | PSO | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| **1** | H | H | H | L | L | H | L | L | L | L | L | L | H | H | H |
| **2** | H | H | M | M | M | M | M | M | L | H | H | M | M | M | M |
| **3** | H | M | M | M | M | L | L | L | M | M | M | M | H | M | H |
| **4** | H | H | H | H | L | L | L | L | L | L | L | L | H | H | H |

L=Low, M=Medium, H=High

**Unit 1: Conventional protection Scheme[6 Hours]**

Revolution from Electromagnetic to Static and Digital Relays. Fundamental principles of fuse and over current protection and application to feeder and motor protection. Arc interruption theories, Types of Circuit Breaker, RRRV, Resistance switching, current chopping, Testing and health monitoring of Switchgear.

**Unit 2: Overcurrent and Distance Relay [ 8 Hours]**

Over current relay, conventional setting process, relay coordination, Fundamental principles of distance relaying and application to transmission system protection. Relay co-ordination in transmission and distribution system.

**Unit 3: Differential Protection [6 Hours]**

Role of Current and Voltage transformers in power system protection.

Fundamental principles of differential protection and application to transformer, bus bar and generator armature winding protection.

**Unit 4: Numerical Relaying**: **[6 Hours]**

Introduction to Numerical relaying, DSP fundamentals like aliasing, sampling theorem, Discrete Fourier Transform and application to current and voltage phasor estimation.

**Unit 5:Issues with in Microgrid and Wide area Protection**:**[6 Hours]**

Numerical relaying algorithms for over current, distance and differential protection with application to transmission system, transformer and bus bar protection. Protection coordination, challenges in differential & difference relays with microgrid, PMU for synchronized measurements and WAMs based wide area protection. System Integrated Protection Scheme(SIPS)

Text/Reference Books:

1. Badri Ram, D. N. Vishwkarma, "Power system Protection& Switchgear ," Macgraw hill IndiaPublishers, New Delhi, 2nd Edition, 2001.

2..Y.G.Paithankar& S. R. Bhide,"Fundamentals of Power System Protection," Prentice Hall' of India Pvt Ltd., New Delhi, 2006.

3. S. Horowitz,"Protective Relaying for Power System H,"IEEE press, New York, Ist edition, 1981.

| **Course Title** | **Power Quality** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-VII/VIII) | Semester | VII |
| Prerequisite Knowledge | Power System, Electrical Machines. | | |
| Course Aim | To provide a brief understanding of power quality and various reasons of its degradation. | | |
| Course Outcomes (COs) | At the end of the course students will (Number may vary)<br>**CO 1.** To study the various power quality issues.<br>**CO 2.** To study the mathematical tools to access the power quality<br>**CO 3.** To understand impact of the power quality on system performance.<br>**CO 4.** To understand techniques to mitigate the power quality issues. | | |

Mapping of COs with POs

| CO ↓ | PO 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | PSO 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H | H | H | M | M | H | L | L | L | L | L | L | H | M | H |
| 2 | H | H | M | M | L | L | M | M | L | H | H | M | M | H | M |
| 3 | H | H | M | M | M | M | M | L | M | M | M | M | M | H | H |
| 4 | H | H | H | H | L | M | M | M | L | L | L | L | H | H | H |

L=Low, M=Medium, H=High

**Unit 1: INTRODUCTION TO POWER QUALITY:[6 Hours]**

Introduction, Classification, Causes and Effects of Power Quality Problems, General Classes of Power Quality Problems, Power Quality disturbances (PQDs), Waveform Distortion, Long-I Short -Duration Voltage Variations, Power Frequency Variations, Power Quality Standards, International Standards, CBEMA and ITI Curves., Useful Tools for Power Quality Analysis: Fourier Series, Fourier Transform, Discrete Fourier Transform, Fast Fourier Transform, STFT, Wavelet Transform.

**Unit 2:HARMONICS: [3 Hours]**

Introduction, Fundamental Wave, Harmonics, Sources of Harmonics, Effects of Harmonics, . Devices for controlling harmonic distortion, General Harmonic Indices, Harmonic Standards, VOLTAGE

**Unit 3:UNBALANCE: [3 Hours]**

Introduction, Unbalance in Three Phase Power System, Sources of Unbalance, Condition of Voltage Unbalance, Effect of Unbalance, Voltage Unbalance Factor, Phase Voltage Unbalance Ratio, Line Voltage Unbalance Ratio

**Unit 4:VOLTAGE UNBALANCE ASSESSMENT USING SEQUENCE COMPONENTS:[4 Hours]**

Sequence Component, Positive Sequence Current and Voltage Components, Negative Sequence Current and Voltage Components, Zero Sequence Current and Voltage Components, Balanced System , Unbalanced System, 'a' Operator and Angle Representation in Complex Plane, Currents and Voltages in Terms of Sequence Components with'a' Operator, Assessment of performance parameters of three-phase induction motor operating under supply voltage unbalance.

**Unit 5: VOLTAGE SAG:[4 Hours]**

Voltage Sags, Voltage Sag Magnitude and Duration, Cause and Effects, RMS Voltage, Peak Voltage, and Fundamental Voltage component Method of Quantification Voltage sags, Phase Angle Jump, Missing Voltage, Point-on-Wave Characteristics, FAULT BASED VOLTAGE SAGS: Symmetrical and Unsymmetrical Voltage Sags, Multi-stage Voltage Sags, Voltage sags associated with (i) three-phase short circuit, (ii) Single line to ground fault, (iii) line to line fault, and (iv) line to line to ground faults.

**Unit 6CHARACTERIZATION AND CLASSIFICATION METHODS**: **[5 Hours]**

Minimum Magnitude and Total Duration Approach, ABC Classification and Characterization Methods, Six Phase Algorithm, Symmetrical Component method of Characterization of Voltage Sags, Merits and limitations of Methods of Characterization.

**Unit 7:TRANSIENTS:[3 Hours]**

Origins and classifications, capacitor switching transients, lightening, load switching, impact on • users, protection, and mitigation.

**Unit 8** :**EQUIPMENT BEHAVIOUR UNDER PQDS**: **[6 Hours]**

Power Quality Monitoring: Monitoring considerations: Power line disturbance analyzer, power quality measurement equipment, harmonic /spectrum analyzer, flicker meters, disturbance analyser. Power Quality Conditioners. Shunt and series compensators, DSTATCOM, DVR, UPQC etc.; Case-stud ies,

References Books:

1. B. Singh, A. Chandra, and K. At-Haddad. "Power Quality: Problems and Mitigation Techniques," John Wiley & Sons, 2014.

2. R. C. Duganet, et aI., "Electrical Power System Quality," Tata McGraw-Hill Education, 2012.

3. M. H.Bollen,"Unclerstanding Power Quality Problems-Voltage sag & Interruptions," IEEE Press, 2000.

4. M. H. Bollen, A.Gu, "Signal Processing of Power Quality Disturbances," Wiley-IEEE Press, 2006.

5. S. J. C. Das, "Power System Harmonics and Passive Filter Designs," John Wiley & Sons, 2015.

6. E. Fuchs, and M. A. S.Masoum,"Power Quality in Power Systems and Electrical Machines," Elsevier, 2008

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|---|---|---|---|
| Course Title | **Flexible AC Transmission Systems** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-VII/VIII) | Semester | VII |
| Prerequisite Knowledge | Power Electronics, Power System | | |
| Course Aim | To teach the student to learn the need of FACTS devices and application of various FACTS Devices in the transmission and distribution system. | | |
| Course Outcomes (COs) | At the end of the course, students will be able to<br>**CO1:** Understand the needs of FACTS devices<br>**CO2:**Investigate the issues with the control of voltage and current source converters<br>**CO3:**Analyze the operation and control of shunt compensation devices<br>**CO4:**Analyze the operation and control of series compensation devices<br>**CO5:** Develop and implement the combination of series and shunt compensation devices. | | |

Introduction to FACTS, challenges and needs, Power Flow in AC transmission line, Power flow control, Description and definition of FACTS controllers, Static power converter structures, Voltage-sourced and current-sourced converters, Converter output and harmonic control, power converter control issues, Shunt Compensation: SVC, STATCOM, Operation and control, Configurations and applications, Series Compensation: TCSC, mitigation of sub-synchronous resonance, SSSC, Combination of shunt-series compensation: UPFC, Power flow studies with FACTS controllers, operational constraints, IPFC, UPQC, other FACTS Controllers: TCPAR, TCBR etc.

**References:**

1. N. G. Hingorani and L. Gyugyi, Understanding FACTS, IEEE Press, New York, 1999.

2. K.R. Padiyar, FACTS Controllers in Transmission & Distribution, New Age International (P) Limited, 1990.

3. V. K. Sood, HVDC and FACTS Controllers: Applications of Static Converters in Power Systems, Kluwer academic publishers, Canada, 2004.

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| 4. Enrique Acha, C.R. Feurte-Esquivel and others, Modelling and Simulation in Power Networks, Wiley, 2004. |

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|---|---|---|---|
| Course Title | **Neuro-Fuzzy Control System** | | |
| Course Code | | Credit | 4 |
| Core/ Elective | CEL (Elective-VII/VIII) | Semester | VII |
| Prerequisite Knowledge | Advanced mathematics<br>Control system | | |
| Course Aim | To discuss the theory of neuro-fuzzy control system for developing intelligent control algorithms. | | |
| Course Outcomes (COs) | After completion of the course students shall be able to:<br>**CO1:**Understand the working of human brain and ANN in general and its application as controller in different areas of engineering<br>**CO2:** Understand the fuzzy logic and implementing it as controller for different<br>**CO3:** Simulate the different models of ANN controller, fuzzy logic controller and neuro-fuzzy controller<br>**CO4:** Apply neuro-fuzzy controller to the real time problem they undertake during their thesis and write research papers related to it. | | |
| | Introduction, neuron model, activation functions, perceptions, multilayer network, Backpropagation, re-current networks, supervised and unsupervised learning, principle component<br>analysis, modeling, identification, prediction and control using neural network controllers, Basicsof sets and fuzzy arithmetic, crisp sets, operation, relation and composition of sets, Fuzzificationanddefuzzification methods, Fuzzy logic, software and hardware application to closed loopcontrol, TSK Fuzzy Models, Fuzzy controllers.<br>***References***<br>1. Simon Haykin, "Neural networks - A comprehensive foundation," Prentice Hall, 2003.<br>2. M. T. Hagan, "Neural network design, Cengage Learning," 2nd edition, 2008<br>3. D. T. Pham and X Liu, "Neural network for identification, prediction and control," Springer,1995<br>4. Klir George 1., Yuan Bo, "Fuzzy Sets and Fuzzy Logic: Theory and Applications," Prentice-Hall (1996)<br>5. B. Kosko, "Neural Networks and Fuzzy Systems," Prentice-Hall, 1994<br>6. T. J. Ross, "Fuzzy Logic with Engineering Applications Wiley-Blackwell;" 3rd edition 2010. | | |
| Course Title | **Process Control & Instrumentation** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-3/4 (Control System) | Semester | VII |
| Prerequisite Knowledge | Control system, Industrial Instrumentation | | |

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| Course Aim | To teach the process control variables and related instrumentation systems. |
| Course Outcomes (COs) | **After completion of the course students shall be able to:**<br>**CO1:**understand the basic principles and importance of process control in industrial process plants.<br>**CO2:**understand the various control schemes used in process plants.<br>**CO3:**explain the use of block diagrams & the mathematical basis for the design of control systems.<br>**CO4:**explain the importance and application of good instrumentation for the efficient design of process control loops for process engineering plants.<br>**CO5:** specify the required instrumentation and final elements to ensure that well-tuned control is achieved. |
| | Introduction to Process Control, Mathematical Modeling: Development of mathematical models, Modeling considerations for control purposes. Dynamic Behaviour of Chemical Processes: Computer simulation and the linearization of nonlinear systems, Transfer functions and the input-output models, Dynamics and analysis of first, second and higher order systems. Feedback Control Schemes: Concept of feedback control, Dynamics and analysis of feedback-controlled processes, Stability analysis, Controller design, Frequency response analysis and its applications Advanced Control Schemes: Feedback controlof systems with dead time or inverse response, Control systems with multiple loops, Feedforward and ratio 'control. Instrumentation: Final control elements, Measuring devices for flow,temperature, pressure and level.<br><br>***References***<br>1. Harriot, P. "Process control," Tata McGraw-Hili Education, 1964.<br>2. Singh, S.K. "Computer Aided process control," PHI Learning Pvt.Lrd., 2004.<br>3. Seborg,Edgar, Mellichamp, "Process dynamics and control," John Wiley & Sons, Inc., 2nd Edition, 2000.<br>4. Marlin,T.E. "Process control -:Designing processes & control systems," McGraw-HiliHigher Education; 2 edition, 2000.<br>5. Bennet, S. "Real time computer control," Pearson India, 2 Edition, 2003. |

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|---|---|---|---|
| Course Title | **Biomedical Instrumentation** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/H R/RS | HR/RS Course-3/4 (Control System) | Semester | VII |
| Prerequisite Knowledge | Instrumentation systems | | |
| Course Aim | To teach the basic of instrumentation systems for biomedical applications. | | |
| Course Outcomes (COs) | After completion of the course students shall be able to:<br>**CO1**: Basic concepts of biomedical instrumentation<br>**CO2:**Understand the method of measuring important parameters of human body like cardiovascular system brain, respiration system etc.<br>**CO3:**Use of advanced technology in the field of diagnostic of different diseases.<br>**CO4:**Modifications and redesign of existing biomedical instrumentation systems. | | |
| | Introduction to Biomedical Instrumentation; Basic concepts of Medical Instrumentation:Generalized medical Instrumentation System, Medical Measurement constraints, classification ofBiomedical Instruments. | | |

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| | Anatomy and Physiology, Biomedical electrode sensors and transducers; Various types ofelectrodes used irl ECG, EEG and EMG, Measurement of EEG, EMG and their diagnostic<br>applications in Medicine, Flow and pressure measuring instruments in biomedical engineering.<br>Instrumentation in Diagnostic Cardiology: Pacemakers and Defibrillators; EEG and EMGInstrumentation; Instrumentation in Respiration; Artifacts and noise med ical instrumentation.<br>Instrumentation in Diagnostic Ultrasound, Instrumentation in medical imaging, Fibre optics andLASER in biomedical instrumentation.<br>Instrumentation inIntensive Care Units, Instrumentation in operating room.<br>Biomedical safety Instrumentation: Medical safety, Regulation and Standards, Preventivemaintenance.<br>Computers and Telernedicine, New technologies and advances in medicalinstrumentation.<br><br>***References***<br>1. Cormwell L. et aI., "Bio medical Instrumentation & Measurements," PHI 2 edition, 1990.<br>2. Khandpur R.S., "Hand book of biomedical instrumentation," Tata Mcgraw-Hill, 1992.<br>3. Shakti Chatterjee, Aubert Miller, "Biomedical Instrumentation Systems," CengageLearning. Cehgage Learning, I edition, 20 IO.<br>4. R. Anandanatarjan, "Biomedical Instrumentation and Measurements," PHI, 2011.<br>5. Carr& Brown, "Introduction to Biomedical Equipment," Prentice Hall, 4 edition, 2000.<br>6. Webster JG, "Medical Instrumentation: Application and Design," 4th eel., John Wiley &Sons, New York, 2009. |

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|---|---|---|---|
| Course Title | **Introduction to Probability Theory& Stochastic Process** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/H R/RS | HR/RS Course-3/4 (Control System) | Semester | VII |
| Prerequisite Knowledge | Probability theory<br>Control system | | |
| Course Aim | To revisit probability theory and demonstrate stochastic processes. | | |
| Course Outcomes (COs) | After completion of the course students shall be able to:<br>**CO1:** Understand concepts of probability, conditional probability.<br>**CO2:** Understand and implement some of the commonly encountered random variables, in particular the Gaussian random variable<br>**CO3:** Relate probability theory to real statistical analysis,<br>**CO4:**Apply the theory of stochastic processes to analyze linear systems<br>**CO5:**Apply the above knowledge to solve basic problems in filtering, prediction and smoothing. | | |
| | Discrete-type random variables - random variables and probability mass function, mean and variance, conditional probabilities -independence, Bayes' formula. discrete distributions: Bernoulli, binomial, geometric, Poisson maximum likelihood estimation, Continuous-type random variables - cumulative distribution functions, probability density function independence, Bayes' formula - continuous distributions: uniform, exponential, Gaussian, chi-square - functions of random variables , Joint distributions, transformation of probability functions under maps, joint Gaussian distribution, Minimum mean square error estimation, Basic ideas of the probabilistic method-the first and second moment techniques.<br><br>***References***<br>1. Robert Brown and Patrick, Hwang, "Introduction to Random Signals and Applied Kalman | | |

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| | Filtering," 3rd Ed, John Wiley and Sons Inc. 1997.<br>2. Goong Chen, Guanrong Chen, Shih-Hsun Hsu, "Linear stochastic control system," CRC Press, 1995.<br>3. Jason L. Speyer and Walter 1-1. Chung, "Stochastic Processes, Estimation and Control," PHI,2013.<br>4. J. S. Meditch, "Stochastic Optimal Estimation and Control," New York, McGraw Hill 1969.<br>5. M. Mitzenmacher and E. Upfal, "Probability and computing: Randomized Algorithms and Probabilistic Analysis," Cambridge University Press, 2005.<br>6. P.E. Pfeiffer, "Conditional Independence in Applied Probability," Birkhauser; 1979<br>7. Dimitri P. Bertsekas and John N. Tsitsiklis, "Introduction To Probability," Athena Scientific; 2nd edition (I June 2008) |

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|---|---|---|---|
| Course Title | **Smart Sensor& Actuators** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/H R/RS | HR/RS Course-3/4 (Control System) | Semester | VII |
| Prerequisite Knowledge | 1. Control System<br>2. Instrumentation System | | |
| Course Aim | To discuss different smart sensors and actuators. | | |
| Course Outcomes (COs) | After completion of the course students shall be able to:<br>**CO1:** understand the performance of sensors & actuators.<br>**CO2:** demonstrate the static and dynamic characteristics of sensors.<br>**CO3:** explain the operating principle of various types of sensors & actuators.<br>**CO4:** understand the applications of sensors and actuators | | |

Performance specification and analysis of sensors: analog and digital motion sensors, opticalsensors, temperature sensors, magnetic and electromagnetic sensors, acoustic sensors, chemical sensors, radiation sensors, torque, force and tactile sensors etc.

The current technology of sensors: electronic, photonic, micro fluidics and new materials.

Integration of electronics with sensors.

Actuators: stepper motors, DC and AC motors, hydraulic actuators, magnet and electromagnetic actuators, acoustic actuators.

Introduction to interfacing methods: bridge circuits, AID and DIA converters, microcontrollers.

**Reference Books:**

1. Ida, N.; Sensors, Actuators, and their Interfaces;20 14; ScitechPublishing.
2. Handbook of Modern Sensors, 2nd Ed. By Jacob Fraden.
3. Semiconductor Sensors, Edited by S. M. Sze.
4. Wireless Sensor Networks: F. Zhao, C. Guibas, Elsevier, Morgan Kaufmann, 2004.

<table>
<tr><td>Course Title</td><td colspan="3">Robot modelling and control</td></tr>
<tr><td>Course Code</td><td></td><td>Credit</td><td>4</td></tr>
<tr><td>Core/ Elective/H R/RS</td><td>HR/RS Course-3/4 (Control System)</td><td>Semester</td><td>VII</td></tr>
<tr><td>Prerequisite Knowledge</td><td colspan="3">1. Control System</td></tr>
<tr><td>Course Aim</td><td colspan="3">To develop models of Robot and design different control strategies.</td></tr>
<tr><td>Course Outcomes (COs)</td><td colspan="3">After completion of the course students shall be able to:<br>CO1: Define the coordinates and the corresponding kinematic parameters for robotic manipulators.<br>CO2: Solve forward and inverse kinematic equations.<br>CO3: Drive robot dynamic model using Lagrange's equations of motion.<br>CO4: Design robot motion trajectories to meet the design specifications and requirements.<br>CO5: Use of different sensors in robotics.</td></tr>
<tr><td colspan="4">Basic Concepts in Robotics, Robotics system components, Homogeneous Transformation, Representation of Transformations, Direction cosine representation, Basic and Composite Rotation matrices, Rotation matrix with Euler angle representation, Specification for position and orientation of end-effectors, Robot arm Kinematics: The direct kinematics problem, Inverse Kinematics for euler angles and Direction cosine angle, DenavitHartenberg convention and its applications, Robot arm Dynamics: Forward Dynamics, Inverse Dynamics, Lagrange-Euler formation and Applications., Actuators-Hydraulic actuators, Pneumatic actuators, Electrical Actuators, DC Servo motor and other actuators.<br><br>Sensors- Positional and velocity sensors, Tactile sensors, proximity and range sensors, Force and Torque sensors, Uses of sensors in robotics..<br><br><u>Reference Books:</u><br><br>1. John J. Craig, "Introduction to robotics, mechanics and control," Prentice Hall; 3 eclition, 2004.<br>2. John .I. Craig, "Adaptive control of mechanical manipulators," Addison- Wesley Pub (Sci), 1987.<br>3. F.L. Lewis, S. Jagannathan, A. Yesildirek, "Neural network control of robot manipulators," CRC Press, 1998.<br>4. F. L. Lewis, Abdallah C. T., and Dawson D.M., "Control of robot manipulators," Macmillan Publishing Co, Oxford, UK, 1993.</td></tr>
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<table>
<tr><td>Course Title</td><td colspan="3">Advanced Digital Control</td></tr>
<tr><td>Course Code</td><td></td><td>Credit</td><td>4</td></tr>
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|---|---|---|---|
| Core/ Elective/HR/RS | HR/RS Course-3/4 (Control System) | Semester | VII |
| Prerequisite Knowledge | 1. Control System<br>2. Signals and Systems | | |
| Course Aim | To discuss different advanced digital control schemes and controllers. | | |
| Course Outcomes (COs) | After completion of the course students shall be able to:<br>**CO1:** formulate the mathematical model of digital control systems.<br>**CO2:** determine the stability of discrete time systems using different techniques.<br>**CO3:** design various advanced digital controllers for sampled-data control systems.<br>**CO4:** demonstrate the design and applications of industrial and embedded digital controllers in real-time testbeds. | | |

Mapping of COs with POs

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|---|---|---|---|---|---|---|
| CO 1 | High | Low | Medium | Low | Low | Low |
| CO 2 | Low | Medium | Medium | Low | Low | Low |
| CO 3 | Low | Low | Medium | Low | Low | Low |
| CO 4 | High | Medium | Medium | Low | Low | Medium |

**Module 1: Digital Control System**

Sampled-data Control System, Components of Digital Control System: A/D Converter, Quantizer, Encoder, Hold Circuits, Ideal LP filter.

Nyquist–Shannon sampling theorem, Aliasing, Anti-aliasing filter.

**Module 2: Modelling and Stability analysis using conventional approach**

Z-transform revisited, Modified Z-transform, Difference equation, Pulse transfer function, Closed-loop sampled-data system, Bi-linear transformation, Impulse invariance method, Jury Stability, Routh-Hurwitz with w-plane.

**Module 3: Modelling and Stability analysis using State-space approach**

State-space modelling, State transition matrix, Cayley–Hamilton theorem, Discretization of Continuous Time state-space model, Lyapunov stability.

**Module 4: Design of Digital Controllers**

Conventional approaches: Root locus, Frequency domain design, Compensators, Dead-beat responses.

State feedback controllers, Observer-aided digital controllers, Digital LQR, Model predictive controller (MPC), Quasi-sliding mode controller (QSMC).

Filters Design: IIR, FIR

**Module 5: Industrial and Embedded Controllers**

SCADA, DSP-based Controllers, The Texas Instruments TMS320 DSP's, Field programmable gate array (FPGA).

**Reference Books:**

1. Katsuhiko Ogata, Discrete-time control systems, 2nd Edt., PHI.
2. Kuo, Digital Control System, 2nd Edt., Oxford University Press.
3. M. Gopal, Digital Control System, New Age Pub.

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|---|---|---|---|
| Course Title | **Energy Storage System** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/R S | HR/RS Course-3/4 (Power System/ Power Electronics) | Semester | VII |
| Prerequisite Knowledge | Power System, Electrical Machines | | |
| Course Aim | To teach different techniques to store the electrical energy and their limitations | | |
| Course Outcomes (COs) | At the end of the course, students will be able to<br>**CO1:** Understand the concept of various energy storage system<br>**CO2:** Understand the chemical effect behind the batteries<br>**CO3:**Analyze the different batteries used in electric vehicles.<br>**CO4:** Develop Simulation model battery storage system<br>**CO5:** Review and describe the structure of battery management system | | |

**UNIT1:**

Introduction , world/India energy storage overview/Storage Strategy/ Indian Installations, energy storage technology overview, Types and applications

**UNIT2:**

Introduction to electrochemistry/ electrochemical techniques for testing and standards, Electrochemical energy storage, basic of batteries and terminology, Lithium Ion batteries: components/working/raw materials/commercials systems, Advancement in battery technology, improvements in cycle life and energy density

**UNIT3:**

Batteries for Electrical Vehicle: standalone grid connected, sizing of batteries, redox flow batteries for large scale storage applications, Beyond lithium ion batteries Sodium Sulphate battery

**UNIT 4:**

Battery modelling, Introduction to battery management system, thermal management and pack Design, battery recycling and circular economy, Novel gravity based energy storage plants, components, details and sizing. Energy system Integration with renewable energy systems.

**Reference Books:**

1. Handbook of lithium-ion battery pack design chemistry, components, types and terminology by Warner, John T, Elsevier.

2. Fundamentals and Application of Lithium-ion Battery Management in Electric Drive Vehicles by San Ping Jiang, Wiley.
3. Lithium ion rechargeable batteries by edited by Kazunori Ozawa, Wiley.
4. E. Lipman, A. Z. Weber, Fuel Cells and Hydrogen Production, A Volume in the Encyclopedia of Sustainability Science and Technology, Second Edition, Springer reference.
5. Modern electric, hybrid electric, and fuel cell vehicles fundamentals, theory, and design by MehrdadEhsani, YiminGao, Sebastien E. Gay, Ali Emadi, CRC press

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|---|---|---|---|
| Course Title | **EHV Transmission Technologies** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-3/4 (Power System) | Semester | VII |
| Prerequisite Knowledge | Power Systems, Power Electronics | | |
| Course Aim | To aware the students about the concepts, performance and application of Extra High Voltage A.C. & D.C. Transmission in power systems | | |
| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:** Demonstrate the knowledge of EHV AC and HVDC transmission in terms of design, power handling capacity etc.<br>**CO2:** Formulate and solve mathematical problems related to the effect of Electrostatic and electromagnetic fields and corona in the EHVAC & HVDC lines<br>**CO3:**Analyze the various causes of overvoltages in the EHV systems developed due to switching<br>**CO4:** Design the EHV lines based upon the steady state and transient limit.<br>**CO5:** Review the existing HVDC systems along with MTDC systems and their controls and recognize the need of EHV AC and HVDC transmission for sustainable development | | |

**UNIT 1 – Introduction to EHV AC Transmission: (6 Hours)**

Necessity of EHV AC transmission, advantages and associated problems, various EHV voltage levels, power handling capacity and line losses, mechanical consideration in line performance, cost of transmission.

**UNIT 2 – Calculation of line and ground parameters: (8 hours)**

Resistance of conductors, temperature rise and current carrying capacity of conductors, calculation of inductance, capacitance of bundle conductors, calculation of sequence inductance and capacitance, surface voltage gradients on conductor and distribution of voltage gradients on subconductor of the bundle.

**UNIT 3– Corona effect in EHV system and Audible noise: (6 hours)**

Calculation of corona loss, charge-voltage diagram and corona loss, attenuation of travelling waves due to corona, Generation & characteristics of AN, Day Night AN level, radio interference.

**UNIT 4 −Over voltages in EHV system caused by switching: (6 hours)**

Types of overvoltage, overvoltages due to low inductive and capacitive current, calculation of switching surges for lumped and distributed parameter lines.

**UNIT 5 – Design of EHV AC lines: (5 hours)**

Design of EHV lines based upon steady state lits, various design factors.

**UNIT 6 – HVDC Transmission: (4 hours)**

Layout/Arrangement of substation, Equipments; converter transformer arrangement, converters, filters, etc. LCC and VSC converters, Multiterminal HVDC system and its applications

***References:***


1. R. D. Begamudre, EHVAC Transmission Engineering, New Age International (P) Ltd.
2. K. R. Padiyar, HVDC Power Transmission System, Wiley Eastern Limited, New Delhi. Second Edition, 1990.
3. S. Rao, EHV-AC, HVDC Transmission & Distribution Engineering


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|---|---|---|---|
| Course Title | **Computer Relaying for Power System Protection** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-3/4 (Power System) | Semester | VII |
| Prerequisite Knowledge | Power System, Power System Protection | | |
| Course Aim | To teach the students to implement the various digital protection schemes in power system | | |
| Course Outcomes (COs) | At the end of the course, students will be able<br>**CO1:**Toanalyze and implement various protection algorithm for computer relaying<br>**CO2:**To understand and designPhasor Measurement Units and wide area measurement systems application in computer relaying<br>**CO3:**Toanalyze and implement various transformation-based protection algorithm for computer relaying<br>**CO4:**To implement the digital protection schemes and fault location identification schemes in microgrids and transmission system | | |

Mathematical background to protection algorithms: Finite difference techniques, Interpolation formulas: forward, backward and central difference interpolation. Numerical differentiation, Curve fitting and smoothing.

Protection algorithms: Sinusoidal wave-based algorithms: Sample and first derivative, first and second derivative, two and three sample techniques, Fourier and Walsh based algorithms: Fourier algorithm: Full cycle window algorithm, fractional cycle window algorithm. Walsh function-based algorithm. Other algorithms: Least squares-based algorithms. Differential equation-based Travelling wave-based techniques. algorithms.

Over Current relays for Distribution system. Issues with DGs, Relay Blinding, sympathetic tripping, Dual setting of OCR, Optimization techniques for relay coordination. Adaptive OCR.

Phasor Measurement Units: Introduction to Phasor measurement units (PMUS), global positioning system (GPS), Functional requirements of PMUs and PDCs, phasor estimation of nominal frequency inputs

PMU Applications: Wide Area Measurement Systems (WAMS), WAMS Applications in Smart Grid, WAMS Based Protection Concepts, Adaptive Relaying, State estimation. System Integrated protection schemes(SIPS)

Recent advances in digital protection of power systems. New technology in microgrids. Communication protocols applied in the protection. Effect of RE penetration on protection scheme and Modification of protective scheme with RE

Signal processing techniques for protection. Intelligent protection techniques for security enhancement.

Fault location: transmission system fault location, Distribution system fault locator, Different techniques.

**References:**


1. A.T. Johns and S.K. Salman, Digital Protection for Power Systems, Peter Peregrinus Ltd. on behalf of the IEE London U.K.,1995
2. Arun G. Phadke and J.S. Thorp, Computer Relaying for Power Systems, John Wiley and Sons Ltd. England and Research Studies Press Ltd,2009
3. A.G. Phadke, J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer Publications, 2008
4. Badri Ram and D.N. Vishvakarma, Power System Protection and Switchgear, TMH, New Delhi,2001.
5. Y.G. Paithankar, and S.R. Bhide, Fundamentals of Power System Protection, $2^{nd}$ Edition, PHI Pvt. Limited, New Delhi, 2013
6. Areva, Network Protection Application Guide,1966.

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| Course Title | **Computer Aided Power System Analysis** | | |
| Course Code | | Credit | 4 |
| Core/<br>Elective/HR/RS | HR/RS Course-3/4 (Power System) | Semester | VII |
| Prerequisite Knowledge | Power System and Electrical machine | | |
| Course Aim | To teach the Algorithms of power flow and fault Calculations for large systems using Computer Methods | | |
| Course Outcomes (COs) | At the end of the course, students will be able<br>**CO 1.** To study the Algebraic Techniques for computer Simulation.<br>**CO 2.** To study Power Flow Analysis of Bigger System.<br>**CO 3.** To study Fault Analysis of Bigger System.<br>**CO 4.** To study the state Estimation and Optimal Power Flow. | | |

**Network Modelling and Power Flow I:** System graph, loop, cutest and incidence matrices, y- bus formation, sparsity and optimal ordering, power flow analysis, Newton Rap son method.

**Network Modelling and Power Flow II:** Decoupled and fast decoupled method, formulation of three phase load flow, dc load flow, formulation of AC-DC load flow, sequential solution technique.

**Analysis of three phase symmetrical and unsymmetrical faults:** in phase and sequence domain, Phase shift in sequence quantities due to transformer, open circuit faults.

**Stability Studies:** Transient stability analysis, swing equation, stability of multimachine system using modified Euler method and Runge-Kutta method

**Power System Security:** Factors affecting security, State transition diagram, contingency analysis using network sensitivity method.

AC power flow method, introduction to state estimation.

Power System analysis with large integration of Renewable sources.

**References:**


1. D. P. Kothari and I. J. Nagrath, Modern Power System Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1994.

2. HadiSaadat, Power System Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2002.

3. George L. Kusic, Computer Aided Power System Analysis, Prentice Hall of India (P) Ltd., New Delhi, 1989.

4.J. Arrilaga, C. P. Arnold, B. J. Harker, Computer Modelling of Electric Power System, John Wiley &Sons.K, 1988

5.Mahailnaos, D. P. Kothari, S. I. Ahson, Computer Aided Power System Analysis & Control, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1988.

6. G. T. Heydt, Computer Analysis Methods for Power Systems, Macmillan Publishing Company, New York, 1992.

7. L. P. Singh Advanced Power System Analysis and Dynamics, New Age International Publishers, New Delhi, 2006.

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|---|---|---|---|
| Course Title | **Advanced Energy Management System** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-3/4 (Power System) | Semester | VII |
| Prerequisite Knowledge | Power System | | |
| Course Aim | To provide a general awareness on the importance of energy and its conservation, its impact on society, various energy sources, energy conversion processes, energy management, energy audit and energy conservation measures. | | |
| Course Outcomes (COs) | At the end of the course students will be able to:<br>**CO1**: Realize the present energy scenario in national and international context.<br>**CO2**: Understand the concepts energy management, auditing and accounting.<br>**CO3**: Design electricity tariff methods based on demand side management.<br>**CO4**: Understand the methods of improving energy efficiency in different electrical systems. | | |

**Module 1:** Energy resources, Energy Mix, Energy Poverty, Barriers to Energy Poverty, Energy Literacy, Energy Security, Distributed Generation, Renewable Energy Sources, Energy Storage Systems, Hybrid System Configurations, Grid-integrated and Stand-alone Systems, Concept of Micro-Grid.

**Module 2:** Energy conservation and its importance, Classification of Energy Conservation Measures,

Government Schemes - Energy Conservation Act, Electricity Act, National Electricity Policy, National Tariff Policy;

Regulatory Authorities - Bureau of Energy Efficiency;

Energy Conservation in Buildings, Energy Conservation Building Codes,

Waste-To-Energy Technology.

**Module 3:** Demand Response, Demand Side Management (DSM) – Need, benefits and role in Power Systems, DSM Techniques, Smart Metering, Communication Systems, Factors affecting DSM, Standards and Labelling, Supervisory Control and Data Acquisition.

**Module 4:** Energy Accounting, Energy Audit, Types of Energy Audit, Methodology for Energy Audit, Phases of Auditing, Energy Audit Report Format, Energy Audit Instruments, Competence Requirements of an Energy Auditor.

**Module 5:** Energy Management, General Principles of Energy Management, Energy Flexibility, Dynamic Tariffs.

**References:**


1. AmlanChakrabarti, *Energy Engineering and Management*, Prentice Hall India, 2011.
2. Anil Kumar, Om Prakash, Prashant Singh Chauhan, Samsher, "Energy Management-Conservation and Audits, CRC Press, 2020, ISBN: 9780429325458
3. Eastop T. D. and D. R. Croft, *Energy Efficiency for Engineers & Technologists*, Longman, 1990.
4. Rao S. and B. B. Parulekar, *Energy Technology*, Khanna Publishers, 2005.
5. Doty S. and W. C. Turner, *Energy Management Hand book*, 7/e, Fairmont Press, 2009.


| **Course Title** | **Power Plant Operation & Controls** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-3/4 (Power System) | Semester | VII |
| Prerequisite Knowledge | Power System, Control System, Electrical Machines | | |
| Course Aim | To teach the different operation principle and safety measures of different Power Plants. | | |
| Course Outcomes (COs) | At the end of the course, students will be able:<br>CO1: To teach the operation of different electrical energy generating plant<br>CO2: To understand the different operating constraints and their control actions<br>CO3: To evaluate the different the safety measures of the power plant<br>CO4: To evaluate the scope and feasibility of power generation from renewables | | |

Mapping of COs with POs& PSOs

| **CO** ↓ | **PO** | | | | | | | | | | | | **PSO** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | **1** | **2** | **3** |
| **1** | H | H | H | M | M | H | L | L | L | L | L | L | H | M | H |
| **2** | H | H | M | M | L | L | M | M | L | H | H | M | M | H | M |
| **3** | H | H | M | M | M | M | M | L | M | M | M | M | M | H | H |
| **4** | H | H | H | H | L | M | M | M | L | L | L | L | H | H | H |

L=Low, M=Medium, H=High

UNIT 1:

Conventional Sources of electrical energy: Steam, hydro, nuclear, diesel and gas, their scope and potentialities for energy conversion. Generation : Different factors connected with a generating station, load curve, load duration curve, energy load curve, base load and peak load plants.

UNIT 2:

Thermal stations : Selection of site, size and no. of units, general layout, major parts, auxiliaries, generation costs of steam stations. Hydro stations : Selection of site, mass curve, flow duration curve, hydrograph, classification of hydro plants, types of hydro turbines, pumped storage plants.

Nuclear stations : Main parts, location, principle of nuclear energy, types of nuclear reactors, reactor control, nuclear waste disposal.

UNIT 3:

power plant process and of unit cycle principles, hazards and the appropriate precautions associated with the plant and process systems Effective communication techniques, instrumentation and control features including permissive conditions, interlocks, alarm and trip conditions, requirements for the competent, safe and reliable operation of plant, abnormal plant and process conditions and the associated incident response mechanisms

UNIT 4:

Power station control and interconnection: Excitation systems, excitation control, automatic voltage regulator action, advantage of interconnection.

UNIT 5:

Alternate energy sources: Solar, wind, geo-thermal, ocean-thermal, tidal wave, MHD and biomass. renewable sources of alternative power generation and their operational requirements

**Reference Books:**


1. Deshpande, M.V., Elements of Electrical Power Station Design, 5th ed.,PHI, 2013.
2. B. R .Gupta,, Generation of Electrical Energy, S. Chand, New Delhi, 2013.
3. Nag, P.K., Power Plant Engineering, 3rd ed., Tata Mc-Graw Hill Education, 2013.
4. Raja, A.K., Srivastava, A.P. and Dwivedi, M., Power Plant Engineering, New Age International Private Limited, New Delhi, 2006


| Course Title | **Renewable Energy & Grid Integration** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-3/4 (Power Electronics) | Semester | VII |
| Prerequisite Knowledge | Power Electronics | | |
| Course Aim | To teach the students to generate power through renewable energy and integration of renewable energy to the grid. | | |

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| Course Outcomes (COs) | At the end of the course students will be able to<br>**CO1:** Demonstrate the concept of solar and wind energy conversion system and its characteristics.<br>**CO2:**Design of various MPPT methods for wind and solar energy conversion system.<br>**CO3:**Design of DC-DC converters and DC – AC converter for grid connected operation<br>**CO4:**Understand the role of energy storage components and its integration with the grids. |

Wind energy conversion systems, Wind turbines, Turbine characteristics, Various electrical generators, Induction generators, doubly-fed induction generator, Synchronous generator and permanent magnet synchronous generator (PMSG), Power conversion through power electronics converters, Maximum Power point tracking (MPPT), Controlled rectifiers and DC-DC converters for MPPT, Voltage source inverters, Modelling and control of WECS for grid interface, Standalone and grid interface application, Solar photovoltaic (PV) system, classifications, PV characteristics, MPPT methods, DC-DC converters and VSI, roof-top and domestic PV systems, Grid connected PV system, Fuel cells, classification and characteristics, power electronics interfaces, Hybrid systems, Other renewable sources of energy, Integration of renewable energy systems.

Components required for grid integration, Energy storage components and integration with the grids, Large energy storage technologies (MW), Grid integration issues and standards. Adequate converter topologies, tariff related to renewable energy interface.Microgrid structure and operation.

**References:**


1. M. R. Patel, Wind and Solar Power Systems, Tailor & Francis CRC Press, USA, 2006.
2. M. H. Rashid (ed), Power Electronics Handbook, Academic Press, Florida, 2001.
3. Bin Wu, Yongqiang Lang, NavidZargari, Power Conversion and Control of Wind Energy Systems, Wiley, 2011.
4. Anaya-Lara, N. Jenkins et al, Wind Energy Generation Modeling and Control, Wiley, 2011.
5. B. Fox et al, Wind Power Integration Connection and system operational aspects, IET, London, 2007.
6. A. Ghosh and G. Ledwich, Power Quality Enhancement using Custom Power Devices, Kluwer Academic, 2002.
7. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, 2nd Edition, Wiley- IEEE Press, 2016.


| Course Title | **Control Techniques in Power Electronics** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |

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|---|---|---|---|
| Core/ Elective/ HR/RS | HR/RS Course-3/4 (Power Electronics) | Semester | VII |
| Prerequisite Knowledge | Power electronics | | |
| Course Aim | To teach the different control techniques of the converters | | |
| Course Outcomes (COs) | CO1: To introduce the control of switched converters through a generic converter for DC-DC, DC-AC, AC-DC and DC-DC conversion and its closed loop operation.<br><br>CO2: To analyze the steady state and dynamic performance using state-space modelling and discrete-time analysis.<br><br>CO3: To analysis stability of power electronics converters using small signal modelling and transfer function approach through conventional root-locus and bode-plot methods.<br><br>CO4: To consider advance control methods such as hysteresis current control and sliding mode control in power electronics converters for tracking of desired current or voltage.<br><br>CO5: To consider the various digital controllers such as Microcontrollers, DSP, ASIC, FPGA etc. for power electronics converters. | | |

**Introduction:** Control of power electronics converters, Switched power converters, Power switching devices, Generic power converters, AC-DC, DC-AC, AC-AC, DC-DC converters control.

**State Space modeling of switched converters:** State space Models of Electrical Networks, Transient and steady state response of switched converters using state models, Instantaneous solution of load current, Device conduction, Pulse width modulation (PWM), single phase H-bridge and three phase inverter, sinusoidal pulse width modulation (SPWM) analysis of VSI.

**Averaging models and Dynamic Analysis:** Output and state feedback switching controllers, Averaged models, small-signal models and transfer functions of dc-dc converters, buck, boost, buck-boost converters, Conventional stability analysis, Root-locus method, Frequency response analysis.

**Discrete-time Analysis:** Discretization of continuous models, Digital control of converter systems, Sampling and ZOH, simulation of Power Electronics converters.

**Variable Structure Systems:** Variable structure and Sliding Mode control, Linear switched systems, Phase-plane and describing function analysis.

**Current Controllers:** Hysteresis, Ramp-comparison, Predictive Current controllers, design and analysis, switching frequency dependency on parameters, current control loop design and analysis, closed loop transfer function, bode plots and bandwidth.

**Multilevel Converters and Control:** Cascaded, Diode-clamp and Flying Capacitor multilevel converters, Multicarrier modulations

**Implementation of Power Electronics Controllers:** Analog controllers, Computer Control, DSP implementation, ASIC's and embedded controller, FPGA's and Virtual Instrumentation

ference Books:


1. N. Mohan, T. M. Undeland and W. P. Robbins, *Power Electronics, Converters, Applications and Design*, Third Edition, Wiley India,2006.
2. M. H. Rashid, *Power Electronics Handbook*, Third Edition, Elsevier,2011.
3. M. P. Kazmierkowski, R. Krishnan and F. Blaabjerg, *Control in Power Electronics (Selected Problems)*, Academic Press, Elsevier Science (USA),2002.
4. H. S. Ramirez and R. S. Ortigoza, *Control Design Techniques in Power Electronics Devices*, Springer Verlag, London,2006.
5. V. Ramanarayanan, *Course Material on Switched Mode Power Conversion*, Second Edition, IISc Bangalore, India,2006.
6. D. O. Neacsu, *Power Switching Converters (Medium and High Power)*, CRC Press, Taylor & Francis Group, LLC, US, 2006.
7. B Wu, *High Power Converter and AC Drives*, IEEE Press, John Wiley & Sons.,2006.
8. T. L. Skvarenina, *The Power Electronics Handbook*, CRC Press,2002.


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|---|---|---|---|
| Course Title | **Power Electronic Converter for Microgrid** | | |
| Course Code | | Credit | 4 |
| Core/ Elective/H R/RS | HR/RS Course-3/4 (Power Electronics) | Semester | VII |
| Prerequisite Knowledge | Power electronics, Electrical Machines | | |

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| Course Aim | To teach the various power electronic converters for micro grid and their controlling techniques |
| Course Outcomes (COs) | **CO1:**Understand and implement the concept different converters for micro grid<br>**CO2:** Understand and implement the basic concept power control techniques<br>**CO3:**Analyze the different control techniques used for modelling and control of the AC and DC converters<br>**CO4:** to teach the techniques to improve the power quality |

Module 1: Characteristic of Converters: Functional characteristics of power converters, Converter designs ,Indirect converter Electromagnetic compatibility (EMC) Protective measures during power conditioning, Grid Protection , Grid Effects 24/7 General compatibility and interference Output behavior of wind power plants

Module 2: Voltage response in grid supply Harmonics and subharmonics ,Voltage faults and the fault-ride-through (FRT) , Remedial Measures against Grid Effects and Grid Resonances ,Filters design , Function of harmonic absorber filters and compensation units, Grid Control and Protection ,Grid Connection Rules. Power conditioning and maximum power point tracking (MPPT) algorithms MPPT algorithms based on based on buck- and boost-converter topologies, Maximum power point tracking (MPPT) algorithms,

Module 3:

Inverter control topologies for stand-alone and grid-connected operation. Analysis of inverter at fundamental frequency and at switching frequency. Feasible operating region of inverter at different power factor values for grid-connected systems, Stand-alone PV systems. Consumer applications, residential systems, PV water pumping, PV powered lighting, rural electrification, etc.,

Module 4: Grid-connected (utility interactive) PV systems. Active power filtering with real power injection, Modeling and simulation of standalone and grid-connected PV systems. Control Concepts,

Text Book:

1. R. Messenger, J. Ventre, Photovoltaic Systems Engineering, 2nd ed., CRC Press, 2004.

2. S. Heier, “Grid Integration of wind energy conversion systems”, Wiley, New York (USA).

3. A. Goetzberger, V. U. Hoffmann, Photovoltaic Solar Energy Generation, Springer-Verlag, 2005

1. L. Castaner, S. Silvestre, Modeling Photovoltaic Systems Using PSpice, John Wiley & Sons, 2002

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|---|---|
| Course Title | **Electric Vehicle Technology** |

| | | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/ HR/RS | HR/RS Course-3/4 (Power Electronics) | Semester | VII |
| Prerequisite Knowledge | Power Electronics | | |
| Course Aim | To teach the Electrical vehicles and their operation | | |
| Course Outcomes (COs) | CO1: Able to understand the electric vehicle design, architecture and types of EV.<br>CO2: Competence in designing the power electronic converters for electric vehicle charging applications<br>CO3: Ability in analyzing the energy storage systems for EVs and carry research on the same<br>CO4: Proficiency in design and control of electric motors for EVs<br>CO5: Able to understand and create the solutions for the impact of EV on grid | | |

**Electric Vehicle Technology**

General Introduction, History of Electric Vehicles (EV), Evolution of Batteries, E-Mobility – advantages, Preference for EV over ICE Vehicles, EV types - Battery EV, Fuel Cell EV, Hybrid EV, Plug-In EV; Policies and Regulations for Faster EV Adoption.

Energy Storage Options for EV Applications-battery types, Li-ion Batteries- Characteristics and Parameters, Modeling and Estimation; Battery Management System; Safety strategies (passive/active) of Li-ion batteries; Alternate energy storage technology.

Electric Motors for EV Applications, Performance requirements, Types of motors, Magnetic materials, Thermal issues and management, Electromagnetic Analysis and Design, Sizing of propulsion motor.

Power Electronic Converters for EV Applications: Si-based devices, Wide-band gap devices, Power losses, Reliability assessment, Role of Power Electronic Converters, Battery charging topologies, Traction drives, Voltage source inverters, Modulation techniques, Sizing of power electronics converters.

Drive-trains: Hybrid Electric and Electric Drive-trains, Energy Management Strategies.

Modeling and Sizing of Batteries used in EVs, EV Battery Management Systems, Critical battery states (State of Charge, State of Energy, State of Health, State of Power, State of Temperature); Safety technologies.

EV Charging Methods(CC/CV), Charging Infrastructures, Standards, Location of Charging Stations, Integration of EV load in Power System - Impact of EV charging on grid, EV charging strategies, Mitigation Techniques.

EVs in Grid Support: Flexibility Services, Vehicle to Everything (V2X), Barriers in V2X Infrastructure, Ancillary services, Dynamic Tariff with EVs.

Communication systems, Integrated Vehicle Health Monitoring

**Reference Books :**


1. SandeepDhameja, Electric Vehicle Battery Systems, Elsevier, First Edition, 2002
2. John Fenton & Ron Hodkinson, *Lightweight Electric/Hybrid Vehicle Design*, Elsevier Oxford, 2000.
3. Seth Leitman, Bob Brant, *Build Your Own Electric Vehicle*, McGraw Hill, Third Edition, 2013.
4. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, CRC Press, Second Edition, 2010.
5. MehrdadEhsani, YiminGao, and Ali Emadi, *Modern Electric*, *Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory and Design*, CRC Press, Second Edition2009.
6. Various IEEE/Science direct journals


| Course Title | **Intelligent Control of Drives** | | |
|---|---|---|---|
| Course Code | | Credit | 4 |
| Core/ Elective/HR/RS | HR/RS Course-3/4 (Power Electronics) | Semester | VII |
| Prerequisite Knowledge | Power System, Electrical Machines | | |
| Course Aim | To teach application of intelligent techniques to control the electric drives | | |
| Course Outcomes (COs) | **CO1:** Understand and implement the concept of Neural Networks in Electric Drives<br>**CO2:** Understand and implement the basic concept of Fuzzy logic in Electric Drives<br>**CO3:**Analyze the different control techniques used for modelling and control of the AC and DC drives<br>**CO4:** Develop Simulation model of controllers using the toolbox of ANN and Fuzzy logic for both A.C. and D.C. drives<br>**CO5:** Review and describe the structure of electric drive systems and their role in various applications such as flexible production systems, energy conservation, renewable energy, transportation etc. | | |
| **Unit1:** | | | |

**Introduction to neural networks**: Introduction – biological neurons – Artificial neurons – activation function – learning rules – feed forward networks – supervised learning – perception networks – adaline – madaline – back propagation networks – learning factors – linear separability – Hopfield network – discrete Hopfield networks

**Unit2:**

**Architecture – types**: Recurrent auto association memory – bi-directional associative memory – temporal associative memory – Boltzmann machine Hamming networks – self – organizing feature maps – adaptive resonance theory network – Instar – Outsar model – counter propagation network – radial basis function networks

**Unit 3:**

**Introduction to Fuzzy sets and Systems**: Crisp set – vaguness – uncertainty and imprecision – fuzzy set – fuzzy operation- properties – crisp versus fuzzy relations – fuzzy relation – cardinality operations, properties – fuzzy Cartesian product and composition – non – interactive fuzzy sets – tolerance and equivalence relations – fuzzy ordering relations – fuzzy morphism – composition of fuzzy relations

**Unit 4:**

**Fuzzy logic controller**: Fuzzy to crisp conversion – Lambda cuts for fuzzy sets and relations – definition methods – structure of fuzzy logic controller – database – rule base – Inference engine

**Application and Design:** Applications of Neural network and Fuzzy system for single phase fully controlled converter, single phase ac voltage controller, DC Drive and AC Drive, designing of controllers using Simulation Software Fuzzy Logic Toolbox – Modelling of DC Machines using Simulation Software and Simulink Toolbox

**Reference Books:**

1. L. Fausatt, Fundamentals of neural networks, Prentice Hall of India, New Delhi, 1994.
2. T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hill International Edition, USA, 1997.
3. B. Kosko, Neural Networks and Fuzzy Systems, Prentice Hall of India, New Delhi, 2011.
4. B. K Bose, Modern Power Electronics and AC Drives, Prentice Hall PTR, USA, 2002.