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|------------------------------|---------------------------------------------------------------------------------|
| <b>Branch Name:</b>          | Electrical Engineering                                                          |
| <b>Program Code:</b>         | ET109                                                                           |
| <b>Course Name:</b>          | Electrical Machine Design-II                                                    |
| <b>Course Code:</b>          | 1ET1090803                                                                      |
| <b>Pre-requisite Course:</b> | Fundamental Knowledge of A.C. electrical machines, Electrical Machine Design-I. |

**Course Objectives:**

1. Electrical machines design is a subject where a student will deal with design aspects of alternating current machines.
2. The main objective is to develop the creative physical realization of theoretical concepts.
3. Engineering design is application of science, technology and invention to produce machines to perform specified tasks with optimum economy and efficiency.

**Teaching and Examination Scheme:**

| Teaching Scheme (Hours per week) |          |           |        | Evaluation Scheme (Marks) |      |                       |      |                       |      |                       |      |       |
|----------------------------------|----------|-----------|--------|---------------------------|------|-----------------------|------|-----------------------|------|-----------------------|------|-------|
| Lecture                          | Tutorial | Practical | Credit | Theory                    |      |                       |      | Practical             |      |                       |      | Total |
|                                  |          |           |        | University Assessment     |      | Continuous Assessment |      | University Assessment |      | Continuous Assessment |      |       |
|                                  |          |           |        | Min.                      | Max. | Min.                  | Max. | Min.                  | Max. | Min.                  | Max. |       |
| 4                                | -        | 2         | 5      | 28                        | 70   | 12                    | 30   | 12                    | 30   | 08                    | 20   | 150   |

**Course Contents:**

| Sr. No. | Topic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Total Hours | Weightage (%) |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------|
| 1       | <b>Design of 3-phase Transformer:</b><br>Specification, Output equation of transformer, Output equation- Volt per turn, Stacking factor, Design of core, Choice of flux density and current density, Choice of window space factor, window dimensions, Design of yoke, Overall dimensions, examples, Design of high voltage and low voltage winding, examples, Estimation of operating characteristics: Primary & Secondary resistance, Leakage reactance of windings, Regulation, examples, Optimum designs, Temperature rise of transformer, Design of tank, examples.                                                                                                                                           | 12          | 20%           |
| 2       | <b>Synchronous Machines Design:</b><br>Choice of specific electrical loadings, Choice of specific magnetic loadings, Output equation and design of main dimensions, Short Circuit Ratio (SCR) and its significance, Length of air gap and shape of pole face. <b>ARMATURE DESIGN:</b> Armature winding (Single layer and double layer), Number of armature slots, Slot dimensions, Length of mean turn, Calculation of armature resistance and reactance. <b>DESIGN OF FIELD SYSTEM:</b> Design of magnetic circuit, Open circuit characteristic, Determination of full load field MMF, Design of field winding, Determination of direct and quadrature axis synchronous reactance, Short circuit characteristics. | 16          | 30%           |

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |    |     |
|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|-----|
|   | DESIGN OF TURBO ALTERNATORS: Main dimensions, Length of air gap, Stator & Rotor design. Design considerations for low speed alternators and vertically operated alternator                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |    |     |
| 3 | <b>Design Of Single Phase Induction Motor:</b><br>Output equation, Choice of specific loadings, Design of main dimensions, Design of stator, Design of rotor, Design of auxiliary winding. Rotor resistance, Stator resistance, Iron loss, Friction and windage loss, Starting torque, Calculation of capacitance for maximum torque.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 08 | 15% |
| 4 | <b>Design Of Three Phase Induction Motor:</b><br>MAIN DIMENSIONS: Output equation, choice of specific loadings, separation of D and L. STATOR DESIGN: Stator winding design, Calculation of no. of turns per phase, Conductor's area, Shape of the stator slots, Area of stator slots, Stator teeth design, Depth of the stator core, Length of air gap, Numerical problems related to above topics.<br>ROTOR DESIGN: Squirrel cage rotor – Selection of no. of rotor slots, Effect of harmonics and choice of rotor slots to minimize harmonics, vibration, noise and voltage ripples, Rules for selecting no. of rotor slots, Methods for reducing harmonic torque, Design of rotor bars and rotor slots. Design of end rings and rotor core. Examples based on above topic.<br>B. Wound rotor - Calculation of number of rotor slots, Number of turns, Cross sectional area of rotor conductors, Types of rotor windings, PERFORMANCE PARAMETERS EVALUATION: No load current calculation, Stator and rotor resistance and reactance calculation, Dispersion coefficient – effect on maximum output power factor Design aspects for large size machine, High voltage machine, High speed machine. Design of submersible motors. Numerical problems based on above topics. | 18 | 35% |

#### Reference Books:

1. A Course in electrical machine design – A. K. Sawhney, Dhanpat Rai and Sons, 1998.
2. Electrical machine design – R. K. Agrawal, S.K. Kataria & Sons, 2004.
3. Design of Electrical machines – V. N. Mittle, Standard Publishers Distributors, 2000.
4. Design and Testing of Electrical Machines – M V Deshpande, PHI, 3<sup>rd</sup> edition, 2009.
5. The performance and design of alternating current machines by M.G. Say, CBS Publishers & Distributors, 2005.

#### List of Experiments:

1. During the laboratory hours, the design problems based on the syllabus should be assigned to the students.
2. After carrying out the detailed design, minimum four (04) drawing sketches (drawing sheets) should be prepared by the students.

#### List of Open Source Software/learning website:

- <http://www.electrical-engineering-portal.com/>
- <http://nptel.iitm.ac.in/courses.php>

**Course Learning Outcomes (CLO):** On completion of this course, the students will be able to:

| CLO  | Description                                               | Bloom's Taxonomy Level          |
|------|-----------------------------------------------------------|---------------------------------|
| CLO1 | To understand the design of 3-phase Transformer           | 2 Understanding                 |
| CLO2 | To design of synchronous machines.                        | 5 Evaluating                    |
| CLO3 | To understand the design of 1-phase Induction machines    | 2 Understanding<br>5 Evaluating |
| CLO4 | To understand the design of 3-phase Induction machines    | 2 Understanding<br>5 Evaluating |
| CLO5 | To learn the basics of computer aided design.             | 1 Remembering                   |
| CLO6 | To select a special Machine for a particular application. | 4 Analyzing                     |

**Mapping of CLOs with POs & PSOs**

| Course Learning Outcomes | Program Outcomes (POs) |     |     |     |     |     |     |     |     |      |      |      | Program Specific Outcomes(PSOs) |      |      |      |
|--------------------------|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|---------------------------------|------|------|------|
|                          | PO1                    | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1                            | PSO2 | PSO3 | PSO4 |
| CLO1                     | M                      |     | M   |     | L   | H   |     | L   | M   |      |      |      | M                               |      | L    |      |
| CLO2                     |                        | M   |     |     |     |     | L   |     |     |      | L    |      |                                 |      |      | L    |
| CLO3                     |                        | H   | L   |     |     |     |     |     | M   |      | M    |      |                                 |      |      |      |
| CLO4                     |                        |     |     | L   |     | M   |     |     |     |      |      |      |                                 | L    |      |      |
| CLO5                     | L                      |     | L   |     |     |     |     |     |     | M    |      |      | I                               |      |      |      |
| CLO6                     |                        |     |     | H   | M   |     | L   |     |     |      | M    |      |                                 |      | H    | L    |

H: High, M: Medium, L: Low