GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Electrical Engineering

Subject Code: BE03009021

Subject Name: Electrical Machines-I

w.e.f. Academic Year:	2024-25
Semester:	3
Category of the Course:	PCC

Prerequisite:	Basics of Electrical Engineering
Rationale:	This course provides foundational knowledge of transformers and induction motors, essential components in electrical power systems and industrial applications. It equips students with analytical and practical skills for evaluating machine performance, efficiency, and control methods. By integrating theoretical concepts with hands-on analysis, the course prepares students for real-world challenges in power engineering.

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Single Phase Transformer:** Review of single phase transformer, E.M.F. equation, Equivalent circuit, phasor diagram for different powerfactor, Losses, separation of no-load losses, conditions for maximum efficiency, determination of equivalent circuit parameters, calculation of efficiency and voltage regulation using O.C. and S.C. Test, Sumpner's test. Polarity test, Determination of Efficiency and Voltage regulation by direct load test, Concept of all-day efficiency. Parallel operation of transformers and Load sharing under different operating conditions. Auto transformer, saving of copper and applications. Numerical based on above topics.	11	25

2.	**Three Phase Transformer:** Construction, types of connection and their comparative features, Vector groups, Types of Transformers, terminal marking and nomenclature, protective and safety devices fitted on Transformers, Parallel operation of three phase transformers, Magnetizing current, Phase conversion - Scott connection, No-load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers. Short Circuit Forces and Mechanical stresses, Application of transformers in various electrical systems	11	25
3.	**Three Phase Induction Machine:** Constructional details, classification, principle of operation, production of rotating magnetic field, Torque equations for starting, full load and maximum operating conditions, condition for maximum-output, slip for maximum-output, Torque-slip characteristics, Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency), Effect of Harmonics, Crawling and Cogging of induction motor, Phasor-diagram, equivalent circuit. Losses and efficiency, Tests on Induction Motor: No load and blocked rotor test-determination of equivalent circuit parameters. Predetermination of performance under different operating condition using circle diagram. Methods of starting and speed control for induction motors with conventional methods and static convertors. Energy Efficient three phase induction motor. Numerical based on above topics. Induction Generator: Principle of operation, equivalent circuit and application.	16	35
4.	**Single Phase AC Motor:** Double field revolving theory, Starting & running performance of 1-phase induction Motor, Equivalent circuit of 1- induction motor, Types of single-phase motors, Principle and operation of split phase, Resistance start, Capacitor start and capacitor start & run induction motor, Shaded pole induction motor, Universal motor. Repulsion motor. Applications of various single phase induction motors	07	15
			100

Suggested Specification Table with Marks(Theory):

DistributionofTheoryMarks					
RLevel	**ULevel**	**ALevel**	**NLevel**	**ELevel**	**CLevel**
20	20	20	20	20	0

WhereR:Remember;U:Understanding;A:Application,N:AnalyzeandE:EvaluateC:Create(asperRevisedBloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1) E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2) I J Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
3) J B Gupta, "Theory and Performance of Electrical Machines", Katson Publication, 2009.
4) B L Theraja, "Electrical Technology – Part II", S Chand Publications, 2011
5) M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
6) P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
7) G C Garg, "Electrical machines – II", Khanna Publishers,
8) S K Sen,"Principle of Electrical Machine Design with Computer Programs" Oxford & IBH

b) Open-Source Software:

Scilab (https://www.scilab.org/) – An open-source alternative to MATLAB, useful for circuit analysis, transformer calculations, and motor performance analysis.

1. **Octave** (https://www.gnu.org/software/octave/) – Useful for numerical calculations and simulation of electrical machines.
2. **PSIM (Free Version) / OpenModelica** (https://openmodelica.org/) – For modeling and simulating electrical circuits and machines.
3. **FEMM (Finite Element Method Magnetics)** (http://www.femm.info/) – Used for electromagnetic field analysis of transformers and induction motors.
4. **KiCad** (https://www.kicad.org/) – Open-source PCB design tool, useful for designing small transformer circuits.
5. **LTspice** (https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html) –

For circuit simulation, including transformer and motor circuits.

C) Websites for Learning and Simulation:

1. **All About Circuits** (https://www.allaboutcircuits.com/) – Excellent resource for learning about transformers, motors, and electrical engineering concepts.
2. **Electrical4U** (https://www.electrical4u.com/) – Provides detailed explanations of electrical machines, transformers, and motor operation.
3. **MIT OpenCourseWare** (https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/) – Free courses on electrical machines and power electronics.
4. **CircuitLab (Free with limited access)** (https://www.circuitlab.com/) – Web-based circuit simulator for testing transformer and motor circuits.
5. **Virtual Labs by IITs (Government of India Initiative)** (https://vlab.co.in/) – Simulations and experiments related to transformers and induction motors.

Suggested Course Practical List:

1) To separate hysteresis and eddy current losses of a single-phase transformer at rated voltage, frequency by conducting no load tests at different frequencies keeping V/f constant.
2) To conduct the open and short circuit tests on a single-phase transformer to determine core losses, copper losses, and hence determine regulation, efficiency and the parameters of the equivalent circuit.
3) To conduct Sumpner test on two identical single-phase transformers and determine their efficiency at various loads.
4) To make Scott connection of two single phase transformer and to verify the three phases to two phase conversion.
5) To conduct open circuit and short circuit test on a three-phase transformer and determine the equivalent circuit parameters.
6) To perform No load test and blocked rotor test on 3 phase Induction motor and determine equivalent circuit parameters
7) To perform No load and blocked rotor test on three phase induction motor to evaluate the performance parameters using circle diagram.
8) To perform direct load test on three phase Induction motor to evaluate its performance parameters at different load conditions
9) To perform various starting and speed control methods for three phase induction motor
10) To perform no load and blocked rotor test on single phase induction motor to obtain the parameters of equivalent circuit

List of Laboratory Resources Required:

1. Transformers and Induction Machines:

- Single-Phase Transformers (Different KVA Ratings)

- Three-Phase Transformers (Star-Delta, Delta-Delta, Star-Star, etc.)
- Auto-Transformers (Variable voltage supply)
- Tap-Changing Transformers (No-load & On-load)
- Scott-Connected Transformer Setup (Three-phase to Two-phase conversion)
- Three-Winding Transformer
- Three-Phase Induction Motors (Squirrel Cage & Slip-Ring types, various power ratings)
- Single-Phase Induction Motors (Split-phase, Capacitor start, Capacitor run, Shaded pole)
- Induction Generators
- Cut section of various machines

2. Testing and Measurement Instruments:

- Multimeters (Digital & Analog)
- Wattmeters (Single-phase & Three-phase)
- AC/DC Voltmeters & Ammeters
- Frequency Meters
- Power Factor Meter
- Open Circuit & Short Circuit Test Setup (for Transformers)
- Polarity Test Kit
- Slip Measurement Setup (Tachometer, Stroboscope)
- No-load & Blocked Rotor Test Setup (for Induction Motors)
- Torque Meter (Digital/Analog)
- Loading Rheostats
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3. Power and Control Systems:

- Three-Phase & Single-Phase Power Supply Panels
- DOL (Direct-On-Line) Starters
- Star-Delta Starters
- Auto-Transformer Starters
- Soft Starters for Induction Motors
- Variable Frequency Drives (VFDs) (for speed control of induction motors)

Capacitor Banks (for Power Factor Improvement)

- Protection Relays (Overload, Overvoltage, Undervoltage)

4. Accessories & Safety Tools:

- Connecting Wires (High voltage & Low voltage)
- Clamp Meters & Power Analyzers
- Autotransformer (Variac)
- Breadboards & Soldering Stations
- Safety Equipment (Insulated gloves, Fire extinguisher, First Aid kit)

- **Activities suggested under self learning**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
4.	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding based assignment of 2h each. Total = 10h	Based on the coding solution submitted.
5.	Self learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
7	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
8	Discussion on research paper based on relevant subject	5 research paper = 20 h	Summarize research paper and evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration = 15 h for industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical	Duration = 1 h each	Based on performance in group discussion, technical depth,

	topics based on subject		knowledge etc.
13.	Real world case studies based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration = 10 h	Depending on the complexity of the Application/Software
15	Blog or Technical Article Writing	10h (Research – 6h, Writing – 4h)	Based on originality, technical content, references cited, and clarity of communication.
16	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
17	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
18	Tech Blog/YouTube Channel Curation	10h (Content curation + Analysis)	Summary report on curated content and learning outcomes.
19	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.
20	Maintenance or Troubleshooting Logbook	10h (For example: lab instruments, computer hardware)	Based on documented cases, approach, and resolution.

Note:

- All the suggested activity should be related to the subject.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
- Rubrics for the evaluation can be prepared by the faculty.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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