PROGRESSIVE EDUCATION SOCIETY'S

# MODERN COLLEGE OF ENGINEERING

1186A, SHIVAJINAGAR, OFF J.M, PUNE-411005

**(AFFILIATED TO SAVITRIBAI PHULE PUNE UNIVERSIT, PUNE)**

## DEPARTMENT OF ELECTRICAL ENGINEERING

# E-CURRICULUM BOOKLET

**ACADEMIC YEAR: 2019-20**

**FOR THE PROGRAMME**

## TE – ELECTRICAL ENGINEERING

**(SEMISTER-II)**

## QUALITY POLICY OF THE INSTITUTE

**We, PES Modern College of Engineering are committed to develop and foster cultured and promising professionals by imparting quality education in the field of Engineering and Management.**

## VISION OF THE INSTITUTION

**To create a collaborative academic environment to foster professional excellence and ethical values**

## MISSION OF THE INSTITUTE

1. **To develop outstanding engineers & professionals with high ethical standards capable of creating and managing global enterprises.**
2. **To foster innovation and research by providing a stimulating learning environment.**
3. **To ensure equitable development of students of all ability levels and backgrounds.**
4. **To be responsive to changes in technology, socio-economic levels and environmental conditions.**
5. **To foster and maintain mutually beneficial partnerships with alumni and industry.**

## QUALITY POLICY OF THE DEPARTMENT

**Electrical Engineering department is committed to develop promising engineers with ethical and social responsibility through excellence in academics, research, skill development and consultancy.**

## VISION OF THE DEPARTMENT

**To build technically competent Electrical Engineers with ethical and social responsibility.**

## MISSION OF THE DEPARTMENT

- **To develop abilities in students for acquiring knowledge and skills to flourish in dynamic technical environment.**
- **To nurture cultured professionals by providing facilities for their overall development.**
- **To motivate the students for research work and activities beneficial to society.**
- **To enhance strong bonding with various organization and alumni.**

## Program Educational Objectives (PEOs)

**Graduates will be able to:**

**PEO 1:** Solve and analyze problems in Electrical Engineering using fundamental knowledge.

**PEO 2:** Adopt lifelong learning ability by acquiring various skills.

**PEO 3:** Practice ethically in their profession.

**PEO 4:** Achieve global competency through interactions with various industries, research and professional organizations.

## PROGRAM OUTCOMES (POs)

**PO1. Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

**PO2. Problem analysis:** Identify, formulate, research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO3. 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.

**PO4. Conduct investigations of complex problems:** The problems that cannot be solved by straight forward application of knowledge, theories and technique applicable to the engineering discipline that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions that require consideration of appropriate constraints/requirements not explicitly given in the problem statement. (Like: cost, power requirement, durability, product life, etc.). Which need to be defined (modeled) within appropriate mathematical framework that often requires use of modern computational concepts and tools.

**PO5. 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.

**PO6. 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.

**PO7. Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**PO8. Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

**PO9. Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO10. 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.

**PO11. Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO12. 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.

## PROGRAM SPECIFIC OUTCOMES:

**PSO 1:** Students will have skill set in Energy Audit, Design of Solar System, and Automation in PLC and SCADA Applications, Microcontroller and analysis for power quality in Power System.

**PSO 2:** Students will be capable of dealing with techno-commercial aspect in Electrical Engineering.

## CORE VALUES

- Excellence in the field of Electrical Engineering.
- Social responsibility with integrity.
- Lifelong Learning.
- Unity in Diversity.

## SHORT TERM GOALS

- To enhance alumni interaction.
- To develop innovation lab to enhance research and entrepreneurship by providing various facilities.

## LONG TERM GOALS

- To promote consultancy activity for revenue generation by developing high-tech standard laboratory.
- To encourage the faculty for research work and up gradation of qualifications.
- To enhance teaching-learning process through ICT.
- To establish competitive entrance exam cell in department.

# INDEX

# Course Structure

**Savitribai Phule Pune University**
**FACULTY OF ENGINEERING**
**T.E. Electrical Engineering (2015 Course)**
**(w.e.f. 2017-2018)**

**SEMESTER-I**

| Sr. No | Subject Code | Subject Title | Teaching Scheme | | | Examination Scheme | | | | | Total Marks | Credit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | PP | | TW | PR | OR | | | |
| | | | Th. | Pr. | Tu. | In Sem | End Sem | | | | | TH/ TU | PR+OR |
| 1 | 311121 | Industrial and Technology Management | 03 | -- | -- | 30 | 70 | -- | -- | -- | 100 | 03 | -- |
| 2 | 303141 | Advance Microcontroller and its Applications | 04 | 02 | -- | 30 | 70 | -- | -- | 50 | 150 | 04 | 01 |
| 3 | 303142 | Electrical Machines II | 04 | 02 | -- | 30 | 70 | -- | 50 | -- | 150 | 04 | 01 |
| 4 | 303143 | Power Electronics | 04 | 02 | -- | 30 | 70 | -- | 50 | -- | 150 | 04 | 01 |
| 5 | 303144 | Electrical Installation, Maintenance and Testing | 03 | 02 | -- | 30 | 70 | 50 | -- | -- | 150 | 03 | 01 |
| 6 | 303145 | Seminar and Technical Communication | -- | 02 | -- | -- | -- | 50 | -- | -- | 50 | -- | 01 |
| | 303152 | Audit Course III | | | | | | | | | | | |
| TOTAL | | | 18 | 10 | -- | 150 | 350 | 100 | 100 | 50 | 750 | 18 | 05 |

**SEMESTER-II**

| Sr. No. | Subject Code | Subject Title | Teaching Scheme | | | Examination Scheme | | | | | Total Marks | Credit | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | PP | | TW | PR | OR | | | |
| | | | Th. | Pr. | Tu | In Sem | End Sem | | | | | TH/ TU | PR+OR |
| 1. | 303146 | Power System II | 04 | 02 | -- | 30 | 70 | -- | 50 | -- | 150 | 04 | 01 |
| 2. | 303147 | Control System I | 04 | 02 | -- | 30 | 70 | - | -- | 50 | 150 | 04 | 01 |
| 3. | 303148 | Utilization of Electrical Energy | 03 | -- | -- | 30 | 70 | -- | -- | -- | 100 | 03 | -- |
| 4. | 303149 | Design of Electrical Machines | 04 | 02 | -- | 30 | 70 | 25 | -- | 50 | 175 | 04 | 01 |
| 5. | 303150 | Energy Audit and Management | 03 | 02 | -- | 30 | 70 | 25 | -- | -- | 125 | 03 | 01 |
| 6. | 303151 | Electrical Workshop | -- | 02 | -- | -- | -- | 50 | -- | -- | 50 | -- | 01 |
| | 303153 | Audit Course IV | | | | | | | | | | | |
| Total | | | 18 | 10 | -- | 150 | 350 | 100 | 50 | 100 | 750 | 18 | 05 |

**Th:** Theory lectures hours/week
**Pr:** Practical hours/week
**Tu:** Tutorial hours/week

**TW:** Term work
**PR:** Theory
**OR:** Oral
**PP:** Paper- In semester and End Semester

# POWER SYSTEMS II
# (303146)

## Name of the Subject –Power Systems II

| Weekly Work Load(in Hrs) | Lecture | Tutorial | Practical |
|---|---|---|---|
| | 04 | - | 02 |

| Online/ In-sem | Theory | Practical | Oral | Term-work | Total Marks | Credit |
|---|---|---|---|---|---|---|
| 30 | 70 | 50 | - | 00 | 150 | |

## Syllabus:

### Unit I: Performance of Transmission Lines. 10Hrs

Evaluation of ABCD constants and equivalent circuit parameters of Long transmission line. Concept of complex power, power flow using generalized constants, receiving end power circle diagram for transmission line (assuming ABCD constants are already given), surge impedance loading, Line efficiency, Regulation and compensation, basic concepts. Numerical based on: ABCD constants of Long transmission line, Power flow, circle diagram

### Unit II: EHV-AC transmission 06Hrs

Role of EHV-AC transmission, standard transmission voltages, average values of line parameters, power handling capacity and line losses, phenomenon of corona, disruptive critical voltages, visual critical voltages, corona loss, factors and conditions affecting corona loss, radio and television interference, reduction of interference, Numerical Based on Corona, Corona loss and power handling capacity.

### Unit IV: Per unit system and Load Flow Analysis. 09Hrs

**Per unit system:** Single line diagram, Impedance and reactance diagrams and their uses, per unit quantities, relationships, selection of base, change of base, reduction to common base, advantages and application of per unit system. Numerical based on network reduction by using per unit system.

**Load Flow Analysis:** Network topology, driving point and transfer admittance, concept of Z-bus and formulation of Y-bus matrix using direct method, singular transformation method, Introduction to load flow analysis, power- flow equations generalization to n bus systems, classification of buses, Newton-Raphson method (using polar coordinates), Gauss- Seidal method. (Descriptive treatment only) Numerical based on Y bus Matrix

### Unit V: Symmetrical Fault Analysis. 08Hrs

3-phase short-circuit analysis of unloaded alternator, sub-transient, transient and steady state current and impedances, D.C. Offset, and effect of the instant of short-circuit on the waveforms, estimation of fault current without pre-fault current for simple power systems, selection of circuit breakers and current

limiting reactors and their location in power system (Descriptive treatment only) Numerical Based on symmetrical fault analysis

**Unit VI : Unsymmetrical Fault Analysis 09Hrs.**

Symmetrical components, transformation matrices, sequence components, power in terms of symmetrical components, sequence impedances of transmission line and zero sequence networks of transformer, solution of unbalances by symmetrical components, L-L, L-G, and L-L-G fault analysis of unloaded alternator and simple power systems with and without fault impedance. Numerical based on symmetrical component and unsymmetrical fault calculation.

**Unit VI: HVDC Transmission** (Descriptive treatment only)**. 06Hrs**

Classification and components of HVDC system, advantages and limitations of HVDC transmission, comparison with HVAC system, introduction to HVDC control methods - constant current, constant ignition angle and constant extinction angle control, recent developments.

**Text Books**

1. I.J. Nagrath and D.P. Kothari – Modern Power System Analysis – Tata McGraw Hill, New Delhi.
2. B R Gupta , "Power System Analysis and Design", S.Chand.
3. Abhijit Chakraborty and Sunita Haldar, "Power System Analysis" PHI, New Delhi.
4. J.B.Gupta. "A course in power systems" S.K. Kataria Publications.
5. P.S.R. Murthy, "Power System Analysis", B.S. Publications.

**Reference Books**

1. H. Hadi Sadat: Power System Analysis, Tata McGraw-Hill New Delhi.
2. G. W. Stagg and El- Abiad – Computer Methods in Power System Analysis – Tata McGraw Hill, New Delhi.
3. M.E.El-Hawary, Electric Power Systems: Design and Analysis, IEEE Press, New York.
4. Rakash Das Begamudre, Extra High voltage A.C. Transmission Engineering, New age publication.
5. M.A.Pai, Computer Techniques in Power System Analysis", Tata McGraw Hill Publication.
6. Stevenson W.D. Elements of Power System Analysis (4th Ed. ) Tata McGraw Hill, New Delhi.
7. K.R.Padiyar: HVDC Transmission Systems, New Age International Publishers Ltd, New Delhi.
8. Olle I. Elgard – Electric Energy Systems Theory – Tata McGraw Hill, New Delhi.
9. NPTEL Web course and video course on power system analysis

**Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:**

**1.** https://www.smartzworld.com/notes/power-system-ii-ps-ii/

**2.** https://books.google.co.in/books/about/Power_System_II.html?id=oOj4NjQ8xGQC

**3.** www.academia.edu/6923342/LECTURE_NOTES_COURSE_POWER_SYSTEMS-II

**4.** www.ee.ntut.edu.tw › Home › Courses › Outline

## Course Objectives:

- To develop analytical ability for Power system subject with prerequisite of power system I
- To introduction of computational methods for solving problems such as load flow
- To discuss in detail techniques and tools for power system analysis with a practical perspective

## Course Outcomes:

After successfully completing the course students will be able to:

CO1. Students will be able to analyze power flow in transmission line its performance and its compensation technique.

CO2. Student will be able to solve problems involving modelling, design and performance evaluation of EHVAC power transmission lines

CO3. Students will be able to apply load flow solutions to various power system network in per unit system by computational technique & software tools.

CO4. Student will be able to examine power system network under symmetrical fault with protection perspective.

CO5. Student will be able to analyze power system network under unsymmetrical fault with protection perspective.

CO6. Students will be able to explain HVDC transmission systems and its control.

PROGRESSIVE EDUCATION SOCIETY'S

# MODERN COLLEGE OF ENGINEERING

## DEPARTMENT OF ELECTRICAL ENGINEERING

## Academic Activity Planner

| Units | Unit Test1 (30 marks) | MCQ (30 Marks) | MCQ (30 Marks) | Unit Test 2 (30 marks) |
|---|---|---|---|---|
| 1 | √ | √ | | |
| 2 | √ | √ | | |
| 3 | √ | √ | | |
| 4 | | | √ | √ |
| 5 | | | √ | √ |
| 6 | | | √ | √ |

# Teaching Plan

**Teaching plan as per University Syllabus**

| Sr.No. | Unit | Broad Topics to be Covered | Total Lecture Planned |
|---|---|---|---|
| 1 | I | Performance of Transmission Lines | 10 |
| 2 | II | EHV-AC transmission | 06 |
| 3 | III | Per unit system and Load Flow Analysis | 09 |
| 4 | IV | Symmetrical Fault Analysis | 08 |
| 5 | V | Unsymmetrical Fault Analysis | 09 |
| 6 | VI | HVDC Transmission (Descriptive treatment only ) | 06 |

## Unit wise Lecture Plan

## Unit No.-I: Performance of Transmission Lines.

**Pre-requisites:-** Constants, circuit representation and generalized constants of short and medium transmission lines

### Objectives:-

- To develop analytical ability for Power system subject with prerequisite of power system I.
- To study the basic concept of short and medium transmission lines.

### Outcomes:

- **Solve problems** involving modeling, design and performance evaluation of HVDC and EHVAC power transmission lines.
- **Analyze** power flow in power transmission networks and apply power flow results to solve simple planning problems.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Evaluation of ABCD constants | T1 | Chalk and Talk |
| 2 | Equivalent circuit parameters of Long transmission line. | T1 | Chalk and Talk |
| 3 | Evaluation of ABCD constants and equivalent circuit parameters of Long transmission line. | T2,T4 | Chalk and Talk+PPT |
| 4 | Concept of complex power, power flow using generalized constants | T2,T4 | Chalk and Talk+PPT |
| 5 | Receiving end power circle diagram for transmission line (assuming ABCD constants are already given). | T2,T4 | Chalk and Talk+PPT |
| 6 | Problems based on above topics | T2,T4 | Chalk and Talk |
| 7 | Basic concepts on surge impedance loading, Line efficiency. | T3,T4 | Chalk and Talk+PPT |
| 8 | Regulation and compensation | T3,T4 | Chalk and Talk+PPT |
| 9 | Numerical based on: ABCD constants of Long transmission line. | T1,T2 | Chalk and Talk+PPT |
| 10 | Power flow, circle diagram numericals | T1,T2 | Chalk and Talk+PPT |

# Question Bank: Theory

## Unit: I

| | | |
|---|---|---|
| **Q. 1** | **a)** | A 132kV, three phase line has the following line parameters : A = 0.98<3°, B = 110<75° ohms per phase. If the receiving end voltage is 132kV determine: Sending end voltage and power angle if a load 50MVA at 0.8 p.f. (lagging) is being delivered at receiving end. |
| | **b)** | Explain the term compensation and what are different methods of compensation? |
| **Q. 2** | **a)** | Derive equation for receiving end active and reactive power flow in the transmission line. |
| | **b)** | Explain the procedure for drawing the receiving end circle diagram. |
| **Q. 3** | **a)** | Determine ABCD parameters of a long transmission line with 160km length having *r* = 0.1157 Ω /km,L = 0.00127 H/km and C=0.00875 μ F/Km.Assume frequency is 50Hz. |
| | **b)** | Explain surge impedance & surge impedance Loading. |
| **Q. 4** | **a)** | Determine sending end complex power, of a transmission line delivering 50MVA at 132kV, 50Hz and 0.8 power factor lagging. The ABCD constants of transmission lines are A = D = 0.9855 ∠ 0.32°, B= 67.3 ∠ 68.69° Ω. |
| | **b)** | Write a short note on Complex power. |
| **Q. 5** | **a)** | A three phase 132 kV overhead line delivers 60 MVA at 132 kV and power factor 0.85 lagging at its receiving end. The constants of line are A = 0.98, α = 3° and B = 110, β = 75° ohm per phase. Find i) Sending end voltage and power angle. ii) Sending end active and reactive power. |
| | **b)** | A 132kV three phase line has the following line constants : A = 0.9 < 2.5°, B = 100 < 70° Ω, C = 0.0006 < 80° S. Draw the receiving end power circle for a load of 40 MW at 0.8 power factor lagging at the receiving end and determine the sending end voltage. |
| **Q. 6** | **a)** | Derive power flow equation for receiving end side of transmission line. |

| | | |
|---|---|---|
| | **b)** | Derive ABCD constant in case of long transmission lines. |
| **Q. 7** | **a)** | Determine sending end complex power, of a transmission line delivering 50MVA at 132kV, 50Hz and 0.8 power factor lagging. The ABCD constants of transmission lines are A = D = 0.9855 ‘0.32 , B = 67.3 ‘ 68.69 :. |
| | **b)** | A transmission circuit is represented by symmetrical network in which the series impedance is 120‘60 : and each shunt admittance is 2.5 x 10–3 ‘90 S . i) Calculate value of general circuit constants ABCD ii) the characteristic impedance of the circuit. |
| **Q. 8** | | Prove the reactive power is proportional to voltage drop (Q α V) |

## Unit No.-II: EHV-AC transmission

### Pre-requisites:-

Basic concepts of EHV-AC transmission

### Objectives:-

- To give overview of aspects of EHV transmission and corona
- To discuss the power handling capability and corona loss .

**Outcomes:-**After successfully completing this unit students will be able to:

- Solve problems involving modeling, design and performance evaluation of EHVAC power transmission lines
- Calculate corona loss and power handling capacity of EHV lines.

| Lecture No. | Details of the Topic to be covered | References |
|---|---|---|
| 1 | Role of EHV-AC transmission | T1,T5,R7 |
| 2 | Standard transmission voltages | T3,R4 |
| 3 | Average values of line parameters, power handling capacity and line losses | T3 |
| 4 | Phenomenon of corona, disruptive critical voltages, visual critical voltages, corona loss | T1,T5 |
| 5 | Factors and conditions affecting corona loss | T1,T5 |
| 6 | Radio and television interference | T1,T2,R7 |
| 7 | Reduction of interference, | T1,T2,R9 |
| 8 | Numerical Based on Corona, Corona loss and power handling capacity. | T1,T2,R9 |

# Question Bank: Theory
## Unit No.-II:

| | |
|---|---|
| **Q. 1** | Explain the phenomenon of corona and state factors affecting corona loss. |
| **Q.2** | Find the disruptive critical voltage and visual critical voltage for local and general corona for a three phase line consisting of 21mm diameter conductors spaced in 6 m delta configuration. Take temperature 25° C, pressure 73 cm of mercury, surface factor 0.84, irregularity factor for local visual corona 0.72 and for general (decided) visual corona 0.82. |
| **Q.3** | Explain power handling capacity and power loss at various voltage levels. |
| **Q.4** | In three phase overhead line the conductors have each diameter of 30mm and are arranged in the form of an equilateral triangle. Assuming fair weather conditions air density factor is 0.95 and irregularity factor 0.95. Find the minimum spacing between the conductors if the disruptive critical voltage is not to exceed 230kV between lines. Breakdown strength of air may be assumed to be 30kV per cm (peak). |
| **Q.5** | In three phase overhead line the conductors have each diameter of 30mm and are arranged in the form of an equilateral triangle.Assuming fair weather conditions air density factor is 0.95 and irregularity factor 0.95. Find the minimum spacing between the conductors if the disruptive critical voltage is not to exceed 230kV between lines. Breakdown strength of air may be assumed to be 30kV Per cm (peak). |
| **Q.6** | Explain phenomena of corona in EHV transmission lines |
| **Q.7** | Estimate the corona loss per phase per km by using Peek's formula for three phase 110kV, 50Hz, 150km long transmission line consisting of three conductors each of 10mm diameter and spaced 2.5m apart in an equilateral triangle formation. The temperature of air is 30°C and the atmospheric pressure of 75mm of Hg.Take the irregularity factor as 0.85. Ionization of air may be assumed to take place at a maximum voltage gradient of 30 kV. |
| **Q. 8** | What are factors and conditions affecting corona? Explain in detail |
| **Q.9** | Estimate the corona loss per phase per km by using peek's formula for three phase 110kV, 50Hz, 150km long transmission line consisting of three conductors each of 10mm diameter and spaced 2.5 m apart in an equilateral triangle formation. The temperature of air is 30ºC and the |

| | |
|---|---|
| | atmospheric pressure of 75 mm of Hg. Take the irregularity factor as 0.85. Ionization of air may be assumed to take place at a maximum voltage gradient of 30kV per cm (peak). |
| **Q.10** | Explain phenomena of corona in EHVAC power transmission |
| **Q.11** | Explain interference of radio and television signals in EHVAC transmission line |
| **Q.12** | Derive the formula for critical disruptive voltage in corona |
| **Q.13** | Explain the advantages and drawbacks of EHVAC transmission |
| **Q.14** | Explain the phenomenon of corona and state various methods to reduce it |
| **Q.15** | Find the disruptive critical voltage and visual critical voltage for local and general corona for a three phase line consisting of 21mm diameter conductors spaced in 6m delta configuration. Take temperature 25° C, pressure 73cm of mercury, surface factor 0.84, irregularity factor for local visual corona 0.72 and for general (decided) visual corona 0.82. |

## Unit No.-III: Per unit system and Load Flow Analysis

### Pre-requisites:-

Constants, circuit representation and generalized constants of short and medium transmission lines

### Objectives:-

- To introduction of computational methods for solving problems such as load flow
- To discuss in detail techniques and tools for power system analysis with a practical perspective

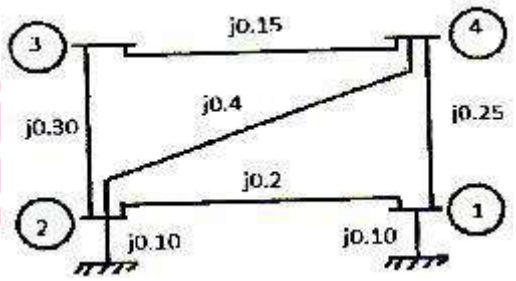
**Outcomes:-**After successfully completing this unit students will be able to:

- Analyze power flow in power transmission networks and apply power flow results to solve simple planning problems.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| **1** | Single line diagram, Impedance and reactance diagrams and their uses. | **T2,T3** | Chalk & Talk |
| **2** | Per unit quantities, relationships, selection of base, change of base, reduction to common base, advantages and application of per unit system | **T1,T4,R4** | Chalk & Talk |
| **3** | Numerical based on network reduction by using per unit system. | **T4,T5,R1** | Chalk & Talk |
| **4** | Network topology, driving point and transfer admittance. | **T2,T4,R3** | Chalk & Talk |
| **5** | Concept of Z-bus and formulation of Y-bus matrix using Direct method. | **T2,T4,R1** | Chalk & Talk |
| **6** | Singular transformation method | **T1,T4,R7** | Chalk & Talk |
| **7** | Introduction to load flow analysis, power-flow equations generalization to n bus systems | **T2,T4,R1** | Chalk & Talk |
| **8** | Classification of buses, Newton- Raphson method (using polar coordinates), Gauss-Seidal method. (Descriptive treatment only) | **T3,T4,R7** | Chalk & Talk |
| **9** | Numerical based on Y bus Matrix | **T2,T4,R1** | Chalk & Talk |

# Question Bank: Theory
## Unit No. - III

| | |
|---|---|
| **Q.1** | What do you mean by p.u. system? Prove that the single phase and three phase values are same in p.u. |
| **Q.2** | Compare Newton Raphson method with Gauss Seidal method of load flow analysis. |
| **Q.3** | Derive YBUS matrix using singular transformation method for 'n' bus system. |
| **Q.4** | What is per unit system? Explain the advantages and applications of per unit system. |
| **Q.5** | Explain with flow chart Gauss Seidel method of load flow analysis. |
| **Q.6** | What are the advantages of per unit system? How the base impedance is converted to per unit system? What formula is to be used if base of per unit values is to be changed? |
| **Q.7** | Give in detail classification of bus for load flow analysis |
| **Q.8** | Derive static load flow equations for *n* bus system. |
| **Q.9** | Derive power flow equation for 'n' bus system. |
| **Q.10** | For the given power system reactances are shown in the fig. find bus admittance matrix [Y BUS] |




| | |
|---|---|
| **Q. 11** | A sample power system has following line data. Form bus admittance matrix (YBUS) for this system. |

| Bus code | Series impedance in pu | PU line charging admittance Y/2 |
|---|---|---|
| 1-2 | 0.02+j0.08 | 0.0+j0.04 |
| 1-3 | 0.06+j0.24 | 0.0+j0.03 |
| 2-3 | 0.04+j0.16 | 0.0+j0.025 |
| 2-4 | 0.04+j0.16 | 0.0+j0.025 |
| 3-4 | 0.01+j0.04 | 0.0+j0.015 |

## Unit No.-IV: Symmetrical Fault Analysis

### Pre-requisites:-

- Constants, circuit representation and generalized constants of short and medium transmission lines
- Inductance and capacitance for symmetrical and unsymmetrical configuration of transmission lines

### Objectives:-

- To understand the basic concepts Symmetrical Fault Analysis

**Outcomes:-**After successfully completing this unit students will be able to:

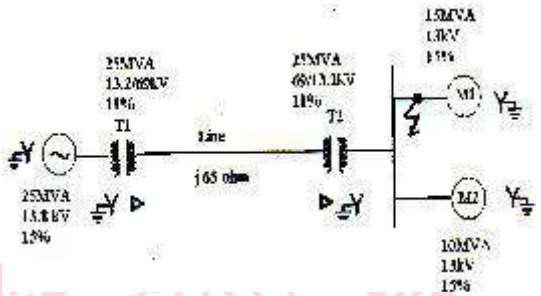
- Calculate the fault current and determine the circuit breaker rating.

| Lecture No. | Details of the Topic to be covered | References |
|---|---|---|
| **1** | 3-phase short-circuit analysis of unloaded alternator | **T3,T2,R1** |
| **2** | 3-phase short-circuit analysis of unloaded alternator | |
| **3** | Sub-transient, transient and steady state current and impedances | **T3,T2,R8** |
| **4** | D.C. Offset, and effect of the instant of short-circuit on the waveforms | **T1,T2,R7** |
| **5** | Estimation of fault current without pre-fault current for simple power systems | **T5,R1** |
| **6** | Selection of circuit breakers and their location in power system (Descriptive treatment only) | **T2,T4,R6** |
| **7** | Selection of current limiting reactors their location in power system (Descriptive treatment only) | **T2,T4,R6** |
| **8** | Numerical Based on symmetrical fault analysis | **T1,T2,R7** |
| **9** | | **T1,T2,R7** |

# Question Bank: Theory

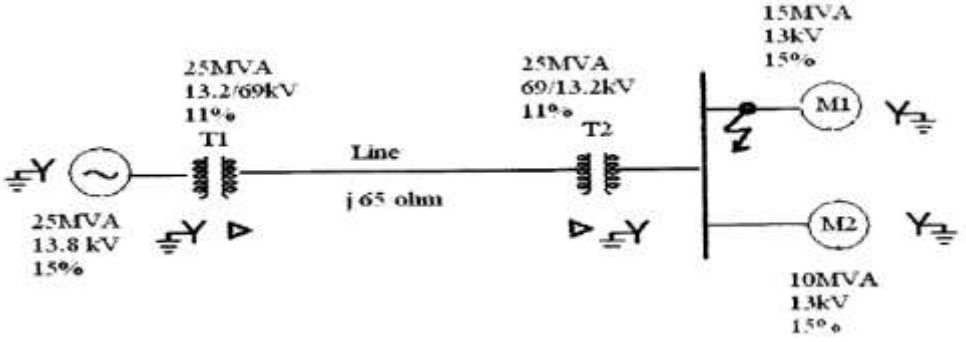
## Unit No.-IV

| | |
|---|---|
| **Q. 1** | A one line diagram of a three phase power system is shown in fig. A three phase short circuit fault occurs at point shown in fig. Choose 13.8k V, the generator voltage as the base voltage and 25MVA as the base MVA, Find fault current at fault location. |

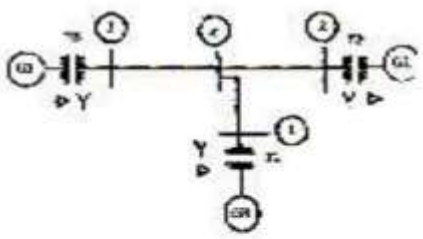



| | |
|---|---|
| **Q. 2** | How the selection of circuit breaker is done in power system? What are the current limiting reactors? Explain its use in power system. |
| **Q. 3** | Explain the concept of sub transient, transient and steady state current and impedances of unloaded alternator under symmetrical fault condition. |
| **Q. 4** | What is current limiting reactor? Explain it with a suitable example. |
| **Q. 5** | Write a short note on Selection of Circuit breakers |
| **Q. 6** | A delta connected load is connected to three phase supply. One line of supply is open. The current in other two lines is 20<0° A and 20<180° A Find symmetrical components of the line currents. |
| **Q. 7** | A 3-phase 11kV, 10MVA alternator have X0 = 0.05 pu, X1 = X2 = 0.15pu. It is on no load and rated terminal voltage. Find the ratio of the line currents for a single line to ground fault to three phase fault if (a) neutral is solidly grounded (b) neutral is grounded through Xn = 0.062pu. |
| **Q.8** | A three phase 11kV, 5MVA generator has a direct axis steady state reactance of 20%. It is connected to a 3MVA transformer having 5% leakage reactance and ratio of 11/33kV. The 33kV side is connected to a transmission line having 30ohm reactance. A three phase fault occurs at other end of transmission line. Calculate steady state fault MVA and current assuming no load prior to the fault. Take base of 11kV, 5MVA on generator. |

| | |
|---|---|
| **Q.9** | A one line diagram of a three phase power system is shown in fig. A three phase short circuit fault occurs at point shown in fig. Choose 13.8kV, the generator voltage as the base voltage and 25MVA as the base MVA, Find fault current at fault location |

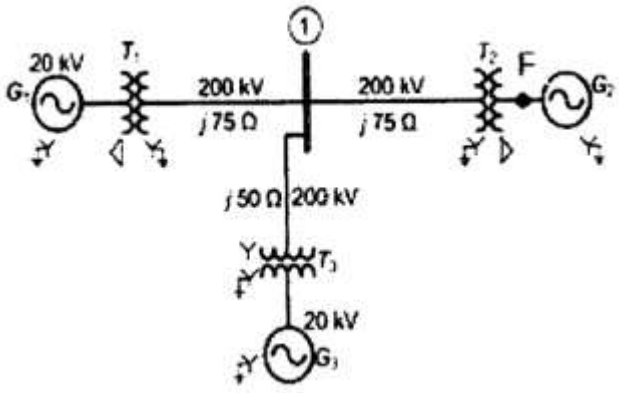



| | |
|---|---|
| **Q. 10** | The power system network shown in figure has the following equipment ratings. A three phase short circuit fault occurs on bus 1 of the network. Find fault current and fault MVA. Select Base power = 500 MVA & base voltage = 400k V on transmission line. |



| | |
|---|---|
| Generator $G_1$ | 500 MVA, 11 kV X" = 0.15 pu |
| Generator $G_2$ | 400 MVA, 11 kV, X" = 0.12 pu |
| Generator $G_3$ | 300 MVA, 11 kV, X" = 0.10 pu |
| Transformer $T_1$ | 500 MVA, 11/400 kV, star - delta, X = 0.08 pu |
| Transformer $T_2$ | 300 MVA, 11/400 kV, star - delta, X = 0.1 pu |
| Transformer $T_3$ | 300 MVA, 22/400 kV, star - delta, X = 0.1 pu |
| Transmission Lines<br>1 – 4 --- X = j 40 Ω, 2 – 4 ---- X = j 50 ,<br>3 – 4 --- X = j 30 Ω | |

| | |
|---|---|
| **Q. 11** | A three phase short circuit fault occurs at a point F shown in the figure. Find fault current and Fault MVA. |




| | |
|---|---|
| Generator $G_1$ | 200 MVA, 20 kV, $X_d$ = 15% |
| Generator $G_2$ | 300 MVA, 18 kV, $X_d$ = 20% |
| Generator $G_3$ | 300 MVA, 20 kV, $X_d$ = 20% |
| Transformer $T_1$ | 300 MVA, 220Y/22 kV, $X_d$ = 10% |
| Transformer $T_2$ | Three single-phase units each rated 100 MVA, 130Y/25 kV, X = 10% |
| Transformer $T_3$ | 300 MVA, 220/22 kV, X = 10% |

## Unit No.-V: Unsymmetrical Fault Analysis

**Pre-requisites:-**Basic concepts of Unsymmetrical Fault Analysis.

**Objectives**: -

- To discuss in detail techniques and tools for power system analysis with a practical perspective under unsymmetrical fault.

**Outcomes:-**After successfully completing this unit, students will be able to:

- Calculate currents and voltages in a faulted power system under and unsymmetrical faults.

| Lecture No. | Details of the Topic to be covered | References |
|---|---|---|
| 1 | Symmetrical components, transformation matrices, sequence components. | T4,T3,R1 |
| 2 | | |
| 3 | Power in terms of symmetrical components, sequence impedances of transmission line and zero sequence networks of transformer. | T4,T3,R6 |
| 4 | | |
| 5 | Solution of unbalances by symmetrical components. | T1,T3,R8 |
| 6 | L-L, L-G, and L-L-G fault analysis of unloaded alternator and simple power systems with and without fault impedance. | T2,T3,R2 |
| 7 | | |
| 8 | Numerical based on symmetrical component and unsymmetrical fault calculation. | T1,T3,R1 |

## Question Bank: Theory

## Unit No.-V

| | |
|---|---|
| **Q. 1** | A 20 MVA, 11kV, Y connected synchronous generator is no load and rated voltage. If X1 = X2 = 12%, X0 = 6%. Estimate<br>i) Reactance Xn to limit SLG fault current, if the ratio of SLG fault current to three phase short circuit current is 1.<br>ii) ii) LLG fault current with Xn in neutral grounding circuit |
| **Q.2** | For the three phase transmission line with self impedances Zs and mutual impedance ZM, show that Z1=Z2=ZS– ZM and Z0=ZS+ 2 ZM. |
| **Q.3** | Derive the expression for fault current in case of LLG fault considering the sequence network under this type of fault with suitable diagram. |
| **Q.4** | Draw zero sequence diagram for all types of combinations of transformer. |
| **Q.5** | Derive formula for fault current in case of LL fault. |
| **Q.6** | Derive formula for fault current in case of LLG fault. |
| **Q.7** | Show that fault current when L-L-G fault occurs at the terminals of solidly grounded star connected alternator. Draw the sequence network. |

$$If = \frac{E}{X_1 \left( \frac{X_2 * X_0}{X_2 + X_0} \right)}$$

## Unit No.-VI: HVDC Transmission (Descriptive treatment only).

### Pre-requisites:-

Basic concepts of HVDC Transmission.

### Objectives:-

HVDC transmission Methodology.

**Outcomes:-**After successfully completing this unit students will be able:

Various control methods.

Advantages and drawbacks of HVDC.

| Lecture No. | Details of the Topic to be covered | References |
|---|---|---|
| **1** | Classification and components of HVDC system. | **T4,T5,R1** |
| **2** | Advantages and limitations of HVDC transmission | **T1,T2,R3** |
| **3** | Comparison with HVAC system. | **T1,T2,R2** |
| 4 | Introduction to HVDC control methods - constant current, constant ignition angle and constant extinction angle control. | **T1,T4,R1** |
| **5** | | |
| **6** | Recent developments. | **T1,T4,R4** |

# Question Bank: Theory
## Unit VI

| | |
|---|---|
| **Q. 1** | What are the recent developments in HVDC transmission system? State any two HVDC systems in India. |
| **Q.2** | Compare HVDC system with EHVAC system. |
| **Q.3** | Give the classification of HVDC transmission system in detail |
| **Q.4** | Explain constant current control characteristic of HVDC transmission system. |
| **Q.5** | Draw single line diagram of HVDC transmission system and explain the components used (any four). |
| **Q.6** | Give the advantages and limitations of HVDC transmission |
| **Q.7** | Write short note on "HVDC lines in India" |
| **Q.8** | Compare bipolar and mono polar HVDC system. |
| **Q.9** | Compare EHV transmission with HVDC transmission. |
| **Q.10** | What are the various components of HVDC system |

## Practical Assessment

### List of Experiments

| Sr.No. | Name of the Practical |
|---|---|
| 1 | Measurement of ABCD parameters of a medium transmission line |
| 2 | Measurement of ABCD parameters of a long transmission line |
| 3 | Plotting of receiving end circle diagram to evaluate performance of medium transmission line |
| 4 | Study of the effect of VAR compensation using capacitor bank. |
| 5 | Static measurement of sub-transient reactance's of a salient-pole alternator. |
| 6 | Measurement of sequence reactance's of a synchronous machine (Negative and zero). |
| 7 | Calculation of inductance and capacitance for symmetrical and unsymmetrical configuration of transmission line using a software. |
| 8 | Formulation and calculation of Y- bus matrix of a system |
| 9 | Solution of a load flow problem using Gauss-Seidal method |
| 10 | Solution of a load flow problem using Newton-Raphson method |
| 11 | Symmetrical and Unsymmetrical fault analysis of a 3-bus system |
| 12 | Simulation of HVDC system |

# CONTROL SYSTEM-I
# (303147)

# Name of the Subject – Control System-I

| Weekly Work Load(in Hrs) | Lecture | Tutorial | Practical |
|---|---|---|---|
| | 4 | - | 02 |

| Online/ In-sem | Theory | Practical | Oral | Term-work | Total Marks | Credit |
|---|---|---|---|---|---|---|
| 30 | 70 | - | 50 | | 150 | |

## Syllabus:

**Unit 01 : General (10 Hrs)**

Basic concepts of control system, classification of control systems. Types of control system: Feedback, tracking, regulator system, feed forward system. Transfer function, Pole and zero concept. Modeling and representation of control system-Basic concept. Mechanical, Electrical and equivalent system, Electromechanical. Block diagram Algebra, signal flow graph, Mason's gain formula.

**Unit 02 : Time domain analysis ( 08 Hrs)**

Standard test signal –step, ramp, parabolic and impulse signal, type and order of control system, time response of first and second order systems to unit impulse, unit step input. steady state errors – static error coefficients. Time domain specifications of second order systems. Importance of dominant closed loop poles of higher order systems Derivation of time domain specifications for second-order under-damped system for unit step input.

**Unit 03 : Stability analysis and Root Locus (08 Hrs)**

Concept of stability- Absolute, Asymptotic, relative and marginal. Nature of system response for various locations of roots in S-plane of characteristics equation. Routh's-Hurwithz criterion. Root Locus: Basic properties of root locus. Construction of root locus. Angle and magnitude condition for stable system.

**Unit 04 : Frequency domain analysis-I (08 Hrs)**

Introduction, relation between time and frequency response for second order system. Frequency domain specifications, Polar Plot, Nyquist plot, stability analysis using Nyquist plot.

**Unit 05 : Frequency domain analysis-II ( 08Hrs)**

Introduction to Bode plot, Asymptotic approximation: Sketching of Bode plot, stability, stability analysis using Bode plot.

**Unit 06 : PID controllers ( 06Hrs)**

Basic concept of P, PI, PID controller, Design specifications in time domain and frequency domain. Design of PID controller by Root-Locus. Tuning of PID controllers. Ziegler-Nichol Method.
Control System Components: Working principle and transfer function of Lag network, lead network, potentiometer, AC and DC servo motors. Working principle of synchros.

## Text Books

1. I.J. Nagrath, M. Gopal, "Control System Engineering", New Age International Publishers, 4thEdition, 2006.
2. Katsuhiko Ogata, "Modern control system engineering", Prentice Hall, 2010.
3. B. C. Kuo, "Automatic Control System", Wiley India, 8th Edition, 2003.
4. Natarajan Ananda, Babu P. Ramesh "Control Systems Engineering" , Second Edition, Scitech Publication, 2010

## Reference Books

1. Richard C Dorf and Robert H Bishop, "Modern control system", Pearson Education, 12th edition,2011.
2. Nise N. S. "Control Systems Engineering", John Wiley & Sons, Incorporated, 2011
3. Jacqueline Wilkie, Michael Johnson, Reza Katebi, "Control Engineering: An Introductory Course", Palgrave Publication, 2002.
4. D. Roy Choudhary, "Modern Control Engineering", PHI Learning Pvt. Ltd., 2005.
5. Smarajiti Ghosh, "Control Systems : Theory and Applications" , Dorling Kindersley (RS), 2012.

## Course Objectives:

- To understand basic concepts of the classical control theory.
- To model physical systems mathematically.
- To analyze behavior of system in time and frequency domain.
- To design controller to meet desired specifications.

## Course Outcomes:

After successfully completing the course:

1. Students will be able to demonstrate and determine control system parameters and model the physical systems.
2. Students will be able to analyse and evaluate the behaviour of control system by time domain specifications and validate it by modern tool.
3. Student will be able to implement the stability analysis in time domain.
4. Student will be able to implement the stability analysis by using Polar and Nyquist plot in frequency domain.
5. Student will be able to implement the stability analysis by using Bode plot in frequency domain.
6. Student will be able to construct, design and validate feedback controller to achieve desired performance specifications.

# Academic Activity Planner

| Units | Unit Test1 | Unit Test2 | Unit Test3 | RLC kit submission | End Term Test |
|---|---|---|---|---|---|
| I | √ | | | √ | |
| II | | √ | | | |
| III | | | √ | | |
| IV | | | | | √ |
| V | | | | | √ |
| VI | | | | | √ |

# Teaching Plan

**Teaching plan as per University Syllabus**

| Sr.No. | Unit | Broad Topics to be Covered | Total Lecture Planned |
|---|---|---|---|
| 1 | I | General | 8 |
| 2 | II | Time domain analysis. | 8 |
| 3 | III | Stability analysis and Root Locus | 8 |
| 4 | IV | Frequency domain analysis-I | 8 |
| 5 | V | Frequency domain analysis-II | 8 |
| 6 | VI | PID controllers | 8 |

## Unit wise Lecture Plan

## Unit No.-I: General.

**Pre-requisites:-** Laplace Transform, ordinary differential equations.

**Objectives :-**

- To understand basic concepts of the classical control theory.
- To model physical systems mathematically.

**Outcomes :**

- Students will demonstrate and determine control system parameters and model the physical system.
- Student can list, categorize and model control system components.
-

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Basic concepts of control system, open loop, close loop, classification of control systems. | **T1,R1,R2** | Chalk and Talk |
| 2 | Types of control system: Feedback, tracking, regulator system, feed forward system. | **T1,T2,R3** | Chalk and Talk |
| 3 | Transfer function, Pole and zero concept. Modelling and representation of control system-Basic concept. | **T3,R1,R3** | Chalk and Talk |
| 4 | Mechanical, Electrical and equivalent system. | **T1,T3,T4,R5** | Chalk and Talk |
| 5 | Block diagram reduction | **T2,T3,T4** | Chalk and Talk |
| 6 | signal flow graph | **T1,T2,R1,R2** | Chalk and Talk |
| 7 | Mason's gain formula. | **T1,R1,R2** | Chalk and Talk |
| 8 | Rubrics | | |

PROGRESSIVE EDUCATION SOCIETY'S

# MODERN COLLEGE OF ENGINEERING

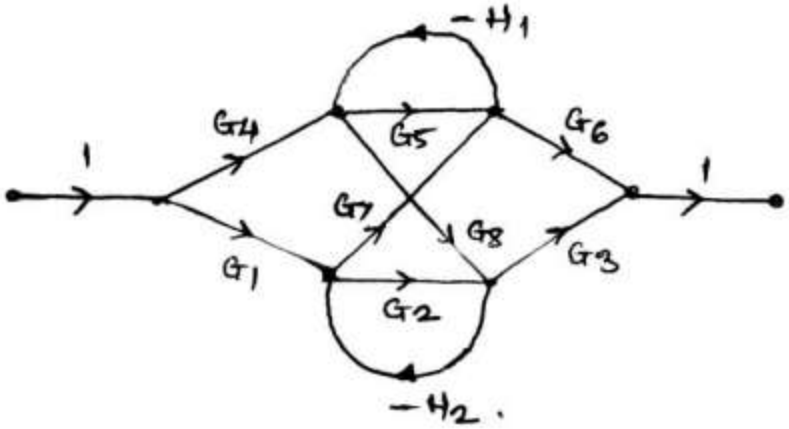
## DEPARTMENT OF ELECTRICAL ENGINEERING

## Question Bank: Theory

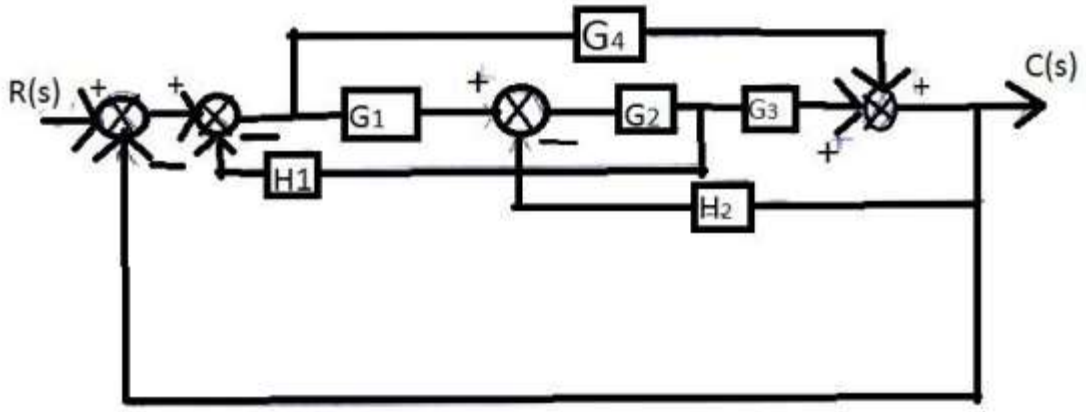
## Unit 1

Q 1 .Discuss feedback characteristics of control system in respect of i) sensitivity ii) disturbance signal iii) system gain and iv) system stability

Q2 Using Mason's gain formula find the gain of the following system shown in




Q3.Find the transfer function for the system shown in Fig. 2 using Mason's Gain Formula.




Q4 .With suitable example distinguish

i)Linear control system and Non-Linear control system

ii)Open loop and closed loop control system

Q5 Obtain transfer function of a R-L-C series ckt excited by a voltage source.

## Unit No.-II: Time domain analysis

### Objectives :-

To analyze behaviour of system in time domain.

**Outcomes:-** After successfully completing this unit students will be able to:

Students can analyse and evaluate the behaviour of control system by time domain specifications and validate it by modern tool.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| **1** | Standard test signal –step, ramp, parabolic and impulse signal, type and order of control system | **T1,T3,R1** | Chalk & Talk |
| **2** | time response of first and second order systems to unit step input, steady state errors – static and dynamic errors coefficients | **T1,T3,R1** | Chalk & Talk |
| **3** | Generalized errors series method. | **T1,T3,R1** | Chalk & Talk |
| **4** | Time domain specifications of second order systems. | **T1,T3,R1** | Chalk & Talk |
| **5** | Dominant closed loop poles of higher order systems | **T1,T3,R1** | Chalk & Talk |
| **6** | Design specifications in time domain. | **T1,T3** | Chalk & Talk |
| **7** | static and dynamic errors coefficients | **T1,T3** | Chalk & Talk |
| **8** | Rubrics | | Chalk & Talk |

## Question Bank: Theory

| | | | |
|---|---|---|---|
| Q1 | | For a unity feedback system having open loop transfer function<br>$G(s)=\frac{K(s+2)}{s(s^3+7s^2+12s)}$<br>Find :<br>1) Type of the system<br>2) Static error coefficients<br>3) Steady state error for an input $\frac{R}{2}t^2$. | [5] |
| Q2 | | Determine time response specifications for $G(s)=\frac{10}{s^2+2s+6}$ with unity feedback. | [5] |

| | | | |
|---|---|---|---|
| Q. 3 | | What are standard test signals used in time domain analysis. Derive steady state errors and static error, coefficients for type '0', type '1' and type '2' systems. | [5] |
| Q4 | | For a system with $G(s)H(s)=\frac{5}{S+5}$, calculate the generalised error coefficients and steady state error. The input to the system is r(t) = 6 + 5t. | |

## Unit No.-III: Stability analysis and Root Locus

### Objectives:-

To analyze behavior of system in time and frequency domain.

**Outcomes:-** After successfully completing this unit students will be able to:

Students can analyze and evaluate the behavior of control system by time domain specifications and validate it by modern tool.

Student can implement the stability analysis in frequency and time domain.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| **1** | Concept of stability-Absolute, relative and marginal. | **T1,T3,R1** | Chalk & Talk |
| **2** | Nature of system response for various locations of roots in S plane of characteristics equation. | **T1,T2,R1** | Chalk & Talk |
| **3** | Routh's criterion and Hurwithz criterion. | **T1,T3,R1** | Chalk & Talk |
| **4** | Root Locus: Basic properties of root locus. | **T1,T3,R1** | Chalk & Talk |
| **5** | Construction of root locus. | **T1,T2,R1** | Chalk & Talk |
| **6** | Angle and magnitude condition for stable system. | **T1,T3,R1** | Chalk & Talk |
| **7** | Root contour design concep | **T1,T3,R1** | Chalk & Talk |
| **8** | Rubrics | | Chalk & Talk |

# Question Bank
## Unit No.-III

| | | | |
|---|---|---|---|
| 0.1 | | Explain the concept of absolute, relative and marginal stability. | [5] |
| Q2 | | For characteristic equation of feedback control system $S^4 + 25S^3 + 15S^2 + 20S + K = 0$ determine the range of K for stability by Routh - Harwitz Criteria. Determine the value of K so that system is marginally stable. Also find the frequency of sustained oscillations. | [5] |
| Q. 3 | | Obtain Root locus for unity feedback system with open loop transfer function $G(s) = \frac{k}{s(s^2+6s+25)}$ | [5] |
| Q4 | | A unity feedback system has<br>G(S) = K / S (S + 10) (S2 + 4S + 5).<br>Determine range of K for closed loop system to be stable. | |
| Q5 | | Explain Routh Huruietz Stability Criterion. | |
| Q6 | | Apply Routh Huruietz Criterion to check the stability of system whose characteristic equation is<br>s3+2.5 s2+20s+10k=0. Find the range of k for which system is absolutely stable. | |
| Q7 | | Explain how to find the following terms during sketching of root locus<br>i) Breakaway points<br>ii) Asymptotes and centroid<br>iii) Angle of arrival<br>iv) Angle of departure | |
| Q8 | | Sketch Root Locus for $G(s) = \frac{k}{s(s^2+6s+12)}$ with H(s)=1 | |

## Unit No.-IV: Frequency domain analysis.-I

**Objectives**:- To analyze behaviour of system in frequency domain.

**Outcomes:-** Student can implement the stability analysis in frequency domain.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| **1** | Steady state response of a system due to sinusoidal input | **T1,T2,R1** | Chalk & Talk |
| **2** | Relation between time and frequency response for second order system | **T1,T2,R1** | Chalk & Talk |
| **3** | Frequency domain specifications, analysis with Bode plot,. | **T1,T2,R1** | Chalk & Talk |
| **4** | Polar plot, | **T1,T2,R1** | Chalk & Talk |
| **5** | Nyquist plot | **T1,T2,R1** | Chalk & Talk |
| **6** | stability analysis using Nyquist plot | **T1,T2,R1** | Chalk & Talk |
| **7** | stability analysis using Bode plot | **T1,T2,R1** | Chalk & Talk |
| **8** | Ruberics | | Chalk & Talk |

## Question Bank:
## Unit No.-V

| | | | |
|---|---|---|---|
| Q1 | | A unity feedback control system has $G(s)=\frac{40}{s(s+2)(s+5)}$ Draw Bode plot. Find GM &PM. | [5] |
| Q2 | | State advantages and disadvantages of frequency & time domain analysis. | [5] |
| Q3 | | Explain Nyquist stability criterion based on mapping theorem. | [5] |
| Q4 | | Draw the bode plot for the system having unity feedback whose open loop transfer function is $G(s)=\frac{10}{s(1+0.1s)(1+0.04s)}$<br>Also determine<br>i) $W_{ge}$ ii) $W_{pc}$<br>iii) GM iv) PM and<br>v) Stability. | [5] |
| Q. 5 | | Sketch the polar plot for the system whose open loop transfer function $G(s)H(s)=\frac{7}{s(1+s)(1+0.5s)}$ Comment on stability.<br>Sketch the Nyquist plot and determine stability for $G(s)H(s)=\frac{1}{(1+s)(1+2s)}$. | [5] |

## Unit No.-VI:

## PID controllers

**Objectives**:- To design controller to meet desired specifications.

## Outcomes:-

(1)Student will be able to analyse and apply various methodology of feedback control system and evaluate the behaviour of system by frequency domain analysis.

(2)Student can construct, design and validate feedback controller to achieve desired performance specification.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| **1** | Basic concept of PID controller | **T1,T3,R1** | Chalk & Talk |
| **2** | Design specifications in time domain | **T1,T3,R1** | Chalk & Talk |
| **3** | Design specifications in frequency domain | **T1,T3,R1** | Chalk & Talk |
| **4** | Time design of P,PI, PID controllers. | **T1,T3,R1** | Chalk & Talk |
| **5** | Frequency domain design of P,PI,PID controllers | **T1,T3,R1** | Chalk & Talk |
| **6** | Tuning of PID controllers | **T1,T3,R1** | Chalk & Talk |
| **7** | Zigler-Nichol Method. | **T1,T3,R1** | Chalk & Talk |
| **8** | Rubrics | | Chalk & Talk |

# Question Bank: Theory
## Unit No.-VI

| | | | |
|---|---|---|---|
| 0.1 | | Explain Zigler-Nichol Method of tuning. | [6] |
| Q2 | | Time Design of P,PI,PID controllers. | [4] |
| Q3 | | Write short note P+I control system. | [6] |
| Q4 | | Explain PD control mode, stating its characteristics. | [6] |
| Q5 | | Write short note on<br><br>Time Design of P,PI,PID controllers | [6] |
| Q6 | | State controller equations for the P, P + I, P + D and PID control actions. | [6] |

## Practical Assessment

### List of Experiments

| Sr.No. | Name of the Practical |
|---|---|
| 1 | Experimental study of time response characteristics of R-L-C second order system: Validation using simulation. |
| 2 | Experimental frequency response of Lag and Lead compensator. |
| 3 | Stability analysis using a) Bode plot b) Root locus c) Nyquist plot using software. |
| 4 | Effect of addition of pole-zero on root locus of second order system |
| 5 | PID control of level/Pressure/Temperature control system. |
| 6 | Transfer function of any physical systems (AC Servomotor/ Two Tank System/ Temperature control/ Level control) |
| 7 | Study of Synchro transmitter receiver. |
| 8 | Time response of second order system effect of P,PI, PID on it. |

# UTILIZATION OF ELECTRICAL ENERGY
# (303148)

## Name of the Subject – Utilization of Electrical Energy, 303148

| Weekly Work Load(in Hrs) | Lecture | Tutorial | Practical |
|---|---|---|---|
| | 03 | - | - |

| In-sem | End-Sem | Practical | Oral | Term-work | Total Marks | Credit |
|---|---|---|---|---|---|---|
| 30 | 70 | - | - | - | 100 | 3 |

## Syllabus:

**Prerequisite:**

- Basics of Electrical Engineering, Effects of electric current
- Chemical reactions in electrolyte
- Control circuit design basics, awareness about artificial lighting, refrigeration, air conditioning
- Characteristics and application of different electric motors, awareness about traction

**Unit 01: Electric Heating (06 Hrs.)**

Modes of heat transfer, mathematical expressions

**Electric heating:** Introduction to electric heating, Advantages of electrical heating

**Heating methods:** - Resistance heating – Direct resistance heating, indirect resistance heating, electric ovens, different types of heating element materials, temperature control of resistance furnaces, and design of heating element (Numerical). Applications of resistance heating

**Induction heating :** Principle, core type and coreless induction furnaces, Ajax Wyatt furnace, Numerical on melting furnaces Applications of induction heating

**Electric arc heating** – Direct and indirect arc heating, types of arc furnaces, equivalent circuit of arc furnace, condition for maximum output, power factor at maximum output (Numerical), Heat control in arc furnace, Applications of arc heating

**Dielectric heating –**Principle, choice of voltage and frequency for dielectric heating (Numerical), Applications of dielectric heating

**Electric Welding** -Welding methods–Electric arc welding and resistance welding, Equivalent circuit of arc furnace (Numerical) Modern welding techniques like ultrasonic welding and laser welding.

**Unit 02: Electrochemical Process (04 Hrs.)**

Need of electro-deposition. Applications of Faraday's laws in electro-deposition. Factors governing electro-deposition. Objectives of electroplating. Equipments and accessories for electroplating plant, Electroplating on non-conducting materials, Principle of anodizing and its applications.

**Electrical Circuits Used in Refrigeration, Air Conditioning**

Brief description of vapour compression refrigeration cycle. Description of electrical circuits used in Refrigerator, Air Conditioner.

**Unit 03: Illumination (04 Hrs.)**

**Definitions** of luminous flux, solid angle, luminous intensity, illumination, luminous efficacy, depreciation factor, coefficient of utilization, space to height ratio, reflection factor; Laws of illumination.

**Design of illumination schemes**-Factors to be considered for design of illumination scheme, **Calculation** of illumination at different points, considerations involved in simple design problems for indoor installation, illumination schemes, standard illumination level. Natural day light illumination (brief information)

**Different sources of light**: Incandescent lamp, fluorescent lamp, comparison between them. Incandescent and discharge lamps – their construction and characteristics; mercury vapour lamp, sodium lamp, halogen lamp, compact fluorescent lamp, metal halide lamp, neon lamps Electroluminescent lamp-LEDs, types, LASERs Comparison of all above luminaries.

**Unit 04: Electric Traction (06 Hrs.)**

History of Indian railways.

**Traction systems** - Steam engine drive, electric drive, diesel electric drive, types of diesel locomotives, Advantages of electric traction, Brief treatment to - Indian railway engine coding terminology, WDM,WDP,WDG series and their capacity . Introduction to metro system, mono rail system.

**Systems of track electrification**: D.C. system, single phase low frequency A.C. system, 3 phase low frequency A.C. systems, composite systems – kando systems, single phase A.C. to D.C. system **Different accessories for track electrification** -overhead wires, conductor rail system, current collector-pentograph, catenary

**Electric locomotive-** Block diagram with description of various equipment and accessories.

**Supply system constituents**-Layout and description of -Traction substation, feeding post(25kV), feeding

and sectioning arrangement, sectioning and paralleling post, neutral section.

**Details of major equipment in traction substation**-transformer, circuit breaker, interrupter

**Unit 05: Traction Mechanics (08 Hrs.)**

**Types of services**- Urban, Sub-urban, Main line Speed time curves, trapezoidal and quadrilateral speed-time curves, average and schedule speed (Numerical), Tractive effort. Specific energy consumption. Factors affecting specific energy consumption (Numerical), Mechanics of train movement, coefficient of adhesion (Numerical).

**Unit 06: Traction Motors, Control of Traction Motors, Train Lighting (08 Hrs.)**

Desirable characteristic of traction motors. Suitability of D.C. series motor, A.C. series motor, 3 phase induction motor and linear induction motor for traction. Control of traction motors -Series- parallel control, Shunt and bridge transition (Numerical), Electrical breaking, Regenerative breaking in traction, Suitability of different motors for braking. Train lighting system.

**Railway signaling: -** History, necessity, block system route relay interlock and necessity. Metro signaling, Electromechanical system for route relay interlock. Introduction to train tracking system, types. Anti-collision system-brief treatment only.

Industrial Visit: Visit to any one location from the following-

1. Railway station (Control room)
2. Loco shed
3. Traction substation



**Text Books:**

**[T1]** E. O. Taylor 'Utilization of Electrical Energy' – Revised in S.I. Units by V.V.L. Rao, Orient Longman
**[T2]** J.B. Gupta, 'Utilization of Electric Power and Electric Traction', S.K. Kataria and sons, Delhi
**[T3]** C. L. Wadhwa, 'Generation, Distribution and Utilization of Electrical Energy', Eastern Wiley Ltd.
**[T4]** A. Chakraborti, M. L. Soni, P. V. Gupta, U.S. Bhatnagar, 'A text book on Power System Engineering', Dhanpat Rai and Co.(P) Ltd – Delhi
**[T5]** Clifford F. Bonntt 'Practical Railway Engineering', (Imperial college press)

**Reference Books:**

**[R1]** 'Art and science of Utilization of Electrical Energy' by H. Partab, Dhanpat Rai and Co.(P) Ltd – Delhi
**[R2]** 'Modern Electric Traction' by H. Partb, Dhanpat Rai and Co. (P) Ltd – Delhi
**[R3]** 'Lamps and lighting' by M. A. Cayless, J.R. Coaton and A. M. Marsden
**[R4]** 'BIS, IEC standards for Lamps, Lighting Fixtures and Lighting' By Manak Bhavan, New Delhi
**[R5]** 'Illumination Engineering from Edison's Lamp to the Laser' Joseph B. Murdoch
**[R6]** 'Two centuries of Railway signalling' by Geoffrey, Kichenside and Alan Willims (Oxford Publishing Co-op)
**[R7]** 'Generation and Utilization of Electrical Energy' S. Sivanagaraju, M. Balsubba Reddy, D. Srilatha (Pearson)
**[R8]** 'Electrical Powers' S. L. Uppal, Khanna Publication

**NOTE**

**Assignments can be given on following topics**

1. Types of Electric Welding- Electric arc welding and resistance welding (accessories involved and working of the system, characteristics of arc welding)
2. Modern welding techniques like ultrasonic welding and laser welding
3. Study of different types of lamps-Incandescent lamp, fluorescent lamp, their construction and characteristics; mercury vapour lamp, sodium lamp, halogen lamp, compact fluorescent lamp, metal halide lamp, neon lamps Electroluminescent lamp-LEDs, types, LASERs
4. Comparison of all above luminaries.
5. WDM, WDP, WDG series and their capacity. Introduction to metro system, mono rail system.

| Unit | Text Books | Reference Books |
|---|---|---|
| 1 | T1,T3,T4 | R1,R7, R8 |
| 2 | T1,T3, T4 | R1, R7 |
| 3 | T1,T3, T4 | R1, R3,R4,R5,R7, R8 |
| 4 | T1,T2,T5, T4 | R1, R2,R7, R8 |
| 5 | T1,T2,T5, T4 | R1, R2,R5, R8 |
| 6 | T1, T2,T5, T4 | R1, R2,R6, R8 |

## Course Objectives

The course aims to:-

1. Ensure that the knowledge acquired can be applied in various fields such as electric heating, illumination, chemical processes, and electric traction.
2. Make the students aware about the importance of maximizing the energy efficiency by optimum utilization of electrical energy.
3. Develop ability amongst the students to design -heating element for resistance furnaces and design- illumination schemes. To develop ability amongst the students to analyze the performance of arc furnaces, electric traction, different sources of light, illumination schemes
4. Provide know how about Refrigeration, Air Conditioning
5. Provide know about electrochemical processes and applications of these in practical world, modern welding techniques.
6. Develop self and lifelong learning skills, introduce professionalism for successful career.

## Course Outcomes

Upon successful completion of this course, the students will revise :-

1. Students will be able to interpret different types of electric heating and welding methods.
2. Students will be able to explain refrigeration and air conditioning and interpret electrochemical processes in practical world.
3. Students will be able to design illumination schemes.
4. Students will be able to explain types of track electrification and traction systems
5. Students will be able to analyze the mechanics of train movement.
6. Students will be able to apply knowledge for selecting motors for traction purpose & will understand process of electrical braking & railway signaling.

**Publication. IS/IEEE Standards:**

**1**. IS : 366(1991) –Electric Irons

**2**. IS : 302-2-30(2007):Safety of household and similar electrical Appliances.

**3**. IS : 16003(2012) –Specification and Qualification of Welding Procedures for Metallic Material.

**4.** National Lighting Code(nlc)-2010-Bureau of Indian Standards.

**5.** IS : 900:1992 – Code of practice for installation and maintenance of Induction Motors

**6.**.IS:14665-2-1to2(2000):Electric Traction Lifts, Code of Practice for installation, maintenance and operation.

**Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:**

1.www.nptel.com

2.Analysis of Power Converters with devices of sic for applications in Traction Systems.2016 IEEE International PEMC.

3.Electrical safety of DC Urban rail Traction Systems 2016 IEEE 16th International(EEEIC).

## ✓ Academic Activity Planner

| Units | Unit Test1 | Unit Test2 | Unit Test3 | End Term Test |
|---|---|---|---|---|
| I | √ | | | |
| II | | √ | | |
| III | | | √ | |
| IV | | | | √ |
| V | | | | √ |
| VI | | | | √ |

# Teaching Plan

**Teaching plan as per University Syllabus**

| Sr. No. | Unit | Broad Topics to be Covered | Total Lecture Planned |
|---|---|---|---|
| 1 | I | Electric Heating | 6 |
| 2 | II | Electrochemical Process | 4 |
| 3 | III | Illumination | 4 |
| 4 | IV | Electric Traction | 6 |
| 5 | V | Traction Mechanics | 8 |
| 6 | VI | Traction Motors, Control of Traction Motors, Train Lighting | 8 |

## Unit wise Lecture Plan

## Unit No.-I: Electric Heating

**Pre-requisite:-** Basics of Electrical Engineering, Effects of electric current.

## Objectives:-

- To ensure that the knowledge acquired can be applied in various field of electric heating application.
- To study the design process of various Electric Furnaces and modern techniques of Welding.

## Outcome:

- Students will be able to understand the importance of maximizing the energy efficiency by its optimum utilization and mould their practical work in professional world accordingly.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Modes of heat transfer, mathematical expressions Electric heating: Introduction to electric heating, Advantages of electrical heating. | T1<br>T2<br>T3<br>R1 | BB |
| 2 | Heating methods: - Resistance heating – Direct resistance heating, indirect resistance heating, electric ovens. | | BB |
| 3 | Different types of heating element materials, temperature control of resistance furnaces, design of heating element(Numerical). Applications of resistance heating | | BB |
| 4 | Induction heating : Principle, core type and coreless induction furnaces, | | BB |
| 5 | Ajaxwyatt furnace, Numerical on melting furnaces Applications of induction heating. | | BB |
| 6 | Electric arc heating – Direct and indirect arc heating, types of arc furnaces, equivalent circuit of arc furnace, condition for maximum output, power factor at maximum output (Numerical),. | | BB |
| 7 | Heat control in arc furnace, Applications of arc heating | | BB |
| 8 | Dielectric heating –Principle, choice of voltage and frequency for dielectric heating(Numerical), Applications of dielectric heating. | | BB |
| 9 | Electric Welding | | Flip lecture |

| | | | |
|---|---|---|---|
| | Welding methods–Electric arc welding and resistance welding. | | |
| 10 | Modern welding techniques like ultrasonic welding and laser welding | | ppt |
| 11 | **Rubrics** | | |

## Question Bank:
## Theory- Unit :I

1. With a neat diagram describe the working of coreless type induction furnace.
2. Describe the construction and working of Ajax Wyatt induction furnace.
3. Explain laser welding with suitable diagram.
4. With suitable diagram explain Dielectric Heating. State its Applications.
5. Explain different methods of controlling temperature of resistance oven with suitable diagrams.
6. Explain resistance welding and its applications.
7. Explain application of arc Heating.
8. Explain advantages of Electric Heating.

## Unit No.-II: Electrochemical Process

**Pre-requisite:-**

Basic concepts of Chemical reactions in electrolyte.

## Objectives:-

- ✓ To ensure that the knowledge acquired can be applied in field of chemical process.
- ✓ To provide know how about various Control devices and their use in Refrigeration, Air Conditioning application.

**Outcomes:-** After successfully completing this unit:

- ✓ Students will be able to design various electrical circuits for controlling application.
- ✓ Students will collect technical information of various electrical devices and deliver it through presentation.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Need of electro-deposition. Applications of Faraday's laws in electro-deposition. Factors governing electro-deposition. Objectives of electroplating. | **T1 T3 R1** | ppt |
| 2 | Equipments and accessories for electroplating plant, Electroplating on non-conducting materials, Principle of anodizing and its applications. | | ppt |
| 3 | Electrical Circuits Used in Refrigeration, Air Conditioning | | video |
| 4 | Brief description of vapour compression refrigeration cycle. Description of electrical circuits used in Refrigerator, Air Conditioner | | video |

# Question Bank: Theory

## Unit 2: Electrochemical Process

1. Explain Vapour compression refrigeration cycle.
2. Explain the electrical circuit used in refrigerator.
3. State the various applications of electrolytic process and write note on anodizing.
4. Draw the electric circuit diagram of window air conditioner and explain it. Out of starting and running capacitor which is of greater value and why?
5. Explain in detail the factors affecting quality of Electro-Deposition.
6. Explain the electrical circuit used in Air Conditioning System.
7. What do you mean by Electroplating?

## Unit No.-III: Illumination

**Pre-requisite:-** Control circuit design basics, awareness about artificial lighting.

## Objectives:-

- To develop ability amongst the students to design illumination schemes.
- To develop ability amongst the students to analyze the performance of different sources of light, illumination schemes.

**Outcomes: -** After successfully completing this unit:

- Students will be able to understand the importance of maximizing the energy efficiency by its optimum utilization and mould their practical work in professional world accordingly.
- Students will be able to design simple illumination schemes.
-

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Definitions of flux, solid angle, luminous intensity, illumination, luminous efficiency, depreciation factor. | **T1 T3 T4 R3 R4 R5** | BB |
| 2 | Coefficient of utilization, space to height ratio, reflection factor; Laws of illumination. | | BB |
| 3 | **Design of illumination scheme**-Factors to be considered for design of illumination scheme, Calculation of illumination at different points, considerations involved in simple design problems for indoor installation. | | BB |
| 4 | illumination schemes, standard illumination level. Design of flood lighting, street lighting Natural day light illumination (brief information) | | BB |
| 5 | **Different sources of light**: Incandescent lamp, fluorescent lamp, comparison between them. | | video |
| 6 | Incandescent and discharge lamps – their construction and characteristics; mercury vapour lamp. | | video |
| 7 | sodium lamp, halogen lamp, compact fluorescent lamp, metal halide lamp, neon lamps. | | video |
| 8 | Electroluminescent lamp-LEDs, types, LASERs Comparison of all above luminaries. | | video |

## Question Bank: Theory
## Unit No.-III

1. Define illumination and explain laws of illumination with statement.
2. Discuss various factors which have to be considered while designing any lighting scheme.
3. Explain construction and working of mercury vapour lamp.
4. Describe with neat sketches various types of electrical light fittings used for illumination.
5. Explain How you will measure the Candle Power of source of light?
6. Define Following Terms i)MSCP ii)MHCP iii)Solid Angle iv)Candela v) Luminous Efficiency.
7. Write the expression that shows the relation between Solid Angle & Plane.
8. Explain Incandescent and discharge lamps of their construction and characteristics.
9. State and Describe Various Types of Lighting Schemes.

## Unit No.-IV: Electric Traction

### Pre-requisite:-

- Characteristics and application of different electric motors, awareness about Railways.

### Objectives:-

- To acquire knowledge of various Traction Systems and Indian railway system.
- To gain detail information on different methods of Track Electrification and its accessories.

**Outcomes:-** After successfully completing this unit:

- Students will be able to understand the modern traction systems and its future trends.
- Students acquire Technical Awareness about Railway transportation and advantages of elecrification

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | History of Indian railways.<br>Traction systems - Steam engine drive, electric drive, diesel electric drive, types of diesel locomotives, Advantages of electric traction, Brief | T1<br>T2<br>T5<br>R1<br>R6 | BB |
| 2 | Brief treatment to - Indian railway engine coding terminology, WDM,WDP,WDG series and their capacity, Introduction to metro system, mono rail system. | | BB,PPT |
| 3 | Systems of track electrification: D.C. system, single phase low frequency A.C. system, 3 phase low frequency. | | BB,PPT |
| 4 | A.C. systems, composite systems – kando systems, single phase A.C. to D.C. system. | | BB,PPT |
| 5 | Different accessories for track electrification -overhead wires, conductor rail system, current collector-pentograph, catenary. | | BB,PPT |
| 6 | Electric locomotive- Block diagram with description of various equipments and accessories. | | BB,PPT |
| 7 | Supply system constituents-Layout and description of - Traction substation, feeding post(25kV) | | BB,PPT |
| 8 | Feeding and sectioning arrangement, sectioning and paralleling post, neutral section. | | BB |
| 9 | Details of major equipments in traction substation-transformer, circuit breaker, interrupter. | | BB,PPT |

## Question Bank: Theory

## Unit No.-IV

1. Explain the advantages and disadvantages of 1 – phase, 25 KV ac system of track electrification over dc system.
2. Draw a general block diagram for electric locomotive and explain the function of each part.
3. Describe the various types of current collectors in common use for overhead contact system.
4. Compare steam engine drive and electric drive.
5. Describe the layout of Electric Traction Substation.
6. Explain Indian railway engine coding terminology.
7. Define different accessories for track electrification.
8. Explain major equipment used in traction substation.

## Unit No.-V: Traction Mechanics

**Pre-requisite:-** Characteristics and application of different electric motors, awareness about traction.

**Objective:-**

- To develop self and lifelong learning skills, introduce professionalism for successful career.

**Outcome:-** After successfully completing this unit:

- Students will be able to understand the importance of maximizing the energy efficiency by its optimum utilization and mould their practical work in professional world accordingly.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Types of services- Urban, Sub-urban, Main line. | **T1 T2 T5 R1 R6** | BB |
| 2 | Speed time curves, trapezoidal and quadrilateral speed-time curves. | | BB,PPT |
| 3 | Average and schedule speed(Numerical). | | BB |
| 4 | Tractive effort. Specific energy consumption. | | BB |
| 5 | Factors affecting specific energy consumption (Numerical). | | BB |
| 6 | Factors affecting specific energy consumption (Numerical). | | BB |
| 7 | Mechanics of train movement. | | BB |
| 8 | Coefficient of adhesion (Numerical). | | BB |
| 9 | Coefficient of adhesion (Numerical). | | BB |

## Question Bank: Theory
## Unit No.-V

1. Draw and explain the speed time curve for urban, suburban and main line service.
2. Define the term specific energy consumption.
3. Derive the expression for total energy output in watt hour for trapezoidal speed time curve.
4. Draw Trapezoidal Speed -Time curve & obtain expression for maximum velocity.
5. Define Coefficient of adhesion.
6. Assuming Quadrilateral Speed time Curve,Develop a method of determining the specific energy consumption of Train.
7. Discuss how different parameters of Speed -Time curve will vary with the type of train service.

## Unit No.-VI: Traction Motors, Control of Traction Motors, Train Lighting

### Pre-requisite:-

Characteristics and application of different electric motors, awareness about traction.

### Objective: -

- To develop self and lifelong learning skills, introduce professionalism for successful career.
- To develop thorough knowledge of practical application of various motors in traction system.

**Outcomes:-** After successfully completing this unit:

- Students will be able to the performance of electric traction.
- Collection of technical information and delivery of collected information through presentations.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Desirable characteristic of traction motors. Suitability of D.C. series motor, A.C. series motor, 3 phase induction motor and linear induction motor for traction. | T1 T2 T5 R1 R6 | BB |
| 2 | Control of traction motors -Series-parallel control, Shunt and bridge transition (Numerical). | | BB |
| 3 | Electrical breaking, Regenerative breaking in traction, Suitability of different motors for braking. Train lighting system. | | BB |
| 4 | Railway signaling: - History, necessity, block system route relay interlock and necessity. | | BB |
| 5 | Metro signaling, Electromechanical system for route relay interlock. | | BB |
| 6 | Introduction to train tracking system, types. Anti-collision system-brief treatment only. | | BB |

## Question Bank: Theory

## Unit No.-VI

1. What are the advantages of regenerative braking and explain how regenerative braking can be obtained in D.C locomotive?
2. State and explain the desired characteristics of motors for traction duty.
3. Write a short note on anti-collision system used for trains.
4. What is transition? State different methods of transition. Explain bridge transition.
5. Define Metro signaling in traction system.
6. Discuss the various factors governing the choice of motors.
7. Describe how Plugging, Rheostat Braking and Regenerative Braking are employed with D.C Series Motors.
8. Explain Different Methods of Electric Braking of three Phase Induction Motor.

# DESIGN OF ELECTRICAL MACHINES (303149)

## Name of the Subject –303149: Design of Electrical Machines

| | Lecture | Tutorial | Practical |
|---|---|---|---|
| Weekly Work Load(in Hrs) | 04 | - | 02 |

| Online/ In-sem | Theory | Practical | Oral | Term-work | Total Marks | Credit |
|---|---|---|---|---|---|---|
| 30 | 70 | | 50 | 25 | 150 | |

## Syllabus:

Unit 01: Transformer (7 Hrs.)

Modes of heat dissipation.Heating and cooling curves.Calculations of heating and cooling time constants.Types and constructional features of core and windings used in transformer. Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator. Specifications of three phase transformers as per IS 2026(Part I).

Unit 02: Transformer Design (8 Hrs.)

Output equation with usual notations, optimum design of transformer for minimum cost and loss.Design of main dimensions, core, yoke and windings of transformer. Methods of cooling and tank design. Estimation of resistance and leakage reactance of transformer.

Unit 03: Performance parameters of Transformer (8 Hrs.)

Estimation of no-load current, losses, efficiency and regulation of transformer. Calculation of mechanical forces developed under short circuit conditions, measures to overcome this effect. Introduction to Computer aided design of transformer, generalized flow chart for design of transformer.

Unit 04: Three phase Induction Motor Design : Part I (9 Hrs.)

Specification and Constructional features. Design of ac windings. Output equation with usual notations, specific electrical and magnetic loadings, ranges of specific loadings, turns per phase, number of stator slots.

Unit 05: Three phase Induction Motor Design : Part II (8 Hrs.)

Suitable combinations of stator and rotor slots .Calculations for main dimensions and stator design

parameters. Selection of length of air gap, factors affecting length of air gap, unbalanced magnetic pull. Design of rotor slots, size of bars, end rings for cage rotor and rotor slots, turns and area of cross section of conductor for wound rotor.

Unit 06: Performance parameters of Three Phase Induction motor (8 Hrs.)

Leakage flux and leakage reactance: Slot leakage, tooth top leakage, zig-zag leakage, overhang leakage, leakage reactance calculation for three phase machines. MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core, effect of saturation, effects of ducts on calculations of magnetizing current, calculations of no-load current. Calculations of losses and efficiency. Calculation of short time and continuous rating of electrical machine.

## Text Books:

[T1] M.G. Say – Theory and Performance and Design of A.C. Machines, 3rd Edition, ELBS London.

[T2] A.K.Sawhney – A Course in Electrical Machine Design, 10th Edition, - DhanpatRai and sons New Delhi.

[T3] K. G. Upadhyay- Design of Electrical Machines, New age publication

[T4] R. K. Agarwal – Principles of Electrical Machine Design, S. K.Katariya and sons.

[T5] Indrajit Dasgupta – Design of Transformers – TMH

## Reference Books:

[R1] K.L. Narang , A Text Book of Electrical Engineering Drawings, Reprint Edition : 1993 / 94 – SatyaPrakashan, New Delhi.

[R2] A Shanmugasundaram, G. Gangadharan, R. Palani, - Electrical Machine Design Data Book, 3rd Edition, 3rd Reprint 1988 - Wiely Eastern Ltd., - New Delhi

[R3] Vishnu Murti, "Computer Aided Design for Electrical Machines", B.S. Publications.

[R4] Bharat Heavy Electricals Limited, Transformers - TMH.

| UNIT | TEXT BOOKS | REFERENCE BOOKS |
|---|---|---|
| 1 | T1, T2, T4, T5 | R1, R2, R4 |
| 2 | T1, T2, T4, T5 | R1, R4 |
| 3 | T2, T5 | R3, R4 |
| 4 | T1, T2, T3, T4 | R1,R2, R3 |
| 5 | T2 | R3 |
| 6 | T2 | R3 |

## Reference Web Links/ Research Paper/ Referred Book other than Mentioned in the Syllabus:

1. Transformers, Second Edition: Book by BHEL
2. https://operafea.com/transformer-design-software/transformer-design-opera-fea-10-minute-video-overview/
3. INTEGRATED Engineering Software (IES)

## Course Objectives:

The course aims:-

- To design transformer.
- To understand determination of parameters of transformer.
- To understand specifications of transformer.
- To design Induction motor.
- To understand determination of parameters of Induction motor.
- To understand specifications of Induction motor.

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Students will be able to **explain** construction of Transformer and modes of heat dissipations. |
| **CO-2** | Students will be able to **evaluate** design parameters of transformer. |
| **CO-3** | Students will be able to **determince** the performance parameter of transformer. |
| **CO-4** | Students will be able to **develop** AC winding using modern tools and **define** different terminology of Three phase induction motor. |
| **CO-5** | Students will be able to **design** three phase induction motor. |
| **CO-6** | Students will be able to **interpret** various performance parameters of Three phase induction motor. |

PROGRESSIVE EDUCATION SOCIETY'S

# MODERN COLLEGE OF ENGINEERING

## DEPARTMENT OF ELECTRICAL ENGINEERING

## Academic Activity Planner

| Units | Unit Test 1 (30 marks) | MCQ (20 marks) | Assignment (60 marks) | End Term Test (70 marks) |
|---|---|---|---|---|
| I | √ | | | |
| II | | | | |
| III | | | | |
| IV | | | √ | √ |
| V | | | √ | |
| VI | | | √ | |

# Teaching Plan

**Teaching plan as per University Syllabus**

| Sr. No. | Unit | Broad Topics to be Covered | Total Lecture Planned |
|---|---|---|---|
| 1 | I | Transformer | (07 hrs) |
| 2 | II | Transformer Design | (08 hrs) |
| 3 | III | Performance parameters of Transformer | (08 hrs) |
| 4 | IV | Three phase Induction Motor Design: Part I | (09 hrs) |
| 5 | V | Three phase Induction Motor Design: Part II | (08 hrs) |
| 6 | VI | Performance parameters of Three Phase Induction motor | (08 hrs) |

PROGRESSIVE EDUCATION SOCIETY'S

# MODERN COLLEGE OF ENGINEERING

## DEPARTMENT OF ELECTRICAL ENGINEERING

### Unit wise Lecture Plan

## Unit No.-I: Transformer

**Pre-requisites:-**Basic knowledge of Transformer

**Objectives:-**

- To understand the modes of heat dissipation in transformer.
- To gain knowledge of Transformer constructions, auxiliaries.

**Outcomes:-**

After successfully completing this unit students will be able:

- Understand the heat dissipation in electrical machines and analyze its relation to the rating of the machine.
- Explain the transformer constructions, and its auxiliaries & their functions.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Modes of heat dissipation; Heating and cooling curves, | T1, T2, T4, T5 R1, R2, R4 | Chalk and talk |
| 2 | Calculations of heating and cooling time constants. | | Chalk and talk |
| 3 | Calculations of short term ratings. | | Chalk and talk |
| 4 | Types and constructional features of core and windings used in transformer | | Chalk and talk and PPT |
| 5 | Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator. | | Chalk and talk and PPT |
| 6 | Transformer auxiliaries such as tap changer, pressure release valve, breather and conservator. | | Chalk and talk and PPT |
| 7 | Specifications of three phase transformers as per IS 2026 (Part I). | | PPT |

## Question Bank: Theory

Q.1 Explain different modes of heat dissipation in an electrical machine.

Q.2 Explain heating and cooling curves of electrical machine and based on it define the heating time constant and cooling time constant. (Relevant numerical problems )

Q.3 Explain short term rating of an electrical machine. (Relevant numerical problems )

Q.4 Which are the different types of windings used in transformer? Explain with labeled diagram.

Q.5 Explain tap changer, pressure release valve, breather and conservator, along with their function.

Q.6 Which are the Specifications of three phase transformers as per IS 2026 (Part I)..

# Unit No.-II: Transformer Design

**Pre-requisites:-**Basic knowledge of **Transformer** .

## Objectives:-

- To design transformer.
- To understand determination of parameters of transformer.

**Outcomes:-**

After successfully completing this unit students will be able:

- To calculate core and main dimensions of a transformer.
- To understand and determine the performance parameters of a transformer.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Output equation with usual notations, | T1, T2, T4, T5 R1, R4 | Chalk and talk |
| 2 | Optimum design of transformer for minimum cost and loss. Related numerical problem. | | Chalk and talk, PPT |
| 3 | Design of main dimensions, core, yoke and windings of transformer. | | Chalk and talk, PPT |
| 4 | Design of main dimensions, core, yoke and windings of transformer. Related numerical problem | | Chalk and talk, PPT |
| 5 | Methods of cooling and tank design. Related numerical problem | | Chalk and talk, PPT |
| 6 | Estimation of resistance of transformer. | | Chalk and talk |
| 7 | Estimation of leakage reactance of transformer. | | Chalk and talk, PPT |
| 8 | Design related numerical problem | | Chalk and talk, PPT |

## Question Bank: Theory

Q.1 Derive the output equation of three phase transformer.
Q.2 What is an optimum design? Derive the equation for the optimization of cost during design.
Q.3 Design a cooling scheme for the transformer so as to maintain the temperature within specified limit.
Q.4 How to estimate the resistance of a three phase transformer?
Q.5 How to determine the leakage reactance of a three phase transformer?

- Numerical problems related to the above points.

# Unit No.-III: Performance parameters of Transformer

Estimation of no-load current, losses, efficiency and regulation of transformer. Calculation of mechanical forces developed under short circuit conditions, measures to overcome this effect. Introduction to Computer aided design of transformer, generalized flow chart for design of transformer.

**Pre-requisites:-** Basic knowledge of **Transformer and its operation**

## Objectives:-

- To estimate Performance parameters of Transformer
- To understand Computer aided design of transformer and generalized flow chart for design.

## Outcomes:-

After successfully completing this unit students will be able to:

- Estimation of no-load current, losses, efficiency and regulation of transformer
- Calculation of mechanical forces developed under short circuit conditions
- Prepare generalized flow chart for design of transformer

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Derive the expression for estimation of no-load current, | T3, T5 R3, R4 | Chalk and talk, PPT |
| 2 | Numerical problems related to estimation of no-load current, | | Chalk and talk, PPT |
| 3 | Estimation of losses, efficiency and regulation of transformer. | | Chalk and talk, PPT |
| 4 | Numerical problem related to estimation of losses and efficiency | | Chalk and talk |
| 5 | Leakage flux and mechanical forces developed in a transformer | | Chalk and talk, PPT |
| 6 | Calculation of mechanical forces developed under short circuit conditions, measures to overcome this effect. | | Chalk and talk, PPT |
| 7 | Numerical problem related to design of a transformer | | Chalk and talk |
| 8 | Introduction to Computer aided design of transformer, generalized flow chart for design of transformer. | | PPT |

## Question Bank: Theory

Q.1 Derive the expression for the estimation of no-load current
Q.2 Explain leakage flux and different forces developed in a transformer.
Q.3 Derive the expression for different forces developed in a transformer under short circuit conditions,
Q.4 Which are the measures taken to overcome the effect of the forces developed in a transformer?
Q.5 What is Computer aided design of transformer, draw generalized flow chart for design of transformer.

- Numerical problems related to the above points.

# Unit No.-IV: Three Phase Induction Motor Design: Part I

**Pre-requisites:-**Basic Knowledge of **working of three phase Induction Motor**

## Objectives:-

- To develop AC winding using modern tools
- Define different terminology of three phase induction motor.
- Determine main dimensions and design stator of three phase induction motor

## Outcomes:-

After successfully completing this unit students will be able to:

- develop AC winding using modern tools
- understand constructional detail and material used in three phase induction motor
- determine main dimensions and
- design stator of three phase induction motor

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Specification and Constructional features of three phase induction motor | T1, T2, T3, T4, R1,R2, R3 | Chalk and talk, PPT |
| 2 | Study and design of lap type ac windings. | | Chalk and talk, PPT |
| 3 | Study and design of wave type ac windings. | | Chalk and talk, PPT |
| 4 | Study and design of hemitropic and whole coil ac windings. | | Chalk and talk, PPT |
| 5 | Study and design of mush type ac windings. | | Chalk and talk, PPT |
| 6 | Specific loadings and their ranges, selection of specific loadings | | Chalk and talk, PPT |
| 7 | Output equation with usual notations, Numerical problems | | Chalk and talk, |
| 8 | turns per phase, number of stator slots. | | Chalk and talk, PPT |
| 9 | Numerical problems | | Chalk and talk, |

## Question Bank: Theory

Q.1 With suitable diagram explain difference in Lap winding and Wave winding.
Q.2 Explain different types of induction motor and their salient features
Q.3 What are the specific loading of the machine?
Q.4 Write the range of the values of specific magnetic loading and specific electric loading in three phase induction motor.
Q.5 Explain the effect of the values of specific magnetic loading and specific electric loading on the design of three phase induction motor.

# Unit No.-V: Three Phase Induction Motor Design: Part II

Suitable combinations of stator and rotor slots, Calculations for main dimensions and stator design parameters. Selection of length of air gap, factors affecting length of air gap, unbalanced magnetic pull. Design of rotor slots, size of bars, end rings for cage rotor and rotor slots, turns and area of cross section of conductor for wound rotor.

**Pre-requisites:-** Basic Knowledge of working of three phase Induction Motor

## Objectives:-

- To design rotor of three phase induction motor
- To study factors affecting length of air gap

**Outcomes:-**After successfully completing this unit students will be able to:

- design rotor of three phase induction motor
- To study factors affecting length of air gap
- To calculate unbalanced magnetic pull in 3 phase induction motor.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Design of the stator: selection of no. of slots | T2, R3 | Chalk and talk, PPT |
| 2 | Suitable combinations of stator and rotor slots, their effect | | Chalk and talk, PPT |
| 3 | Calculations for main dimensions and stator design parameters. | | Chalk and talk, PPT |
| 4 | Selection of length of air gap, factors affecting length of air gap, unbalanced magnetic pull | | Chalk and talk, PPT |
| 5 | Numerical problems, | | Chalk and talk, PPT |
| 6 | Design of rotor slots, size of bars, end rings for cage rotor and rotor slots, | | Chalk and talk, PPT |
| 7 | turns and area of cross section of conductor for wound rotor | | Chalk and talk, |
| 8 | Numerical problems | | Chalk and talk, |

## Question Bank: Theory

Q.1 Derive the output equation for a three phase induction motor.
Q.2 List the steps to design the stator of three phase induction motor.
Q.3 List the steps to design the rotor of three phase induction motor.
Q.4 Which are the suitable combination of the no. of the slots for stator and rotor?
Q.5 Explain the phenomenon of crawling and cogging of three phase induction motor
Q.6 What is an unbalanced magnetic pull? Write the causes and its effects.

# Unit No.-VI: Performance parameters of Three Phase Induction motor

**Pre-requisites:-**Basic knowledge of design and operation of induction motor

## Objectives: -

- To calculate performance parameters of Three Phase Induction motor
- To calculate short time and continuous rating of electrical machine.

## Outcomes:-

After successfully completing this unit, students will be able to:

- To calculate performance parameters of Three Phase Induction motor
- To determine short time and continuous rating of electrical machine

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Leakage flux and leakage reactance: Slot leakage | T2, R3 | Chalk and talk, PPT |
| 2 | tooth top leakage, zig-zag leakage, overhang leakage | | Chalk and talk, PPT |
| 3 | Numerical problems | | Chalk and talk, PPT |
| 4 | leakage reactance calculation for three phase machines | | Chalk and talk, PPT |
| 5 | Numerical problems | | Chalk and talk, PPT |
| 6 | MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core, effect of saturation, effects of ducts on calculations of magnetizing current, calculations of no-load current. | | Chalk and talk, PPT |
| 7 | Calculations of losses and efficiency. | | Chalk and talk, |
| 8 | Calculation of short time and continuous rating of electrical machine. | | Chalk and talk, |

## Question Bank: Theory

Q.1 Which are the different types of leakage reactance in a three phase Induction motor?
Q.2 Write down the procedure for the calculation of tooth top leakage reactance, zig-zag leakage reactance, overhang leakage reactance.
Q.3 What is the effect of ducts on calculations of magnetizing current?
Q.4 Write down the procedure for MMF Calculation for air gap, stator teeth, stator core, rotor teeth and rotor core.
Q.5 How to calculate the no load current of the three phase induction motor?
Q.6 How to calculate the losses and efficiency of a three phase induction motor?

Q.7 What is short term rating of an electrical machine?

## List of Practical's

**1** Details and assembly of three phase transformer with design report.(Sheet in CAD)

**2** Details and layout of AC winding with design report.(Sheet in CAD)

**3** Assembly of 3-phase induction motor.( Sheet optional CAD or Drawing)

**4** Use of Finite Element Analysis(FEA) software for analysis of electrical machines, the report

**5** Report on industry visit

# ENERGY AUDIT AND MANAGEMENT (303150)

# Name of the Subject –: Energy Audit and Management

| Weekly Work Load(in Hrs) | Lecture | Tutorial | Practical |
|---|---|---|---|
| | 04 | - | 02 |

| Online/ In-sem | Theory | Practical | Oral | Term-work | Total Marks | Credit |
|---|---|---|---|---|---|---|
| 30 | 70 | - | - | 25 | 125 | |

## Syllabus

**Unit I : Energy Scenario: 06Hrs**

Classification of Energy resources, Commercial and noncommercial sources, primary and secondary sources, commercial energy production, final energy consumption. Energy needs of growing economy, short terms and long terms policies, energy sector reforms, energy security, importance of energy conservation, energy and environmental impacts, emission check standard, salient features of Energy Conservation Act 2001 and Electricity Act 2003. Indian and Global energy scenario. Introduction to IE Rules. Study of Energy Conservation Building Code (ECBC).

**Unit II: Energy Management. 06Hrs**

Definition and Objective of Energy Management, Principles of Energy management, Energy Management Strategy, Energy Manager Skills, key elements in energy management, force field analysis, energy policy, format and statement of energy policy, Organization setup and energy management. Responsibilities and duties of energy manager under act 2001. Energy Efficiency Programs. Energy monitoring systems..

**Unit III: Demand Management 06Hrs**

Supply side management (SSM), Generation system up gradation, constraints on SSM. Demand side management (DSM), advantages and barriers, implementation of DSM. Use 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.) Introduction to Net Metering.

**Unit IV : Energy Audit 6 Hrs**

Definition, need of energy audits, types of audit, procedures to follow, data and information analysis, energy audit instrumentation, energy consumption – production relationship, pie charts. Sankey diagram, Cusum technique, least square method and numerical based on it. Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options. Bench- marking energy performance of an industry. Report formats

**Unit V : Energy Conservation in Applications (6 Hrs.)**

a) Motive power (motor and drive system). b) Illumination c) Heating systems ( boiler and steam systems) d) Ventilation( Fan, Blower and Compressors) and Air Conditioning systems e) Pumping System f) Cogeneration and waste heat recovery systems g) Utility industries ( T and D Sector)

**Unit VI :Financial analysis (6 Hrs.)**

Financial appraisals; criteria, simple payback period, return on investment, net present value method, time value of money, break even analysis, sensitivity analysis and numerical based on it, cost optimization, cost of energy, cost of generation.

## Text Books:

[T1] Guide books for National Certification Examination for Energy Managers/Energy Auditors Book , 1-General Aspects ( available on line )
[T2] Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 2 – Thermal Utilities ( available on line )
[T3] Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 3-Electrical Utilities ( available on line )
[T4] Guide books for National Certification Examination for Energy Managers/Energy Auditors Book 4 ( available on line )

## Reference Books:

[R1] Success stories of Energy Conservation by BEE (www. Bee-india.org)
[R2] Utilization of electrical energy by S.C. Tripathi, Tata McGraw Hill.
[R3] Energy Management by W.R. Murphy and Mackay, B.S. Publication
[R41] Generation and utilization of Electrical Energy by B.R. Gupta, S. Chand Publication
[R5] Energy Auditing made simple by Balasubramanian, Bala Consultancy Services.

## Reference Web Links/ Research Paper/ Referred Book other than Mention in Syllabus:

[W1] www.energymanagertraining.com
[W2] www.em-ea.org
[W3] www.bee-india.org

## Course Objectives:

- ✓ Understand importance of energy Conservation and energy security.
- ✓ Understand impact of use energy resources on environment and emission standards.
- ✓ Follow format of energy management, energy policy.
- ✓ Learn various tools of energy audit and management
- ✓ Calculate energy consumption and saving options with economic feasibility.

## Course Outcomes:

| | |
|---|---|
| **CO-1** | Students will able to analyze and understand energy consumption patterns and environmental impacts and its mitigation method. |
| **CO-2** | Students will able to define energy management strategies and analyze the energy utility management system |
| **CO-3** | Students will able to list out various energy conservation measures for Demand side management. |
| **CO-4** | Students will able to implement preliminary audits. |
| **CO-5** | Students will able to recognize energy conservation application. |
| **CO-6** | Students will able to analyze and work out economic feasibility of energy conservation options. |

# Academic Activity Planner

| Units | Unit Test1 (10marks) | Unit Test2 (20marks) | Unit Test3 (70marks) |
|---|---|---|---|
| 1 | ✓ | | |
| 2&3 | | ✓ | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 1 to 6 | | | ✓ |

# Teaching Plan

**Teaching plan as per University Syllabus**

| Sr. No. | Unit | Broad Topics to be Covered | Total Lecture Planned |
|---|---|---|---|
| 1 | I | Energy Scenario | 06 |
| 2 | II | Energy Management | 06 |
| 3 | III | Demand Management | 06 |
| 4 | IV | Energy Audit | 06 |
| 5 | V | Energy Conservation in Applications | 06 |
| 6 | VI | Financial analysis | 06 |

## Unit No.-I: Energy Scenario

### Pre-requisites:-

Concept of power and energy in three phase and single phase

### Objectives:-

To understand the significance of Energy Conservation and Energy security.

### Outcomes:

- Understand the concepts of Energy Conservation and Energy security.
- Demonstrate the knowledge of BEE Energy policies, Electricity Acts.
- Understand impact of use energy resources on environment and emission standards.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | **Classification of Energy resources,** Commercial and noncommercial sources, primary and secondary sources, | **T1 W1,W2** | Chalk and Talk |
| 2 | Commercial energy production, final energy consumption. Energy needs of growing economy, **short terms and long terms policies**, | **T1 W1,W2** | Chalk and Talk |
| 3 | energy sector reforms, energy security, importance of energy conservation, energy and environmental impacts | **T1 W1,W2** | Chalk and Talk |
| 4 | emission check standard, salient features of Energy Conservation Act 2001 and Electricity Act 2003 | **T1 W1,W2** | Chalk and Talk |
| 5 | Indian and Global energy scenario. Introduction to IE Rules. | **T1 W1,W2** | Chalk and Talk |
| 6 | Study of Energy Conservation Building Code (ECBC). | **T1 W1,W2** | Chalk and Talk |

# Question Bank: Theory

## Unit I

1. List at least five States where coal deposits are concentrated in India.
2. What do you think of strategies required for long-term management of energy in India?
3. Discuss the subsidies and cross subsidies in oil sector in India.
4. What are the implications of Global warming?
5. Describe the Greenhouse effect.
6. Differentiate between energy conservation and energy efficiency.
7. Why energy conservation is important in the prevailing energy scenario?
8. Name five designated consumers under the energy conservation act.
9. Write in few words about the various reforms in the energy sector.

## Unit No.-II: Energy Management

### Pre-requisites:-

Basic concepts of Energy scenario in India and Energy management.

### Objectives:-

To understand the formats and structure of energy management, energy policy.

.

**Outcomes:-**After successfully completion of this unit students will be able to demonstrate and describe the formats and structure of energy management, energy policies in India.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Definition and Objective of Energy Management, Principles of Energy management,. | T1 W1,W2 | Chalk and Talk |
| 2 | Energy Management Strategy, Energy Manager Skills, key elements in energy management | T1 W1,W2 | Chalk and Talk |
| 3 | force field analysis, energy policy, format and statement of energy policy, | T1 W1,W2 | Chalk and Talk |
| 4 | Organization setup and energy management. | T1 W1,W2 | Chalk and Talk |
| 5 | Responsibilities and duties of energy manager under act 2001. | T1 W1,W2 | Chalk and Talk |
| 6 | Energy Efficiency Programs. Energy monitoring systems | T1 W1,W2 | Chalk and Talk |

## Question Bank: Unit II

1. Explain the concept of energy management and its objectives.
2. Explain Energy Management Strategy.
3. Explain in detail Force Field Analysis.
4. What are the Responsibilities of Energy Manager under ECA 2001?
5. What are the key elements of Energy Management?

## Unit No.-III: Demand Management

**Pre-requisites:-**Basic concepts of Supply Side Management and Demand Side Management

**Objectives: -** To understand the overview of demand side management through various tariffs structure

**Outcomes:-**After successfully completion of this unit students will be able to: Understand and compare various types of tariffs and its implementation to different sectors; Also recognize the role of renewable energy sources in energy management

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Concepts of Supply side management (SSM)& Demand Side Management (DSM) Generation system up gradation, | R4 | Chalk and Talk |
| 2 | Constraints on SSM. Demand side management (DSM), advantages and barriers, implementation of DSM. | R4 | Chalk and Talk |
| 3 | Use of demand side management in agricultural, domestic and commercial consumers. | R4 | Chalk and Talk |
| 4 | Demand management through tariffs (TOD). Power factor penalties and incentives in tariff for demand control. | R4 | Chalk and Talk |
| 5 | 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.) | R4 | Chalk and Talk |
| 6 | Introduction to Net Metering. | R4 | Chalk and Talk |



## Question Bank: Unit No.-III

1. What is Supply side Management SSM)?
2. What are various methods involved in SSM?
3. Explain the concept of Demand Side Management (DSM).
4. Explain DSM in agricultural, domestic and commercial consumers.
5. Explain the role of renewable energy sources in energy management.
6. Explain TOD.

## Unit No.-IV: Energy Audit

**Pre-requisites:-**Concepts of Electricity Act- 2003

**Objectives:-**Learn various tools of energy audit and management

**Outcomes: -** After successfully completion of this unit students will be able to:

- Understand the use of various energy measurement and audit instruments
- Execute preliminary energy audit of various sectors.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Definition, need of energy audits, types of audit, procedures to follow. | T1 , R4, R5 W1,W2 | Chalk and Talk |
| 2 | Data and information analysis, energy audit instrumentation. | T1 , R4, R5 W1,W2 | Chalk and Talk |
| 3 | Energy consumption – production relationship, pie charts. Sankey diagram, | T1 , R4, R5 W1,W2 | Chalk and Talk |
| 4 | Cusum technique, least square method and numerical based on it. | T1 , R4, R5 W1,W2 | Chalk and Talk |
| 5 | Outcome of energy audit and energy saving potential, action plans for implementation of energy conservation options | T1 , R4, R5 W1,W2 | Chalk and Talk |
| 6 | Bench- marking energy performance of an industry. Report formats | T1 , R4, R5 W1,W2 | Chalk and Talk |



## Question Bank: Unit No.-IV

1. Define energy audit and its need.
2. What are different types of energy audit?
3. What are various instruments used in energy audit?
4. Explain in detail Sankey Diagram.
5. Explain in detail Cusum Technique.
6. What is the typical format of Energy Audit Report?

## Unit No.-V: Energy Conservation in Applications

**Pre-requisites**:- Energy Conservation Act 2001

**Objectives: -** To understand the basic concepts Energy conservation measures and its application

**Outcomes:-**After successfully completion of this unit students will be able to: Enlist energy conservation and demand side measures for electrical, thermal and utility Systems.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | a) Motive power (motor and drive system) g) Utility industries ( T and D Sector) | T1, T2, T3 W1,W2 | Chalk and Talk, PPT |
| 2 | b) Illumination c) Heating systems ( boiler and steam systems | T1, T2, T3 W1,W2 | Chalk and Talk, PPT |
| 3 | d) Ventilation( Fan, Blower and Compressors) and Air Conditioning systems | T1, T2, T3 W1,W2 | Chalk and Talk, PPT |
| 4 | e) Pumping System f) Cogeneration and waste heat recovery systems | T1, T2, T3 W1,W2 | Chalk and Talk, PPT |
| 5 | Utility industries ( T and D Sector) | T1, T2, T3 W1,W2 | Chalk and Talk, PPT |
| 6 | Utility industries ( T and D Sector) | T1, T2, T3 W1,W2 | Chalk and Talk, PPT |



## Question Bank: Unit No.-V

Explain energy conservation in:

a) Motive power (motor and drive system).

b) Illumination

c) Heating systems (boiler and steam systems)

d) Ventilation (Fan, Blower, Compressors) and Air conditioning systems

e) Pumping System

f) Cogeneration and waste heat recovery systems

g) Utility industries (T and D Sector)

h) Diesel generators.

## Unit VI: Financial Analysis and Case Studies

**Pre-requisites:** Basic concepts of energy billing.

**Objectives**: Enable to understand financial management in energy consumption.

**Outcomes:-**After successfully completion of this unit, students will be able to explain and implement concepts of financial management in energy consumption.

| Lecture No. | Details of the Topic to be covered | References | Mode of Delivery |
|---|---|---|---|
| 1 | Costing techniques; cost factors, budgeting, | T1,R4 | Chalk and Talk |
| 2 | Standard costing, sources of capital, cash flow diagrams and activity chart. | T1,R4 | Chalk and Talk |
| 3 | Financial appraisals; criteria, simple payback period, return on investment | T1,R4 | Chalk and Talk |
| 4 | net present value method, time value of money, break even analysis | T1,R4 | Chalk and Talk |
| 5 | sensitivity analysis and numerical based on it, cost optimization, cost of energy, cost of generation, | T1,R4 | Chalk and Talk |
| 6 | Energy audit case studies such as IT sector, Textile, Municipal corporations, Educational Institutes, T and D Sector and Thermal Power stations. | T1,R4 | Chalk and Talk |



## Question Bank: Unit No.-VI

1. Describe different costing techniques used for energy management?
2. Explain cash flow diagrams and activity chart.
3. Explain in detail net present value method.
4. Explain in detail Break even analysis
5. Explain sensitivity analysis

## List of Experiments

| Sr. No. | Name of the Practical |
|---|---|
| 1 | 1. Study of Clean Development mechanism<br>2. Study of Energy Conservation Building Codes |
| 2 | Analysis and interpretation of electricity Bills<br>a) Residential Consumers.<br>b) Commercial consumers(College Campus) |
| 3 | Assessment and calculation of energy generated by solar PV or ther Renewable sources available in college campus. |
| 4 | Use of power analyzer for measurement of electrical parameters useful for energy audit or Power Quality audit. |
| 5 | Adequacy assessment of illumination systems by using Lux meter. |
| 6 | Execute Preliminary Energy Audit of Laboratory/Educational Institute/Small scale industry/Residential Building/Agricultural equipment/Municipal Corporation. |
| 7 | Study of energy audit success stories any one: Paper and pulp industry/Sugar industry/steel Industry/Commercial/Electrical Generation Plant. |
| 8 | Study of Ethical Practices in Energy Audit |

PROGRESSIVE EDUCATION SOCIETY'S

# MODERN COLLEGE OF ENGINEERING

## DEPARTMENT OF ELECTRICAL ENGINEERING

**Unit No.__**

**Theory Paper**

**[Total No. of Questions = 3 ]**

**[Total No. of Pages = 1 ]**

**T.E. (Electrical) 2015-Course**

**Subject Code:_____ Subject Name: _____**

**Semester: II (2019-20) Exam: _____**

**[Time: 1 Hours] [Max Marks = 10]**

**Instructions to Candidates:**

1. **Answer any __2___ Questions out of _____3__ questions**
2. **Use single answer book for all questions.**
3. **Figures to the right of each question indicate full marks.**
4. **Use of Scientific calculator is allowed.**

| | | | |
|---|---|---|---|
| **Q. 1** | **a)** | | **[ ]** |
| | **b)** | | **[ ]** |
| **Q. 2** | **a)** | | **[ ]** |
| | **b)** | | **[ ]** |
| **Q. 3** | **a)** | | **[ ]** |
| | **b)** | | **[ ]** |

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PROGRESSIVE EDUCATION SOCIETY'S

# MODERN COLLEGE OF ENGINEERING

## DEPARTMENT OF ELECTRICAL ENGINEERING

**Tutorial**

**[Total No. of Questions = 5 ]**

**[Total No. of Pages = 1 ]**

**T.E. (Electrical) 2015-Course**

**Subject Code:_____ Subject Name: _____**

**Semester: II (2019-20) Exam: _____**

**[Time: 1 Hours] [Max Marks = 20 ]**

**Instructions to Candidates:**

1. **Answer any ___4__ Questions out of __5_____ questions**
2. **Use single answer book for all questions.**
3. **Figures to the right of each question indicate full marks.**
4. **Use of Scientific calculator is allowed.**

| | | |
|---|---|---|
| **Q. 1** | | **[ ]** |
| **Q. 2** | | **[ ]** |
| **Q. 3** | | **[ ]** |
| **Q. 4** | | **[ ]** |
| **Q. 5** | | **[ ]** |

PROGRESSIVE EDUCATION SOCIETY'S

# MODERN COLLEGE OF ENGINEERING

## DEPARTMENT OF ELECTRICAL ENGINEERING

**Assignment**

**[Total No. of Questions = 5 ]**
**[Total No. of Pages = 1 ]**
**T.E. (Electrical) 2015-Course (Credit pattern)**
**Subject Code:_____ Subject Name: _____**
**Semester: II (2019-20) Exam: _____**
**[Time: 1 Hours] [Max Marks = 20 ] [ -Credits]**

**Instructions to Candidates:**

1. **All Questions are compulsory.**
2. **Use of Scientific calculator is allowed.**

| | | |
|---|---|---|
| **Q. 1** | | **[ ]** |
| | | |
| **Q.2** | | **[ ]** |
| | | |
| **Q.3** | | **[ ]** |
| | | |
| **Q.4** | | **[ ]** |
| | | |
| **Q.5** | | **[ ]** |
| | | |
| | | |

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