# Annasaheb Dange College of Engineering and Technology

Ashta, Dist: Sangli-416301 (An Autonomous Institute Affiliated to Shivaji University, Kolhapur)

**Department of Electrical Engineering**

## Vision & Mission of Institute

**Vision:** **To be a Leader in preparing professionally competent engineers**

**Mission:** **We, at Annasaheb Dange College of Engineering and Technology, Ashta, are committed to achieve our vision by**

- **Imparting effective outcome based education.**
- **Preparing students through skill oriented courses to excel in their profession with ethical values.**
- **Promoting research to benefit the society.**
- **Strengthening relationship with all stakeholders.**

## Vision & Mission of Department

**Vision:** **To be a leader in developing electrical engineering graduate with knowledge, skill & ethics.**

**Mission:** **We, at department of electrical Engineering, are committed to achieve our vision by,**

- **Facilitating learning through outcomes based education**
- **Cultivating Skills & attitude among graduates to excel in their career**
- **Strengthening relationship with all stakeholders for continues improvement**

Annasaheb Dange College of Engg. & Tech. ASHTA 416301

Head of Department

Head
Electrical Engineering Department
ADCET, Ashta

# Annasaheb Dange College of Engineering and Technology

Ashta, Dist: Sangli-416301 (An Autonomous Institute Affiliated to Shivaji University, Kolhapur)

**Department of Electrical Engineering**

## Program Educational Objectives (PEOs)

**The graduates of the Department of Aeronautical Engineering at ADCET, Ashta will be able to,**

| | |
|---|---|
| **PEO 1:** | **Domain Knowledge:- Solve related problems using Electrical Engineering principles, tools and practices.** |
| | |
| **PEO 2:** | **Core Competency:- Become a practicing Engineer in diversified fields of Electrical Engineering.** |
| | |
| **PEO 3:** | **lifelong learning:-Engage in lifelong learning for effective adaptation to technological challenges.** |
| | |
| **PEO 4:** | **Professionalism :-Demonstrate leadership skills at workplace and function professionally in competitive environment.** |

Head of Department

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ADCET, Ashta

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Ashta, Dist: Sangli-416301 (An Autonomous Institute Affiliated to Shivaji University, Kolhapur)

**Department of Electrical Engineering**

## Program Outcomes (POs)

| | |
|---|---|
| PO 1 | Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. |
| PO 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. |
| PO 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. |
| PO 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. |
| PO 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. |
| PO 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. |
| PO 7 | Environment and stainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. |
| PO 8 | Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice. |
| PO 9 | Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. |
| PO 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. |
| PO 11 | Project management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to ones own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. |
| PO 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. |

# Annasaheb Dange College of Engineering and Technology

Ashta, Dist: Sangli-416301 (An Autonomous Institute Affiliated to Shivaji University, Kolhapur)

**Department of Electrical Engineering**

## Program Specific Outcomes (PSOs)

| | |
|---|---|
| PSO 1 | Ability to apply electrical engineering knowledge, skills for testing, control & maintenance of electrical systems such as Machines, Power Systems, Drives & Automation |
| PSO 2 | Ability to identify problems in the diversified areas of Electrical Engineering and determine the hardware or software solutions to support the Societal, Environmental & Industrial needs. |

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# Annasaheb Dange College of Engineering and Technology, Ashta

## Curriculum Structure (Autonomous)

## M. Tech.
## ELECTRICAL POWER SYSTEM
## SEM I – SEM IV

**(To be implemented from Academic Year 2017-18 onwards)**

Annasaheb Dange College of Engineering and Technology, Ashta

# Department of Electrical Engineering

## M. Tech. (Electrical Power System)

### Teaching and Evaluation Scheme

**M. Tech Electrical Power System: I Semester**

| Course Code | Course | Teaching Scheme | | | | Evaluation Scheme | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Scheme | Theory (Marks) | | Practical (Marks) | |
| | | L | T | P | Credits | | Max | Min. for Passing | Max | Min. for Passing |
| 0EEPS501 | Advanced Computer Methods in Power Systems | 3 | 1 | -- | 4 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS502 | Advanced Power System Protection | 3 | -- | -- | 3 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | | |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS503 | Application of Power Electronics with Smart Grid | 3 | 1 | -- | 4 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS504 | Extra High Voltage AC Transmission | 3 | 1 | -- | 4 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS505 | Power System Dynamics and Stability | 3 | 1 | -- | 4 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS551 | Power Systems Lab-I | -- | -- | 4 | 2 | ISE | -- | | 25 | 10 |
| | | | | | | ESE | -- | POE | 50 | 20 |
| 0EEPS552 | Advanced Power System Protection | -- | -- | 2 | 1 | ISE | -- | -- | 25 | 10 |
| Audit Course | | | | | | | | | | |
| 0EEPS506 | Energy Audit | 4 | -- | -- | -- | -- | -- | GRADE | -- | -- |
| | **Total** | **19** | **4** | **06** | **22** | -- | **500** | -- | **100** | -- |
| **Total Contact Hours/Week: 29 hrs** | | | | | | | | | | |

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# Department of Electrical Engineering

## M. Tech. (Electrical Power System)

### Teaching and Evaluation Scheme

**M. Tech Electrical Power System: II Semester**

| Course Code | Course | Teaching Scheme | | | | Evaluation Scheme | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Scheme | Theory (Marks) | | Practical (Marks) | |
| | | L | T | P | Credits | | Max | Min. for Passing | Max | Min. for Passing |
| 0EEPS507 | Power System Planning and Reliability | 3 | 1 | -- | 4 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS508 | High Voltage Engineering | 3 | -- | -- | 3 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS509 | Power System Operation and Deregulation | 3 | 1 | -- | 4 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS510 To EEPS512 | Elective-I | 3 | 1 | -- | 4 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS513 To 0EEPS515 | Elective-II | 3 | 1 | -- | 4 | ISE | 20 | 40 | -- | -- |
| | | | | | | MSE | 30 | | -- | -- |
| | | | | | | ESE | 50 | | -- | -- |
| 0EEPS553 | Power Systems Lab-II | -- | -- | 4 | 2 | ISE | -- | -- | 50 | 20 |
| | | | | | | ESE | -- | POE | 50 | 20 |
| 0EEPS554 | High Voltage Engineering | -- | -- | 2 | 1 | ISE | -- | -- | 50 | 20 |
| 0EEPS555 | Seminar II | -- | -- | 2 | 1 | ISE | -- | -- | 50 | 20 |
| Audit Course | | | | | | | | | | |
| 0EEPS516 | Research Methodology | 2 | -- | -- | -- | -- | -- | GRADE | -- | -- |
| **Total** | | **17** | **4** | **8** | **23** | -- | **500** | -- | **200** | -- |
| **Total Contact Hours/Week: 29hrs** | | | | | | | | | | |

| Course Code | Elective-I | Course Code | Elective-II |
|---|---|---|---|
| 0EEPS510 | Electrical Power Quality and Harmonics | 0EEPS513 | Flexible AC Transmission and High Voltage DC System |
| 0EEPS511 | Supervisory Control and Data Acquisition & Automation | 0EEPS514 | Power System Optimization Techniques |
| 0EEPS512 | Real Time Control of Power Systems | 0EEPS515 | Power System Transient Analysis |

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# Department of Electrical Engineering

## M. Tech. (Electrical Power System)

### Teaching and Evaluation Scheme

**M. Tech Electrical Power System: III Semester**

| Course code | Course | Teaching Scheme | | | | Evaluation Scheme | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Scheme | Practical (Marks) | |
| | | L | T | P | Credits | | Max | Min for Passing |
| 0EEPS651 | Dissertation Phase I | -- | -- | 5** | 5 | ISE | 50 | 20 |
| 0EEPS652 | Dissertation Phase II | -- | -- | | 10 | ISE | 50 | 20 |
| | | | | | | ESE | 100 | 40 |
| | Total | -- | -- | 5 | 15 | -- | 200 | -- |
| | Total Contact Hours/Week: 5 hrs | | | | | | | |

**M. Tech Electrical Power System: IV Semester**

| Course code | Course | Teaching Scheme | | | | Evaluation Scheme | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Scheme | Practical (Marks) | |
| | | L | T | P | Credits | | Max | Min for Passing |
| 0EEPS653 | Dissertation Phase III | -- | -- | 5** | 10 | ISE | 100 | 40 |
| 0EEPS654 | Dissertation Phase IV | -- | -- | | 10 | ISE | 100 | 40 |
| | | | | | | ESE | 100 | 40 |
| | Total | -- | -- | 5 | 20 | -- | 300 | -- |
| | Total Contact Hours/Week: 5 hrs | | | | | | | |

** Indicates: 1) Faculty contact hours per student per/ week

2) Student working Hours: 30 Hrs/Week

Total number of Credits: 80

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**M. Tech Electrical Power System: I Semester**

**Course Details:**

| | |
|---|---|
| **Class** | M. Tech, Sem.-I |
| **Course Code and Course Title** | 0EEPS501, **Advanced Computer Methods in Power Systems** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 3/1 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To understand the concept of network topology. |
| 02 | To analyze power networks by different methods for formation of admittance matrices. |
| 03 | To analyze power networks by different methods for formation of impedance matrices. |
| 04 | To understand concept of power flow study and study different numerical methods for power flow solution. |
| 05 | To discuss simultaneous faults in power networks. |
| 06 | To understand two component method to obtain the results in case of various faults on the power system. |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS501_1 | Develop various network Matrices (Cognitive Level 6) |
| 0EEPS501_2 | Apply different methods to write admittance matrices of power network. (Cognitive Level 3) |
| 0EEPS501_3 | Use different methods to develop impedance matrices of power network. (Cognitive Level 3) |
| 0EEPS501_4 | Explain algorithm of different numerical methods used for power flow solution. (Cognitive Level 2) |
| 0EEPS501_5 | Develop two port networks parameters equations in case of simultaneous faults. (Cognitive Level 6) |
| 0EEPS501_6 | Apply two component methods to obtain the results in case of various faults on the power system. (Cognitive Level 3) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Network Topology**<br>Introduction, Basic Principles in Power System Analysis, Elementary Graph Theory, Incidence Matrices, Connectivity, Primitive Network, Numerical Treatment Expected | **06 Hrs.** |

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| | | |
|---|---|---|
| **Unit 2** | **Computer Solution Methods Using the Admittance Matrix**<br>Introduction, Formation of YBUS by Singular Transformation, Non-singular Transformation, inspection- Modeling of transmission lines, Modeling of transformer, Modeling of shunt elements, Modeling of loads, Modeling of generator internal impedance, Step by Step Algorithm for Formation of YBUS, Numerical treatment expected | **09 Hrs.** |
| **Unit 3** | **Computer Solution Methods Using the Impedance Matrix**<br>Impedance matrix in shunt fault computations, impedance matrix algorithm, adding a radial impedance to the reference node, adding a radial branch to a new node, closing a loop to the reference, closing a loop not involving the reference, adding a mutually coupled radial element, adding a group of mutually coupled lines, comparison of admittance and impedance matrix techniques, Numerical treatment expected | **07 Hrs.** |
| **Unit 4** | **Computer techniques for Load flow analysis**<br>Introduction, Impact of computers, orientation of engineering problems to computers, Power Flow equation, Classification of buses, Operating constraints, Data for load flow, Bus Classification, Modelling for Load Flow Studies, Gauses - Seidel Iterative Method, Newton - Raphson Method-Rectangular Coordinates Method, The Polar Coordinates Method, Sparsity of Network Admittance Matrices, Decoupled Methods, Fast Decoupled Methods, Load Flow Solution Using Z Bus, Comparision of Various Methods for Power Flow Solution. | **06 Hrs.** |
| **Unit 5** | **Simultaneous Faults**<br>Simultaneous Faults by Two-Port Network Theory- Two port networks, interconnection of two port networks, simultaneous fault connection of sequence networks, series-series connection (Z-type faults), Parallel - parallel connection (Y-type faults), series-parallel connection (H-type faults), Simultaneous faults by matrix transformations- constraint matrix for Z-type faults, constraint matrix for Y-type and H-type faults, Numerical treatment expected. | **07 Hrs.** |
| **Unit 6** | **Analytical Simplifications**<br>Two Component Method Shunt Faults- SLG Fault, LL Fault, DLG Fault, Three phase fault, Series Faults- 2LO Fault, 1LO Fault, Change in symmetry with two component calculations- phase shifting transformer relations, SLG faults with arbitrary symmetry, DLG faults with arbitrary symmetry, series faults with arbitrary symmetry. | **07 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Circuit Theory (Analysis and Synthesis) | A. Chakrabarti | DhanpatRai& Co. |
| 02 | Advanced Power System Analysis & Dynamics | L.P. Singh | New Age International Publishers |

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| Text Books: | | | |
|---|---|---|---|
| **Sr. No** | **Title** | **Author** | **Publisher** |
| 03 | Power System Analysis | Grainger, J.J. and Stevenson, W. D. | Tata McGraw-Hill Edition |
| 04 | Computer Techniques and Models in Power Systems | K. Uma Rao | I.K. International Publishing House Pvt Ltd |

| Reference Books: | | | |
|---|---|---|---|
| **Sr. No** | **Title** | **Author** | **Publisher** |
| 01 | Analysis of Faulted Power Systems | Paul.M. Anderson | IEEE Press Power Systems Engineering Series |
| 02 | Circuits Analysis of A,C. power system VOL-II | Edith Clarke | J. Wiley & sons, Incorporated, 1950 |
| 03 | Introduction to Matrices & Power System | R.Bruce Shipley | Wiley Eastern Ltd |
| 04 | Computer methods in Power System Analysis | Stagg G.W. & E.L. Abiad | McGraw-Hill |
| 05 | Operation and Control in Power Systems | Prof. P. S. R. Murty | B.S. Publications |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech, Sem.-I |
| **Course Code and Course Title** | 0EEPS502, **Advanced Power System Protection** |
| **Prerequisite/s** | ---- |
| **Teaching Scheme: Lecture/Tutorial** | 3/0 |
| **Credits** | 03 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To introduce students to digital power system protection |
| 02 | To teach students basic terminology regarding digital protection |
| 03 | To teach students the advanced techniques for various power system protection conditions |
| 04 | To enhance student's knowledge of various advanced relays. |
| 05 | To develop an ability and skills to design the feasible protection systems |
| 06 | To develop student's research ability in fundamental things needed for digital protection |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| EEPS502_1 | Describe modern protection schemes like applications of microprocessor based relays for the protection of the power system equipment($3^{rd}$ cognitive level) |
| EEPS502_2 | Explain use of CT / PT & its modeling for digital protection ($2^{nd}$ Cognitive level) |
| EEPS502_3 | Choose appropriate comparator for different protection schemes for various power system conditions ($3^{rd}$cognitive level) |
| EEPS502_4 | Explain relay coordination to achieve reliability in advanced protection scheme ($2^{nd}$cognitive level) |
| EEPS502_5 | Explain appropriate differential scheme for various machines ($2^{nd}$ cognitive level). |
| EEPS502_6 | To design suitable digital protection scheme for distance protection ($6^{th}$ cognitive level) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Introduction to Digital Relay:** Introduction, Basic Components of Digital Relays with block diagram advantages of microprocessor technology, microprocessor applications to protection | **04 Hrs.** |
| **Unit 2** | **Current and Voltage Transformers:** Introduction, current transformers, equivalent circuits, transient performance, modeling for transient simulation, use of mimic impedance, voltage transformers, VT model, modeling for transient simulation, wound voltage transformers, relay performance, dynamic compensation for CTs and PTs, compensating | **06 Hrs.** |

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| | | |
|---|---|---|
| | algorithms for CTs and dynamic compensation of CTs, analysis of simulation results.Study of electromagnetic CT & PT, Steady state & Transient state analysis of CVT, Study of residual voltage transformer, natural CT, Mixing Transformer, summation transformer, Optical CT | |
| **Unit 3** | **Comparator:** Characteristic & study of different types of two input phase & amplitude Comparator, Study of multi input comparator | **05 Hrs.** |
| **Unit 4** | **Coordination of Inverse Definite Minimum Time (IDMT)/Directional Over Current (DOC) Relays in an Interconnected Power System Network:** Plug setting, time setting, radial feeder and ring mains protection, earth fault and phase fault, Directional relay, and microprocessor based o/c relay, Protection of an interconnected system, relay coordination | **06 Hrs.** |
| **Unit 5** | **Auto-reclosing and Differential Protection**<br>Introduction, history of auto-reclosing, advantageous of auto-reclosing, classification of auto-reclosing, circulating current and opposed voltage principles, percentage differential relay, line protection, carrier aided protection scheme. | **06 Hrs.** |
| **Unit 6** | **Protection of Power System Components:** Introduction, bus bar protection, digital protection schemes for bus bars, digital protection schemes for generators<br>**a) Transformer Protection**: Introduction, digital techniques for protection of transformers, harmonic restraint percentage differential protection, voltage restraint technique, flux restraint approach.<br>**b) Distance protection:** Impedance, reactance and admittance characteristics, relay settings for 3-zone protection, out of step blocking scheme, blinder relay, numerical relays for transmission line protection, microprocessor based impedance, reactance and mho relays & digital techniques for distance protection. | **09 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Switchgear and protection | U A Bakshi<br>M V Bakshi | Technical Publication |
| 02 | Power System protection and Switchgear | Badri Ram,<br>Vishwakarma, | Tata McGraw Hill |

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| Reference Books: | | | |
|---|---|---|---|
| **Sr. No** | **Title** | **Author** | **Publisher** |
| 01 | Digital Protection of Power Systems | K. Parthasarathy | ISTE WPLP Learning Material Series, Indian Society for Technical Education, Bangalore |
| 02 | Fundamentals of Power system Protection | Paithankar Bhide | PHI Learning |
| 03 | Power System Protection – Static Relays | T.S. Madhava Rao | TMH Publication |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech., Sem.-I |
| **Course Code and Course Title** | 0EEPS503, **Application of Power Electronics with Smart Grid** |
| **Prerequisite/s** | ---- |
| **Teaching Scheme: Lecture/Tutorial** | 3/1 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To introduce various aspects of the smart grid, including technologies, components, architectures and applications |
| 02 | To teach the power electronics devises in smart grid |
| 03 | To discuss issues and challenges involved in smart grid |
| 04 | To discuss communication and information technology in smart grid |
| 05 | To discuss Energy Storage devices |
| 06 | To explain concepts of Micro-grid |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS503_1 | Understand the various aspects of the smart grid, including technologies, components, architectures and applications. (Level-2) |
| 0EEPS503_2 | Evaluate Power Electronics devices like Multilevel Inverter in Smart Grid. (Level-5) |
| 0EEPS503_3 | Judge the issues and challenges involved in smart grid. (Level-5) |
| 0EEPS503_4 | Conclude the role of communication and information technology in smart grid. (Level-5) |
| 0EEPS503_5 | Explain various Energy Storage devices. (Level-4) |
| 0EEPS503_6 | Evaluate concepts of micro-grid. (Level-5) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Introduction to Smart Grid:** Concept, definitions, difference between conventional and smart grid, challenges in smart grid implementation, Overview of the technologies required for the Smart Grid | **06 Hrs.** |
| **Unit 2** | **Power Electronics in Smart Grid:** Introduction, Multilevel Inverter (MLI) Concept, Types of Multilevel Inverters, Diode-Clamped Multilevel Inverter, Flying-Capacitor Multilevel Inverter, Cascade Multilevel Inverter, Applications, Switching Device Current, DC-link Capacitor Voltage Balancing, and Comparisons of Multilevel Inverters. | **07 Hrs.** |
| **Unit 3** | **Renewable energy integration:** Carbon Footprint, Renewable Resources: Wind and Solar, Micro-grid Architecture, Modeling PV and wind systems, | **07 Hrs.** |

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| | | |
|---|---|---|
| | Tackling Intermittency, Issues of interconnection, protection & control of micro-grid, Islanding | |
| **Unit 4** | **Smart Distribution Systems and Energy Storage:** Introduction to Smart Meters, Real time pricing, Smart appliances, Automatic meter reading(AMR), Demand response, Energy Storage Technologies: Batteries, Fuel Cell and Hydrogen electrolyser, Flywheels, Superconducting magnetic energy storage systems, super capacitors | **07 Hrs.** |
| **Unit 5** | **Introduction of Electric and Hybrid Electric Vehicles (EVs & HEVs):** A brief history of EV &PHV, Basics of EV & HEV, Architectures of EV & HEV, HEV fundamentals. Vehicle-to-grid technology | **06 Hrs.** |
| **Unit 6** | **Micro-grids:** Concept of micro-grid, need and applications of micro-grid, formation of micro-grid, Issues of interconnection, protection and control of micro-grid. Plastic and Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources | **07 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Smart Grid: Technology and Applications | JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama | Wiley |
| 02 | Power Electronics Circuits, Devices, and Applications | Muhammad H. Rashid | Pearson Publication |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Smart Grid: Fundamentals of Design and Analysis | James Momoh | IEEE Press Series on Power Engineering |
| 02 | Integration of Green and Renewable Energy in Electric Power Systems | Ali Keyhani, Mohammad N. Marwali, Min Dai | Wiley |
| 03 | Recent literature on Smart Grid | | |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech, Sem. – I |
| **Course Code and Course Title** | 0EEPS504, **Extra High Voltage AC Transmission** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 3/1 |
| **Credits** | 4 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To introduce EHVAC transmission system. |
| 02 | To apply voltage gradient calculation and corona in EHVAC lines. |
| 03 | To analyze travelling waves on EHVAC transmission line. |
| 04 | To propose over voltages occurring in EHVAC lines. |
| 05 | To design insulation for different over voltages. |
| 06 | To design EHVAC lines and propose EHV cables. |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS504_1 | Describe the basics of EHVAC transmission lines & determine parameters. ($3^{rd}$ cognitive level) |
| 0EEPS504_2 | Determine the voltage gradient on conductor. ($3^{rd}$ cognitive level) |
| 0EEPS504_3 | Explain about travelling waves and analyze EHVAC lines. ($4^{th}$ cognitive level) |
| 0EEPS504_4 | Apply the over voltages knowledge, their causes in EHVAC. ($3^{rd}$ cognitive level) |
| 0EEPS504_5 | Explain lightning phenomena & design insulation system for lightning .($5^{th}$ cognitive level) |
| 0EEPS504_6 | Design EHVAC lines.($5^{th}$ cognitive level) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Introduction to EHVAC transmission:** Role of EHVAC transmission, standard transmission voltage, average values of line parameters, power handling capacity, line loss, cost of transmission line, mechanical considerations of line performance, resistance of the conductor, temperature rise, inductance & capacitance calculations | **06 Hrs.** |
| **Unit 2** | **Voltage Gradients& Corona:** Charge potential relations for multi-conductor relations, surface voltage gradients on conductor, distribution of voltage gradient on sub conductor of bundle. I^2R & corona loss, corona loss formula, charge voltage diagram with corona, Attenuation of travelling waves due to the corona loss, audible noise; corona pulses, their generation & properties, limits for radio | **07 Hrs.** |

| | | |
|---|---|---|
| | interference fields, CIGRE formula, RI excitation function | |
| **Unit 3** | **Travelling waves:**<br>Introduction, Differential equation & solution for general case, Standing Waves & natural frequency, Open ended line, Double exponential response, Response to the sinusoidal excitation, Line energization with trapped charge voltage, Reflection & refraction of traveling waves. | **07Hrs.** |
| **Unit 4** | **Over voltages in EHV Lines by switching operations & Over voltages at power frequency:**<br>Introduction to switching over voltages, recovery voltage & circuit breakers, over voltage due to interruption of low inductive current & capacitive currents Ferro resonance over voltage & calculation of switching surges & single phase equivalents.<br>Generalized constants, charging currents, power circle diagram & its use, voltage control, shunt & series compensation, sub synchronous resonance in series capacitor compensated line & static reactive compensating system. | **08 Hrs.** |
| **Unit 5** | **Lightning & Insulation coordination:**<br>Lightning introduction, general principles of lightning protection problem, Tower footing resistance, Lightning arresters.<br>Insulation levels voltage withstand levels of protected equipment & Insulation co-ordination based on lightning | **06 Hrs.** |
| **Unit 6** | **Design of the EHVAC lines & EHV cable transmission:**<br>Introduction, design factor under steady state, design examples steady state, any one example<br>Introduction to EHV cable, EHV cable electrical properties, cable insulating material properties, design basics of cable insulation, gas insulated EHV lines | **06 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | EHVAC transmission Engineering | R. D. Begamudre | New Age international |
| 02 | EHVAC & HVDC Transmission Engg. &Design | S. Rao | S.V. Rao |
| 03 | Power Transmission System Engg. Analysis & Design | Turon Gonen | John Wiley & sons |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech. Sem.-I |
| **Course Code and Course Title** | **0EEPS505, Power System Dynamics and Stability** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 03/01 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | Students will be able to understand Basic Concepts of dynamical system |
| 02 | Students will be able to Model the Power System Components |
| 03 | Students will be able to Analyze Sub-Synchronous oscillation |
| 04 | Students will be able to Analyze small signal stability of SMIB |
| 05 | Students will be able to analysis improving voltage stability |
| 06 | Students will be able to Analysis using digital system simulation |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS505_1 | Understand Basic Concepts of dynamical system. (Level 2) |
| 0EEPS505_2 | Evaluate the Power System Components. (Level 5) |
| 0EEPS505_3 | Analyze Sub-Synchronous oscillation. (Level 4) |
| 0EEPS505_4 | Analyze small signal stability of SMIB. (Level 4) |
| 0EEPS505_5 | Analysis improving voltage stability. (Level 4) |
| 0EEPS505_6 | Analysis using digital system simulation. (Level 4) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Basic Concepts:** Basic Concepts of dynamical system, formation of State space equations: Concept of Dynamic Instability, Voltage Instability, Angle Instability, Steady State & Dynamic problem in A.C. Systems. | **06 Hrs.** |
| **Unit 2** | **Modeling of Power System Components:** Synchronous machine, excitation system, prime movers, governors, Transmission lines, transformers & loads. | **08 Hrs.** |
| **Unit 3** | **Sub-Synchronous oscillation:** Turbine generator torsional characteristics, torsional interaction with power system controls, sub- synchronous resonance Analysis & counter measures using PSS. | **07 Hrs.** |
| **Unit 4** | **Small Signal Stability:** Fundamental concepts of stability of dynamic systems, Eigen properties of | **07 Hrs.** |

| | | |
|---|---|---|
| | the state matrix, small signal stability of SMIB, effects of excitation system. | |
| **Unit 5** | **Voltage stability:**<br>Basic concepts of voltage stability, voltage collapse, voltage stability analysis & methods of improving voltage stability. | **06 Hrs.** |
| **Unit 6** | **Transient Instability:**<br>Analysis using digital simulation, Analysis using energy function, Study of various numerical methods, Fix step method, Variable step method. | **08 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 1. | Power System Stability & Control | P. Kundur | New Age |
| 2. | Power System Dynamic and Stability | C. W. Taylor | Willey |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 1. | Power System Voltage Stability | K. R. Padiyar | New Age |
| 2. | Power System Stability & Control | P. M. Anderson Fauad | Tata Macro hill |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech Sem.I |
| **Course Code and Course Title** | 0EEPS506, **Energy Audit and Management** |
| **Prerequisite/s** | -- |
| **Teaching Scheme: Lecture/Tutorial** | 04/00 |
| **Credits** | 00 |
| **Evaluation Scheme: ISE / MSE / ESE** | Grade |

| **Course Educational Objectives(CEOs):** The course aims to: | |
|---|---|
| 01 | Understand importance of energy and energy security. |
| 02 | Understand impact of use energy resources on environment and emission standards, different operating frame work. |
| 03 | Follow format of energy management, energy policy. |
| 04 | Learn various tools of Demand Control. |
| 05 | Calculate economic viability of energy saving option |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS506_1 | Explain overall Energy Scenario (Cognitive Level 2) |
| 0EEPS506_2 | Identify various forms of Energy (Cognitive Level 1) |
| 0EEPS506_3 | Explain basics of Energy Auditing and instruments for energy audit (Cognitive Level 2) |
| 0EEPS506_4 | Analyze various parameter of audit for different systems (Cognitive Level 4) |
| 0EEPS506_5 | Understand concept of demand side management (Cognitive Level 2) |
| 0EEPS506_6 | Implement work with economic feasibility(Cognitive Level 4) |

| **Course Contents** | | |
|---|---|---|
| Unit 1 | **Energy Scenario** Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment, Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy Conservation Act-2001 and its Features. | 6Hrs. |
| Unit 2 | **Basic of Energy and its various forms** Electricity basics - DC & AC currents, Electricity tariff, Load managemen and Maximum demand control, Power factor. Thermal basics -Fuels, Thermal energy contents of fuel, Temperature & Pressure, Heat capacity, Sensible and Latent heat, Evaporation, | 6Hrs. |

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| | | |
|---|---|---|
| | Condensation, Steam, Moist air and Humidity & Heat transfer, Units and conversion. | |
| Unit 3 | **Energy Management & Audit**<br>Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments | 6 Hrs. |
| Unit 4 | **Energy Conservation in Applications**<br>Motive power (motor and drive system). b) Illumination c) Heating systems ( boiler and steam systems) c) Ventilation( Fan, Blower, Compressors) and Air Conditioning systems d) Pumping System e) Cogeneration and waste heat recovery systems f) Utility industries ( T and D Sector)g) Diesel generators | 8Hrs. |
| Unit 5 | **Demand Management**<br>Supply side management (SSM), various measures involved such as use of FACTS, VAR Compensation, Generation system up gradation, constraints on SSM. Demand side management (DSM), advantages and Barriers, implementation of DSM, areas of development of demand side management in agricultural, domestic and commercial consumers. Demand management through tariffs (TOD). Power factor penalties and incentives in tariff for demand control. Apparent energy tariffs. Role of renewable energy sources in energy management, direct use (solar thermal, solar air conditioning, biomass) and indirect use (solar, wind etc.) | 10Hrs. |
| Unit 6 | **Financial Management and Case Studies**<br>Investment-need, Appraisal and criteria, Financial analysis techniques-Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis; Financing options, Energy performance contracts and role of ESCOs.Energy audit case studies such as IT sector, Textile, Municipal corporations, Educational Institutes, T and D Sector and Thermal Power stations. | 6 Hrs. |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Energy Management, Audit and Conservation | Barun Kumar de | Vriand Publication |

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**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 1 | Success stories of Energy Conservation | Bureau of Energy Efficiency | Bureau of Energy Efficiency |
| 2 | Energy Management | W.R. Murphy and Mackay | Reed Elsevier India Private Limited |
| 3 | Energy Auditing made simple | Balasubramanian | Bala Consultancy Services |
| 4 | Utilization of electrical energy | S.C. Tripathi | Tata McGraw Hill |
| 5 | Generation and utilization of Electrical Energy | B.R. Gupta | S. Chand Publication |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech, Sem.-I |
| **Course Code and Course Title** | 0EEPS551, **Power System Lab-I** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial/Practical** | 0/0/4 |
| **Credits** | 02 |
| **Evaluation Scheme: ISE / ESE** | 25/50 |

| **Course Educational Objectives(CEOs):** The course aims to: | |
|---|---|
| 01 | To allow students to practically verify several concepts and procedures learned in power system analysis. |
| 02 | To develop hands-on experience of how certain procedures of power system operation are carried out. |
| 03 | To Understand the performance of transmission line parameter with help of MATLAB ETAP and Power World Simulator. |
| 04 | To carry out system studies using power systems analysis software to assess system operation in steady state and under faulted conditions. |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS551_1 | Write codes for to measure electrical parameters of transmission line. ( Level 6) |
| 0EEPS551_2 | Create a model in power world simulator ( Level 6) |
| 0EEPS551_3 | Solve and write codes in MATLAB for load flow problem using Gauss-Seidal and Newton-Raphson method. ( Level 6) |
| 0EEPS551_4 | Analyze the transient performance of transmission systems. ( Level 4) |
| 0EEPS551_5 | Analyze the performance of transmission line in MATLAB. ( Level 4) |
| 0EEPS551_6 | Evaluate problems of power systems in ETAP ( Level 5) |

**List of Experiments:**

| Sr. No | Title of Experiments |
|---|---|
| 1. | MATLAB Primer |
| 2. | Analyze the Transients on a Transmission Line |
| 3. | Calculate Symmetrical Short Circuit on a Synchronous Machine |
| 4. | Calculate Symmetrical Components from Unbalance Currents |
| 5. | Calculate Unbalanced Voltages from Symmetrical Components |
| 6. | Analyze the Transient Power-angle Curve for Synchronous Machine |
| 7. | Calculate Equal area Criterion of power system |
| 8. | Formulation and calculation of Y- bus matrix of a system using MATLAB. |
| 9. | Solution of a load flow problem using Gauss-Seidal and Newton-Raphson method |

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| | |
|---|---|
| | using MATLAB. |
| 10. | Symmetrical fault analysis of a 3-bus system using MATLAB. |
| 11. | Determination of voltages sequence using MATLAB. |
| 12. | Power flow analysis using power world simulator |
| 13. | Building a One-Line Diagram using ETAP |
| 14. | Balanced and Unbalanced load flow analysis using ETAP |
| 15. | DC Load flow analysis using ETAP |
| 16. | Hardware Design using Ardiuno |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Advanced Power System Analysis & Dynamics | L.P. Singh | New Age International Publishers |
| 02 | Power System Analysis | Grainger, J.J. and Stevenson, W. D. | Tata McGraw-Hill Edition |
| 03 | Computer Techniques and Models in Power Systems | K. Uma Rao | I.K. International Publishing House Pvt Ltd |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Analysis of Faulted Power Systems | Paul.M. Anderson | IEEE Press Power Systems Engineering Series |
| 02 | Circuits Analysis of A,C. power system VOL-II | Edith Clarke | J. Wiley & sons, Incorporated, 1950 |
| 03 | Computer methods in Power System Analysis | Stagg G.W. & E.L. Abiad | McGraw-Hill |
| 04 | Operation and Control in Power Systems | Prof. P. S. R. Murty | B.S. Publications |

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**Course:**

| | |
|---|---|
| **Class** | M. Tech, Sem.-I |
| **Laboratory Course Code and Course Title** | 0EEPS552, **Advanced Power System Protection** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Practical/Tutorial** | 0/0/2 |
| **Credits** | 01 |
| **Evaluation Scheme : ISE** | 25/00 |

| **Course Educational Objectives(CEOs):** Laboratory practice aims to | |
|---|---|
| 1 | To give practical awareness and acquaintance with construction, principle operation protective devices of the power system. |
| 2 | How to connect the relays and circuit breakers to a line. |
| 3 | To develop relay and circuit breaker settings for different conditions |

| **Course Outcomes (COs):** On successful completion of laboratory practice, student will be able to, | |
|---|---|
| 0EEPS552_1 | Interpret different Protection system components. ($2^{nd}$ cognitive level) |
| 0EEPS552_2 | Compare different protection schemes. ($2^{nd}$ cognitive level) |
| 0EEPS552_3 | Illustrate of different types of circuit breakers. ($3^{rd}$ cognitive level) |
| 0EEPS552_4 | Discriminate of different types of relays. ($5^{th}$ cognitive level) |

**List of Experiments**

| Experiment No. | Title of Experiment |
|---|---|
| 1 | Drawing sheet showing construction of Circuit Breakers. |
| 2 | Drawing sheet showing construction of generator protection schemes. |
| 3 | Drawing sheet showing construction of Transformer protection schemes. |
| 4 | To study electromechanical induction disc type relay |
| 5 | To plot time/current characteristic and study of electro-mechanical over current relay. |
| 6 | To plot different characteristic and study of Microprocessor over current relay. |
| 7 | Experimental study of Electromechanical over voltage relay. |
| 8 | Experimental study of Microprocessor Based over voltage Relay. |

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| | |
|---|---|
| 9 | Experimental study of Microprocessor Based over voltage Relay. |
| 10 | Experimental study of microprocessor based IMPEDANCE Relay. |
| 11 | Introduction to Power World Software for different relay and circuit breaker settings |
| 12 | Study of relay coordination in Power World simulator |
| 13 | Study of transient stability during faults in Power World simulator |
| 14 | Study of CT construction in detail & find out Ratio error and Phase angle error |
| 15 | Study of PT construction in detail & find out Ratio error and Phase angle error |

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Annasaheb Dange College of Engineering and Technology, Ashta

**Department of Electrical Engineering**

**M. Tech. (Electrical Power System)**

**M. Tech Electrical Power System: II Semester**

**Course Details:**

| | |
|---|---|
| **Class** | M. Tech. (Electrical Power System) Sem.-II |
| **Course Code and Course Title** | **0EEPS507, Power System Planning and Reliability** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 03/01 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To introduce the objectives of Power System Planning at Generation, Transmission and Distribution level. |
| 02 | To know about Load Forecasting Techniques based on time horizon perspective of power system. |
| 03 | To impart learning about Reliability concepts & Reliability models to determine power sector reliability with various techniques. |
| 04 | To understand the criteria of Generation Planning & determination of Generation Reliability based on Generator Model. |
| 05 | To explore the objectives of Transmission Expansion Planning and its Reliability. |
| 06 | To learn about various concepts related to Distribution Planning and determine Distribution Reliability. |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS507_1 | Evaluate various aspects of power system planning. (Level 5) |
| 0EEPS507_2 | Use the basics of load forecasting that will be useful foe engineering profession practice in the power sector operation. (Level 3) |
| 0EEPS507_3 | Understand the concepts of reliability and apply the various techniques to determine the reliability of power system operation and planning. (Level 2) |
| 0EEPS507_4 | Apply reliability models to determine the reliability of Generation, Transmission and Distribution Expansion planning. (Level 3) |
| 0EEPS507_5 | Evaluate the optimal power system model based on reliability. (Level 5) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Power System Planning:** Introduction, Objectives of Planning, Power system elements & structure, Power system planning issues, time horizon perspectives of power system studies, Short Term Planning, Medium Term Planning, Long Term Planning, Reactive Power Planning. | **06 Hrs.** |

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|---|---|---|
| **Unit 2** | **Load Forecasting:**<br>Classification and Characteristics of Loads, approaches to load forecasting, Forecasting methodologies: i) Extrapolation, ii) Correlation, Energy forecasting, Peak Demand Forecasting, Weather Load Model, Weather Sensitive and Non-Weather Sensitive Load Forecasting, Total Forecast. | **08 Hrs.** |
| **Unit 3** | **Reliability:**<br>Reliability concepts, General Reliability Function, Simple Series and parallel Models, Reliability Evaluation Techniques: i) Markov Chains and Processes ii) Recursive Techniques, Adequacy of reliability, Reliability Costs. | **07 Hrs.** |
| **Unit 4** | **Generation Planning & Reliability:**<br>Generation Resources, Factors affecting generation planning, Generation system model, Loss of Load, Outage, Loss of Energy, Reliability based generation system, Reliability analysis of Isolated & Interconnected System, Generator system cost analysis. | **07 Hrs.** |
| **Unit 5** | **Transmission Planning & Reliability:**<br>Introduction, Objectives, Transmission Expansion Planning, Transmission System Reliability Model Analysis, Determination of Reliability indices like LOLP, Average Interruption Rate Method. | **06 Hrs.** |
| **Unit 6** | **Distribution Planning & Reliability:**<br>Introduction, Overview of Distribution system expansion planning, Design consideration of primary and secondary distribution, Distribution system voltage regulation, distribution system protection & coordination of protective devices, Distribution reliability indices, parallel & meshed networks and Effect of Protection failure. | **08 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Power System Planning | R.L. Sullivan | McGraw Hill International Book Co |
| 02 | Electrical Power System Planning | A.S. Pabla | Macmillan |
| 03 | Electric Power System Planning: Issues, Algorithms and Solutions | Hossein Seifi Mohammad Sadegh Sepasian | Springer |
| 04 | Power System Reliability Evaluation | Roy Billington | Gordan& Breach Scain Publishers, |

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**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Modern Power System Planning | X. Wang, J.r. McDonald | McGraw Hill Int. Ed. |
| 02 | Power Generations, Operation & Control | Allen J. Wood, B.F. Wollenberg | Wiley India, Reprint |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech, Sem.II |
| **Course Code and Course Title** | 0EEPS508, **High Voltage Engineering** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 3/0 |
| **Credits** | 03 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Educational Objectives(CEOs):** The course aims to: | |
|---|---|
| 01 | Introduce basic knowledge about High Voltage Engineering |
| 02 | Explain the concept related to ionization process and its theories |
| 03 | Explain process of breakdown in Gaseous, Liquid and Solids |
| 04 | Illustrate generation and Measurement of High Voltages and Current |
| 05 | Describe insulation Co-ordination. Over voltage phenomenon |
| 06 | Explain High Voltage Testing of Electrical Equipment |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS508_1 | Understand the concepts related to electrostatic field stress (Cognitive Level 2) |
| 0EEPS508_2 | Illustrate electrical breakdown in air, solid and liquid insulation (Cognitive Level 3) |
| 0EEPS508_3 | Analyze generation of High voltage and High current. (Cognitive Level 4) |
| 0EEPS508_4 | Demonstrate and analyze measurement of High voltage and High current for testing purposes (Cognitive Level 4) |
| 0EEPS508_5 | Testing and analyzing of Insulation coordination, over voltage and transient in power system (Cognitive Level 5) |
| 0EEPS508_6 | Analyze high voltage test on various electrical equipment (Cognitive Level 4) |

| **Course Contents** | | |
|---|---|---|
| Unit 1 | **Electric Stress Estimation and Control:** Electrical field distribution and breakdown strength of insulating materials - fields in homogeneous, isotropic materials - fields in multi-dielectric, isotropic materials - numerical method: Finite difference method ,charge simulation method (CSM), Control of Electric Field Intensity | 4Hrs |
| | **Breakdown Mechanism of Gaseous, Liquid and Solid Materials** Gases as insulating media - ionization and decay processes, Townsend first | |

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| | | |
|---|---|---|
| Unit 2 | ionization coefficient, photo-ionization, photoelectric emission, thermionic emission, Townsend second ionization coefficient, the Townsend mechanism, Paschen's law,<br>Liquid as insulators, breakdown in liquids - electronic breakdown, suspended solid particle mechanism, cavity breakdown, Breakdown in solids, intrinsic breakdown, streamer breakdown, electromechanical breakdown, breakdown due to treeing & tracking, thermal breakdown, solid dielectrics used in practice. | 9Hrs |
| Unit 3 | **Generation of high voltages and Current:**<br>Generation of high direct voltages, half and full wave rectifier circuits, voltage multiplier circuits, Cockcroft-Walton Voltage Multiplier Circuit working, Van de Graff generators, electrostatic generators, generation of alternating voltages, cascaded transformers, resonant transformers- series, parallel, impulse voltages, Standard lightning and switching surge, impulse voltage generator circuits, Analysis of circuit "a", Marx circuit, operation, impulse current generator. | 7Hrs |
| Unit 4 | **Measurement of high Voltages and Current**:<br>High direct voltage measurement, peak voltage measurements by spark gaps, sphere gaps, reference measuring systems, uniform field gaps, rod gaps, factors affecting sphere gap measurements, electrostatic voltmeters, generating voltmeters and field sensors, Potential Dividersfor Impulse Voltage Measurements- resistance & Capacitance voltage divider, Measurement Of High D.C., A.C. And Impulse Currents- hall generators, Rogowaski coil, Faraday Generator, the measurement of peak voltages, the Chubb–Fortescue method, Surge Recorder (Klydonograph) with Litchenberg Pattern. | 9Hrs |
| Unit 5 | **Transient in Power System, insulation coordination &Non-destructive insulation tests:**<br>Transients in simple Circuit, Capacitance Switching, Natural causes for over voltages, Lightning phenomenon, Overvoltage due to switching surges, system faults and other abnormal conditions, Principles of Insulation Coordination on High voltage and Extra High Voltage power systems, Measurement of d.c. resistivity, dielectric loss and Loss factor, The Partial Discharge-internal & external, Equivalent Circuit. | 7Hrs |
| Unit 6 | High voltage testing of Electrical Equipment:<br>Testing of insulators and bushings, testing of isolators and circuit breakers Testing of cables, testing of transformers - testing of surge diverters | 6Hrs |

| **Text Books:** | | | |
|---|---|---|---|
| **Sr. No** | **Title** | **Author** | **Publisher** |
| 01 | High Voltage Engineering | M.S.Naidu and V. Kamaraju | TMH Publications |

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| Reference Books: | | | |
|---|---|---|---|
| **Sr. No** | **Title** | **Author** | **Publisher** |
| 1 | High Voltage Engineering:. Fundamentals: E.Kuffel | E.Kuffel, W.S.Zaengl, J.Kuffel | Elsevier |
| 2 | High Voltage Engineering | C.L.Wadhwa | New Age Internationals (P) Limited |
| 3 | High Voltage Insulation Engineering | Ravindra Arora Wolfgang Mosch | New Age International (P) Limited |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech, Sem. – II |
| **Course Code and Course Title** | 0EEPS509, **Power System Operation and Deregulation** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 3/1 |
| **Credits** | 4 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To apply generation dispatch is optimally. |
| 02 | To apply power flows optimally to run the system without violating constraints. |
| 03 | To propose restructuring of power system. |
| 04 | To apply forecasting methods to operate the system. |
| 05 | To apply unit commitment method to run power system economic manner. |
| 06 | To propose the different problem management method in deregulated electricity market. |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS509_1 | Apply generation dispatch economically in power system. ($3^{rd}$ cognitive level) |
| 0EEPS509_2 | Apply power flows optimum manner. ($3^{rd}$ cognitive level) |
| 0EEPS509_3 | Propose the deregulated power system and different electricity markets. ($3^{rd}$ cognitive level) |
| 0EEPS509_4 | Apply forecasting methods to estimate load and price. ($5^{th}$ cognitive level) |
| 0EEPS509_5 | Apply unit commitment methods to operate power system economically.($3^{rd}$ cognitive level) |
| 0EEPS509_6 | Apply various methods congestion management & ancillary service to operate power system in deregulated environment.($3^{rd}$ cognitive level) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Economic operation of power system:** Introduction, Generator operating cost, performance curves, economic dispatch neglecting loss, economic dispatch including generator limits, losses, B matrix loss formula, calculating penalty factors, | **07 Hrs.** |
| **Unit 2** | **Optimal power flow:** Introduction, solution of optimal power flow, linear sensitivity analysis, and security constrained optimal power flow. | **06 Hrs.** |
| **Unit 3** | **Restructured power systems:** Deregulation: Concepts and evaluation, need for deregulation, Competition and direct access to market, Independent system | **07 Hrs.** |

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| | | |
|---|---|---|
| | operator(ISO), study of deregulation from UK, Norway, New Zealand, whole sale electricity market | |
| **Unit 4** | **Short time load & Price forecasting:** Load forecasting introduction, time series data, simple forecast using mean, short time load forecasting by ANN, transmission pricing in open access, price forecasting, | **07 Hrs.** |
| **Unit 5** | **Unit commitment:** Unit commitment, constraints in unit commitment, unit commitment solution methods, and price based unit commitments, security constraint base unit commitment. | **06 Hrs.** |
| **Unit 6** | **Congestion management & Ancillary services:** Introduction to congestion management, cost allocation methods, LMP, FTR and zonal congestion management, general description of ancillary services, ancillary service management, Electricity Bill 2003 and its impact on ESI in India | **07 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Power system operation & control | K. Uma rao | Wiley India |
| 02 | Power generation, operation & control | Allen J Wood, Bruce F. Wollenberg | Wiley India |
| 03 | Power system Restructuring & deregulation | LOI LEI LAI | John Wiley & Sons |
| 04 | Power system Forecasting, Scheduling and risk management | MahammadShahidepour, HatimYamin, Zuyi Li | IEEE & Wiley |
| 05 | Operation of the restructured power system | KankarBattacharya, Math H J Bollen, Jaap E Daalder | Springer Science |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Operation & Control in power system | P S R Murty | BS Publication |
| 02 | Electrical Power Generation, Transmission & Distribution | S N Singh | PHI learning PVT LTD |
| 03 | Understanding Electrical Utilities & Deregulation | LorrinPhillipson, H Lee Willis | Taylor & Francis |

29/7/17

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech. Sem.-II |
| **Course Code and Course Title** | 0EEPS510, **Electrical Power Quality and Harmonics** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 03/01 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To get familiar with power quality issues. |
| 02 | To gain knowledge of harmonics and their sources |
| 03 | To suppress harmonics through active and passive filters. |
| 04 | To mitigate voltage sags and interruptions. |
| 05 | To learn harmonic measurement and power quality monitoring techniques. |
| 06 | To learn harmonic limits set by different regional bodies. |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS510_1 | Describe different power quality related issues, causes and their effects on power system equipment. (Level 2). |
| 0EEPS510_2 | Classify the harmonic in three phase and single phase circuit. (Level 4). |
| 0EEPS510_3 | Design the filter for suppression of current harmonics. (Level 6). |
| 0EEPS510_4 | Distinguish the different methods for mitigation of voltage sags and interruptions. (Level 4). |
| 0EEPS510_5 | Evaluate the different power quality monitoring techniques. (Level 5). |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Introduction to power quality:** What is power quality, power quality related issues in distribution system, loads and their characteristics, electromagnetic phenomena, power quality evaluation procedure, | **06 Hrs.** |
| **Unit 2** | **Voltage sag, interruptions and mitigation:** End user issues, ups system, Ferro-resonant transformers, super conducting storage devices, dynamic voltage restorer and application of DSTATCOM. | **08 Hrs.** |
| **Unit 3** | **Wiring and grounding:** Reasons for grounding, typical wiring and grounding problem, solution to wiring and grounding problem. | **07 Hrs.** |
| **Unit 4** | **Power quality monitoring:** | **07 Hrs.** |

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| | | |
|---|---|---|
| | Monitoring considerations, power quality measurement equipment, and assessment of power quality, power quality monitoring and standard. | |
| **Unit 5** | **Fundamentals of harmonics:** Sources of harmonics, effect of harmonics, types and characterization, THDs, influence on power factor, interference with communication network, harmonic indices, and synthesis of harmonic waveform originating from non-linear loads with the help of Fourier analysis. Power definitions and components-single phase circuits and three phase circuits. | **06 Hrs.** |
| **Unit 6** | **Harmonic suppression filters:** Shunt passive filters, design considerations case studies, voltage/ current source active filters- types: shunt, series and hybrid types, comparison. | **08 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Electrical Power System Quality | Roger C. Dugan, Mark F. McGranaghan, Surya Snatoso, H. Wayne Beaty | Tata McGraw -Hill |
| 02 | Electrical Power System Quality | J. Arnillaga , D A Bradey& P S Bodger | John Wiley Sons |
| 03 | Power System Harmonics | George J. Wakileh | Springer |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Uninterrupted Power Supplies and Active filters | Ali Emadi, AbdolhorienNasiri & Stoyon B Bekiarov | CRC Press |

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**Course Details:**

| | |
|---|---|
| **Class** | M.Tech, Sem. II |
| **Course Code and Course Title** | 0EEPS511, **Supervisory Control and Data Acquisition & Automation** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 3/01 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To impart knowledge on Process automation |
| 02 | To create expertise in the field of process automation using PLC, DCS and SCADA. Program Outcomes |
| 03 | To understand the generic architecture and constituent components of a Programmable Logic Controller. |
| 04 | To develop architecture of SCADA explaining each unit in detail. |
| 05 | To develop a software program using modern engineering tools and technique for SCADA. |
| 06 | To apply knowledge gained about PLCs and SCADA systems to identify few real-life industrial applications. |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS511_1 | Select the appropriate controller for a particular application(Cognitive Level 6) |
| 0EEPS511_2 | Develop and explain the working of PLC with the help of a block diagram. (Cognitive Level 2) |
| 0EEPS511_3 | Designing various controllers used in the industries. (Cognitive Level 6 ) |
| 0EEPS511_4 | Develop architecture of SCADA and explain the importance of SCADA in critical infrastructure. (Cognitive Level 4) |
| 0EEPS511_5 | Execute, debug and test the programs developed for digital and analog operations. (Cognitive Level 5) |
| 0EEPS511_6 | Reproduce block diagram representation on industrial applications using PLC and SCADA. (Cognitive Level 6) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Automation Fundamentals** Automation and its importance, automation applications, expectations of automation. Types of plant and control – categories in industry, open loop and close loop control functions, continuous processes, discrete processes, and mixed processes. Automation hierarchy – large control system hierarchy, data quantity & quality and hierarchical control. Control system architecture – evolution and current trends, comparison of different architectures. | **05 Hrs.** |
| **Unit 2** | **Programmable Logic Controller** Hardware Evolution of PLC, | **08 Hrs.** |

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|---|---|---|
| | Definition, functions of PLC, Advantages, Architecture, working of PLC, Scan time, Types & Specifications. DI-DO-AI-AO examples and ratings, I/O modules, local and remote I/O expansion, special purpose modules, wiring diagrams of different I/O modules, communication modules, Memory & addressing memory organization (system memory and application memory), I/O addressing, hardware to software interface. Software- Development of Relay Logic Ladder Diagram, introduction to PLC Programming, programming devices, IEC standard PLC programming languages, LD programming- basic LD instructions, PLC Timers and Counters: Types and examples, data transfer & program control instructions, advanced PLC instructions, PID Control using PLC | |
| **Unit 3** | **Applications of PLC**<br>**PLC interface to various circuits :** Encoders, transducer and advanced sensors (Thermal, Optical, Magnetic, Electromechanical, Flow, Level sensors) Measurement of temperature, flow, pressure, force, displacement, speed, level .Developing a ladder logic for Sequencing of motors, Tank level control, ON OFF temperature control, elevator, bottle filling plant, car parking<br>**Motors Controls**: AC Motor starter, AC motor overload protection, DC motor controller, Variable speed (Variable Frequency) AC motor Drive. | **07 Hrs.** |
| **Unit 4** | **Distributed Control System**<br>Introduction to DCS – Evolution of DCS, DCS flow sheet symbols, architecture of DCS – controller, Input and output modules, communication module, data highway, local I/O bus, workstations, specifications of DCS. Introduction to Hierarchical Control and memory: Task listing, Higher & Lower Computer level tasks. Supervisory computer tasks and DCS configuration –Supervisory Computer functions, Control techniques, Supervisory Control Algorithm, DCS & Supervisory Computer displays, advanced control Strategies, Computer interface with DCS. DCS – system integration with PLCs and computer: Man machine interface- sequencing, supervisory control, and integration with PLC, personal computers and direct I/O, serial linkages, network linkages, links between networks. | **09Hrs.** |
| **Unit 5** | **SCADA System**<br>Introduction, definitions and history of Supervisory Control and Data Acquisition, typical SCADA system Architecture, Communication requirements, Desirable Properties of SCADA system, features, advantages, disadvantages and applications of SCADA. SCADA Architectures (First generation - Monolithic, Second generation - Distributed, Third generation – Networked Architecture), SCADA systems in operation and control of interconnected power system, Power System Automation (Automatic substation control and power distribution ), Petroleum Refining Process, Water Purification System, Chemical Plant. | **09 Hrs.** |

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|---|---|---|
| **Unit 6** | **SCADA Protocols**<br>Open systems interconnection (OSI) Model, TCP/IP protocol, DNP3 protocol, IEC61850 layered architecture, Control and Information Protocol (CIP), Device Net, Control Net, Ether Net/IP, Flexible Function Block process (FFB), Process Field bus (Profibus). Interfacing of SCADA with PLC. | **04 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Introduction to Programmable Logic Controllers | Gary Dunning | Thomson |
| 02 | Programmable Logic Controllers Programming Methods and Applications | John R. Hackworth | PHI Publishers |
| 03 | Programmable Logic Controllers: Principles and Application", PHI Learning, New Delhi | John W. Webb, Ronald A. Reis | -- |
| 04 | Securing SCADA System | Ronald L. Krutz | Wiley Publications |
| 05 | SCADA supervisory control and data acquisition | Stuart A Boyer | ISA |
| 06 | Switchgear and Protections | Sunil S. Rao | -- |
| 07 | Programmable Controllers Theory and Implementation | L.A. Bryan, E. A. Bryan | Industrial Text Company Publication |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Programmable Controllers | Batten G. L | McGraw Hill Inc |
| 02 | Real Time Computer Control | Bennett Stuart | Prentice Hall |
| 03 | Measurement Systems | Doebelin E. O. | McGraw-Hill International Editions |
| 04 | Practical Modern SCADA Protocols | Gordan Clark, Deem Reynders | ELSEVIER |
| 05 | Computer Based Industrial Control | Krishna Kant | PHI |
| 06 | Computer Control of Process | M. Chidambaram | Narosha Publishing |
| 07 | Programmable Logic Controllers with Applications | P. K. Srivstava | BPB Publications |
| 08 | Distributed Computer Control for Industrial Automation | Poppovik, Bhatkar | Dekkar Publications |
| 09 | Computer Aided Process Control | S. K. Singh, | PHI |

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**Course Details:**

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|---|---|
| **Class** | M. Tech, Sem. – II |
| **Course Code and Course Title** | 0EEPS512, **Real Time Control of Power Systems** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 3/1 |
| **Credits** | 4 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To introduce real time systems to monitor power system. |
| 02 | To propose generation control to maintain frequency. |
| 03 | To propose optimal control method to select hydro & thermal plant. |
| 04 | To apply reactive control methods to maintain voltage. |
| 05 | To propose state estimation application to power system. |
| 06 | To introduce SCADA. |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS512_1 | Apply analytical methods to process data and monitor system. ($3^{rd}$ cognitive level) |
| 0EEPS512_2 | Design and apply automatic generation control to maintain frequency. ($5^{th}$ cognitive level) |
| 0EEPS512_3 | Schedule hydro thermal generation optimally using different control methods. ($3^{rd}$cognitive level) |
| 0EEPS512_4 | Design various reactive control methods to maintain voltage within limits. ($5^{th}$ cognitive level) |
| 0EEPS512_5 | Apply state estimation techniques to power system.($3^{rd}$ cognitive level) |
| 0EEPS512_6 | Describe SCADA for power system application.($3^{rd}$ cognitive level) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Analytical Methods:** Modeling and identification of power system components, real time data processing, real time monitoring using phasor measurement | **06 Hrs.** |
| **Unit 2** | **Automatic generation (Load frequency) control:** Objectives, tie line bias control, flat frequency control, supplementary control, interconnected areas, two area, three area systems, state variable model for single, two and three area cross coupling between control loops, AVG , AVR, Application of modern control theory, application of artificial intelligence, AGC using Kalman methods. | **07 Hrs.** |
| **Unit 3** | **Optimal control of Hydro – thermalGeneration:** Generation mix, optimum economic dispatch, optimum generation allocation solution techniques for optimum power flow such as gradient | **07 Hrs.** |

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|---|---|---|
| | Newton's linear programming, nonlinear programming methods such as Dommeltinney, EL Abiad- James. Dynamic programming methods fuel scheduling using linear programming. Hydro thermal scheduling short range and long range dynamic programming, scheduling problems Kirchmayers method of coordinate equation. | |
| **Unit 4** | **Reactive power control:**<br>Need for adjustable reactive power, excitation control, tap changing transformers, fundamental concept of series and dynamic shunt compensation, principles of static compensator and applications automatic power factor controlling schemes. | **07 Hrs.** |
| **Unit 5** | **State estimation:**<br>Power system state estimation least square estimation of A.C networks, estimation by orthogonal decomposition, and application of state estimation to power systems. | **06 Hrs.** |
| **Unit 6** | **SCADA and DAS:**<br>Power system security, contingency analysis energy control, centralized and decentralized control, SCADA systems, and recent trends on real time operations. Substation automation, remote metering, energy audit reconfiguration of distribution networks under normal conditions for loss minimization and restoration of distribution systems | **07Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Real time control of electric power system | E. Handschiw | IEEE Press |
| 02 | Recent trends in electric energy system | J.Nanda and D.P.Kothari | S Chand |
| 03 | Computer aided system analysis and control | Mahalanable Kothari | S Chand |
| 04 | Power operation and control | P.S.R.Murthy | BS Publication |
| 05 | Electric energy systems theory an introduction | Olle .I.Elgerd | Tata Hill |
| 06 | Power generation operation and control | Wood, Wollenberg | Wiley India |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Reactive power control of electric power system | J.E.Miller | -- |
| 02 | Electric power distribution | A.S.Pable | Tata Hill |
| 03 | Automatic electric utility | G.A.Gnadt and | -- |

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| Reference Books: | | | |
|---|---|---|---|
| **Sr. No** | **Title** | **Author** | **Publisher** |
| | distribution systems | J.S.Lawler | |
| 04 | Power system operation & control | K. Uma rao | Wiley India |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech. (Electrical Power System) Sem.-II |
| **Course Code and Course Title** | 0EEPS513, **Flexible AC Transmission and High Voltage DC System** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 03/01 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To introduce what is reactive power and what are the FACTS devices. |
| 02 | To Describe and compare Shunt and Series FACTS Devices |
| 03 | To evaluate the performance of various control schemes of combined shunt and series compensators. |
| 04 | To Understand the concepts of High Voltage Direct Current Systems |
| 05 | To analyze voltage & current characteristics for different converters and correlate with actual HVDC systems. |
| 06 | Calculate Reactive Power Requirement of HVDC Converter |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS513_1 | Compare all FACTS devices (Level 4) |
| 0EEPS513_2 | Apply the control schemes for series and shunt compensating devices (Level 3) |
| 0EEPS513_3 | Analyze the performance of various control schemes of combined shunt and series compensators. (Level 4) |
| 0EEPS513_4 | Evaluate performance of TCVR, TCPAR(Level 5) |
| 0EEPS513_5 | Analyze the working principles and constructions of HVDC Converters, Filters, Protection etc. (Level 4) |
| 0EEPS513_6 | Analyze voltage & current characteristics for different converters and correlate with actual HVDC systems. (Level 4) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **FACTS Concept and General, System Considerations:** Transmission Interconnections, What Limits the Loading Capability, Power flow in AC Systems, Basic Types of FACTS Controllers, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Benefits from FACTS Technology, Compare HVDC and FACTS | **06 Hrs.** |
| **Unit 2** | **Static Shunt and Series Compensators:** Objectives of Shunt Compensation, Operation & Control Scheme of TSC, & TCR, FC-TCR, TSC-TCR, STATCOM, Objectives of Series | **09 Hrs.** |

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|---|---|---|
| | Compensation, GCSC, TSSC, TCSC, Static Synchronous Series Compensator (SSSC) | |
| **Unit 3** | **Combined Compensator:**<br>TBSC, TBSR, TBSC-TBSR, UPFC and IPFC. Their advantages and disadvantages. | **06 Hrs.** |
| **Unit 4** | **General Background of HVDC and MTDC System:**<br>General aspects HVDC Transmission, Constitution of EHVAC and DC links, Kinds of DC links, HVDC projects in India and abroad, limitations and advantages of HVDC transmission over EHVAC, Layout of HVDC station. Types of MTDC Systems, Reversal of Power in MTDC System, Comparison between MTDC and AC Interconnections. | **07 Hrs.** |
| **Unit 5** | **Grid Control and Characteristics:**<br>Grid control of thyristor, valve-Analysis with grid control with no overlap, overlap less than 60 degrees and overlap greater than 60 degrees. Basic means of control, Power reversal, manual control and its limitations-constant current versus constant voltage Control, desired features of control, actual control characteristics-constant minimum ignition angle, current and extinction angle controls –power control and current limits. | **06 Hrs.** |
| **Unit 6** | **Protection:**<br>Disoperation of converters-short circuit on a rectifier commutation failure, causes and remedies, Protection of HVDC system, d.c. rectors, Over current protection and over-voltage protection, fault clearing and reenergizing the line. | **08 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Understanding FACTS | Narain G. Hingorani | IEEE Press |
| 02 | EHVAC and HVDC Transmission Engineering and Practice | S. Rao | Khanna publication |
| 03 | HVDC power transmission systems | K R Padiyar | New Age International (p)Ltd |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | Direct Current Transmission | Edward Wilson Kimbark | Wiley publication Inter science |

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**Research Papers:**

1. Maffrand, J. W. Dixon, and L. Morán, ***"Binary controlled, static VAR compensator, based on electronically switched capacitors,"*** in Proc. IEEE PESC'98, pp.1392–1396, 1998.
2. J. W. Dixon, Y. Del Valle, M. orchard, M. Ortizar, L. Moran and C. Maffrand, **"A full compensating system for general loads based on a combination of thyristor binary compensator and a PWM-IGBT active power filter"**, IEEE Trans. Ind. Electron., Vol. 50, No. 5, pp982-989, Oct. 2003.
3. Swapnil D. Patil, Anwar M. Mulla, U. Gudaru, D. R. Patil, *Member IAENG*. **"An Innovative Transient Free TBSC Compensator with Closed Loop Control for Fast Varying Dynamic Load"**, Proceedings of WCECS 2014, Vol I 23-25 October, 2014, San Francisco, USA.
4. S. R. Lokhande, Swapnil D. Patil, Anwar M. Mulla and D. R. Patil, **"Introduction to FC-TBSR Based SVC for Voltage Regulation and Reactive Power Compensation"**, IJEEE Volume 8 Issue 01 Jan.-June 2016, pp. 963-968.

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech. (Electrical Power System) Sem.-II |
| **Course Code and Course Title** | 0EEPS514,**Optimization Techniques** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial** | 03/01 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | Student must be Understand the Introduction optimization theory |
| 02 | Student must be Apply Linear Programming problem theory |
| 03 | Student must be Apply theory to nonlinear programming |
| 04 | Student must be Constrained optimization |
| 05 | Student must be Create System Modeling |
| 06 | Student must be Apply Conventional tools for linear system modeling |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS514_1 | Understand the Introduction optimization theory. (Level 2) |
| 0EEPS514_2 | Apply Linear Programming problem theory. (Level 3) |
| 0EEPS514_3 | Apply theory to nonlinear programming. (Level 3) |
| 0EEPS514_4 | Evaluate the Constrained optimization. (Level 5) |
| 0EEPS514_5 | Design System Modeling. (Level 6) |
| 0EEPS514_6 | Apply Conventional tools for linear system modeling. (Level 3) |

| **Course Contents:** | | |
|---|---|---|
| **Unit 1** | **Optimization Theory:** Introduction to optimization theory, Importance in solving system engineering problems, Convex sets & Functions; affine and convex sets, supporting and separating hyper planes, dual cones and generalized inequalities. | **06 Hrs.** |
| **Unit 2** | **Linear Programming problem:** Formulation, Simplex Method, Dual Simplex method, sensitivity analysis, duality in programming, transportation and assignment problems, traveling salesman problem. | **07 Hrs.** |
| **Unit 3** | **Introduction to nonlinear programming;** Unconstrained Optimization-formulation of quadratic optimization problems, Kuhn–Tucker conditions, gradient descent and steepest descent methods, Newton's method, self-concordance. | **08 Hrs.** |
| **Unit 4** | **Constrained optimization:** Direct optimization, Cutting plane methods, methods of feasible direction, analytic center cutting plane methods. | **08 Hrs.** |

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|---|---|---|
| | Multi-objective optimization, Application to approximation and filling problems, Dynamic Programming. | |
| **Unit 5** | **System Modeling:** Introduction, types of modeling, modeling of time-varying, distributed, stochastic, nonlinear, discrete event and hybrid systems. | **06 Hrs.** |
| **Unit 6** | **Conventional tools for linear system modeling:** Introduction to non-conventional modeling tools, Neural models, fuzzy models, Model simulation languages and tools. | **07 Hrs.** |

**Text Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 1 | Optimization theory and applications | S S Rao | Wiley Eastern Ltd. |
| 2 | Optimization methods | K V Mittal | Wiley Eastern Ltd. |
| 3 | Interactive Dynamic System Simulation | Korn G.A | McGraw Hill, N.Y. |
| 4 | Introduction to Optimization | J.C. Pant | Jain Brothers |

**Reference Books:**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 1 | System modeling and computer simulation | NA Kheir | Marcel Decker, New York |

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**Course Details:**

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|---|---|
| **Class** | M. Tech, Sem.-II |
| **Course Code and Course Title** | 0EEPS515, **Power Systems transient Analysis** |
| **Prerequisite/s** | ----- |
| **Teaching Scheme: Lecture/Tutorial** | 3/1 |
| **Credits** | 04 |
| **Evaluation Scheme: ISE / MSE / ESE** | 20/30/50 |

| **Course Objectives:** | |
|---|---|
| 01 | To study the generation of switching transients and their control using circuit – theoretical concept. |
| 02 | To study the mechanism of lighting strokes and the production of lighting surges. |
| 03 | To study the propagation, reflection and refraction of travelling waves. |
| 04 | To study the impact of voltage transients caused by faults, circuit breaker action, load rejection on integrated power system. |
| 05 | To understand the transient causes and effect of transients on power systems |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS515_1 | Explain the propagation, reflection and refraction of travelling waves. (Level 2) |
| 0EEPS515_2 | Describe the causes of transients. (Level 2) |
| 0EEPS515_3 | Analyze the impact of voltage transients caused by faults, circuit breaker action, and load rejection on integrated power system. (Level 4) |
| 0EEPS515_4 | Analyze the switching and lightning transients. (Level 4) |
| 0EEPS515_5 | Evaluate the transient response of systems. (Level 5) |
| 0EEPS515_6 | Compare mechanism of lightning discharges and characteristics of lightning strokes. (Level 4) |

| **Course Contents:** | | |
|---|---|---|
| Unit 1 | **Introduction And Survey:** Source of transients, various types of power systems transients, effect of transients on power systems, importance of study of transients in planning. | 05 Hrs. |
| Unit 2 | **Transient and Types:** RL circuit transient with sine wave excitation - double frequency transients – basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems – role of the study of transients in system planning. | 07 Hrs. |
| Unit 3 | **Switching Transients:** Over voltages due to switching transients - resistance switching and the equivalent circuit for interrupting the resistor current - load switching and | 09 Hrs. |

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|---|---|---|
| | equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit. Capacitance switching - effect of source regulation - capacitance switching with a restrike, with multiple restrikes. Illustration for multiple re-striking transients – Ferro resonance. | |
| Unit 4 | **Lightning Transients:** Review of the theories in the formation of clouds and charge formation - rate of charging of thunder clouds – mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design – protection using ground wires - tower footing resistance - Interaction between lightning and power system. | 07 Hrs. |
| Unit 5 | **Traveling Waves On Transmission Line Computation Of Transients:** Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves. | 07 Hrs. |
| Unit 6 | **Transients In Integrated Power System:** The short line and kilometric fault - distribution of voltages in a power system – Line dropping and load rejection - voltage transients on closing and reclosing lines – over voltage induced by faults - switching surges on integrated system. Qualitative application of EMTP for transient computation. | 07 Hrs. |

Reference Books:

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 01 | 'Electrical Transients in Power Systems' | Allan Greenwood | Wiley Interscience New York |
| 02 | 'Extra High Voltage AC Transmission Engineering' | R.D.Begamudre | Wiley Eastern Limited |
| 03 | 'High Voltage Engineering' | M.S.Naidu and V.Kamaraju | Tata McGraw Hill |

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**Course Details**

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|---|---|
| **Class** | M. Tech, Sem.-II |
| **Course Code and Course Title** | 0EEPS516,**Research Methodology** |
| **Prerequisite/s** | -- |
| **Teaching Scheme: Lecture/Tutorial** | 2/0 |
| **Credits** | -- |
| **Evaluation Scheme:** | GRADE |

| **Course Objectives:** The course aims to | |
|---|---|
| 1 | Provide depth knowledge of research methods and ethics, from design to data analysis and report writing. |

| **Course Outcomes (COs)** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS516_1 | Define research, explain and apply research terms, describe the research process and the principle activities, skills and ethics associated with the research process. **(2nd cognitive level)** |
| 0EEPS516_2 | Explain the relationship between theory and research. **(2nd cognitive level)** |
| 0EEPS516_3 | Describe and compare the major quantitative and qualitative research method. **(2nd cognitive level)** |
| 0EEPS516_4 | Propose a research study and justify the theory as well as methodological decisions including sampling and measurement. **(5th cognitive level)** |
| 0EEPS516_5 | Summarize the importance of research ethics and integrate it into research process. **(2nd cognitive level)** |
| 0EEPS516_6 | Construct an effective research proposal that will serve as the launching point for the further study. **(6th cognitive level)** |

| **Course Contents** | | |
|---|---|---|
| **Unit 1** | **Research methodology an Introduction:** Meaning ,objectives and motivation of research , Types of research , research approaches , significance of research , research methods vs. methodology , research and scientific methods ,Importance of knowing how research is done , Research process , Criteria of good research , Problem encountered by researchers in India | **04 Hrs.** |
| **Unit 2** | **Defining the research problem and research design** Selecting the problem, Techniques involved in defining the problem , meaning and need of research design , features of good design , important concepts relating to research design , different research designs , Basic concepts of experimental designs | **03 Hrs.** |
| **Unit 3** | **Sampling design :** Census and sample survey , Implications of sample design , Steps in sampling design ,Criteria of selecting sampling procedure ,Characteristics of good sample design ,Different types of sample designs, Random sample | **03Hrs.** |

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| | | |
|---|---|---|
| | from an infinite universe , Complex random sampling designs | |
| **Unit 4** | **Measurement and scaling techniques:** Measurement in research , measurement scales , Sources of error in measurement ,Tests of sound measurement , Technique of developing measurement Tools , scaling, meaning of scaling ,sale classification bases , Important scaling Techniques , scale construction Techniques | **02 Hrs.** |
| **Unit 5** | **Sampling fundamentals:** Need of sampling , Important sampling distribution, central limit theorem ,sampling theory , Sandler's A-Test ,Concept of standard error ,Estimation , Estimating the population mean , Estimating Population Proportion , Sample Size and its Determination , Determination of Sample Size through the Approach Based on Precision Rate and Confidence Level, Determination of Sample Size through the Approach Based on Bayesian Statistics | **03 Hrs.** |
| **Unit 6** | **Testing of Hypothesis-I and II:** Basic concept of Testing of Hypotheses , Procedure for hypothesis testing , measuring the power of hypothesis test ,Flow diagram of hypothesis testing ,Important parametric tests , Hypothesis testing of means , Testing the Equality of Variances of Two Normal Populations , Hypothesis Testing of Correlation Coefficients , Limitations of the Tests of Hypotheses, Hypothesis –II , Important Nonparametric or Distribution-free Test ,Relationship between Spearman's r's and Kendall's, Characteristics of Distribution-free or Non-parametric Tests | **05 Hrs.** |
| **Unit 7** | **Interpretation and report writing:** Meaning of interpretation, Why Interpretation?, Techniques of interpretation , Precaution in interpretation , Significance of report writing , Different steps in writing report ,Layout of research report ,Types of reports ,Oral presentation ,Mechanism of writing research report , Precaution for writing research reports | **02 Hrs.** |
| **Unit 8** | **Introduction to LaTex:** Understanding Latex compilation, Basic Syntax, Writing equations, Page Layout. | **02 Hrs.** |

**Text Books**

| Sr. No. | Title | Author | Publisher |
|---|---|---|---|
| 1 | Research Methodology: Methods and Techniques | C. R. Kothari | New Age International |
| 2 | Research Methodology concepts and cases | Deepak Chawla Neena Sondhi | Vikas |

**Reference Books**

| Sr. No | Title | Author | Publisher |
|---|---|---|---|
| 1 | Research Methodology | Panneerselvam R | PHI |

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Annasaheb Dange College of Engineering and Technology, Ashta

**Department of Electrical Engineering**

**M. Tech. (Electrical Power System)**

**Course Details:**

| | |
|---|---|
| **Class** | M. Tech, Sem.-II |
| **Course Code and Course Title** | 0EEPS553, **Power System Lab-II** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial/Practical** | 0/0/2 |
| **Credits** | 01 |
| **Evaluation Scheme: ISE / ESE** | 50/50 |

| **Course Educational Objectives(CEOs):** The course aims to: | |
|---|---|
| 01 | To demonstrate and design modeling of converters |
| 02 | To study and analyze HVDC converter Characteristic |
| 03 | To analyze the Modeling & Simulation of Three Phase Harmonic Filters |
| 04 | To Design simulation models for circuit breakers, surge arrestors, Filter |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS553_1 | Design Simulation Model of converter using MATLAB (Level 6) |
| 0EEPS553_2 | Design simulation model of HVDC system using MATLAB (Level 6) |
| 0EEPS553_3 | Analyze the Harmonic and transient performance of HVDC transmission system (Level 4) |
| 0EEPS553_4 | Analyze and Design the simulation model of Circuit Breaker and surge arresters for HVDC System (Level 4 & 6) |
| 0EEPS553_5 | Design and analyze simulation model of free switching Binary Current generation of TBSC & TBSR(Level 6) |

**List of Experiments:**

| Sr. No | Title of Experiments |
|---|---|
| 1. | To analyze ideal switch of inductor current chopping |
| 2. | Design transient free switching of capacitor |
| 3. | Design transient free switching of inductor |
| 4. | Design and Analyze Binary Current Generation of TBSC & TBSR |
| 5. | Modeling & Simulation of Two Identical Single-Phase Rectifiers. |
| 6. | Modeling & Simulation of Three-phase diode rectifier. |
| 7. | Design Simulation model of 3 phase SPWM and ISPWM Inverter. |
| 8. | Design Simulation of 6 and 12 pulse 3 phase HVDC system. |
| 9. | Steady-state and transient performance of a 12-pulse, 1000 MW (500 kV-2kA) 50/60 Hz HVDC transmission system. |
| 10. | Study and Simulation of Circuit Breaker and surge arresters. |
| 11. | Analyze VSC-Based HVDC Transmission Link. |
| 12. | Modeling & Simulation of Three-Phase Harmonic Filters used on a 12-pulse AC/DC Converter. |

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| | |
|---|---|
| 13. | Harmonic analysis on sinusoidal waveform and working of sinusoidal PWM inverter. |
| 14. | Study and simulation of 6 pulse HVDC system & observe Vd-Id characteristics. |
| 15. | Hardware Design using Ardiuno |

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**Course Details:**

| | |
|---|---|
| **Class** | M. Tech, Sem.-II |
| **Course Code and Course Title** | 0EEPS554, **High Voltage Engineering** |
| **Prerequisite/s** | --- |
| **Teaching Scheme: Lecture/Tutorial/Practical** | 0/0/2 |
| **Credits** | 1 |
| **Evaluation Scheme: ISE/ESE** | 50/00 |

| **Course Educational Objectives(CEOs):** The course aims to: | |
|---|---|
| 01 | Get familiar with measurement of insulation of dielectric materials |
| 02 | Understand construction and working of impulse generator |
| 03 | Understand field mapping using electrolyte tank |
| 04 | Measure capacitance of cables |

| **Course Outcomes (COs):** Upon successful completion of this course, the student will be able to: | |
|---|---|
| 0EEPS554_1 | Demonstrate electrical breakdown voltage of transformer oil (Cognitive Level 3) |
| 0EEPS554_2 | Illustrate generation and measurement of high voltage and current (Cognitive Level 3) |
| 0EEPS554_3 | Analyze insulation strength of any dielectric material, Cables (Cognitive Level 4) |
| 0EEPS554_4 | Demonstrate field mapping using Electrolyte Tank (Cognitive Level 3) |
| 0EEPS554_5 | Calculate Capacitance of cables (Cognitive Level 3) |

**List of Experiments:**
Minimum 8 Experiments to be performed

| Sr. No | Title of Experiments |
|---|---|
| 1 | To determine breakdown voltage of transformer oil |
| 2 | To study 5 KV AC Insulation Test |
| 3 | To study 5 stage 150 KV and 225J impulse generator and to measure wave shape (front time, tail time and peak voltage)of impulse wave |
| 4 | Measurement of breakdown voltage (for AC and DC) of air, using sphere gap assembly |
| 5 | Field mapping using electrolyte tank |
| 6 | Capacitance Measurement of Cables |
| 7 | Measurement of Dielectric properties with Schering Bridge |
| 8 | Partial Discharge Measurements of Transformer windings and Cables |
| 9 | Insulation Testing of Cables, wires |
| 10 | Application of High Voltage in Domestic level- Demonstration of working of |

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| | |
|---|---|
| | Mosquito Rackets, Electric gas Lighters, High Voltage Stun gun, microwave ovens. Electronic Pulse igniter, CRT devices. |
| 11 | A report on visit to high voltage laboratory |

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