GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL & ELECTRONICS ENGINEERING (08) & ELECTRICAL ENGINEERING (09)

AC MACHINES

SUBJECT CODE: 2140906

B.E. 4th SEMESTER

Type of Course: Engineering Science (Electrical)

Prerequisite: Elements of Electrical Engineering

Rationale: The course will provide strong foundation on A. C. Machines which will be useful for understanding foundation of operation, working, analysis testing and applications of single and three phase motors. The students will learn to proper applications of motors for their efficient use in industry. Students will also explore the industrial applications of such motors.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Poly-phase Induction Motor:** Construction, Types of motor, Working principle, Rotating magnetic field. Operating parameters at different load, No-load & blocked rotor test, Equivalent circuit, Phasor diagram, Circle diagram, Efficiency and slip scale with the help of circle diagram, Effect of rotor resistance on performance of motor, Double cage motor and its equivalent circuit, Introduction to machine dynamics. Starters of poly-phase induction motor including soft starter, Methods of speed control of 3- phase motor, Schematic diagram and advantages of Variable Voltage Variable Frequency drive. Electrical transients in induction machine, Magnetic levitation : Principle, advantages and application of linear induction motor. Effect of harmonics, Harmonic torques, Cogging & Crawling, Effect of unbalanced voltages on performance of motor. Performance of motor with variable voltage and frequency. Testing of induction motor as per IS, Energy efficient motors.	**20**	**35**
2	**Induction Generator**, Principle of operation and application, Its load and p. f. control.	**2**	**5**
3	**Single phase A. C. motors:** Double field revolving theory, Starting & running performance of 1-phase induction Motor, Equivalent circuit of 1phase induction motor, Types of single phase motors, Principle and operation of split phase, Resistance start, Capacitor start and capacitor start & run induction	**6**	**10**

	motor, Shaded pole induction motor, Fractional horse power motors.		
4	**Synchronous Machines:** Construction, Types, Applications, Working principle. Equation of induced emf with and without harmonics in MMF, pitch factor and distribution factor, MMF of distributed windings, Torque equation, Machine efficiency, Armature reaction and its compensation, Short circuit ratio, Effect of change in excitation, Effect of change in torque and speed, Voltage regulation, Determination of voltage regulation by Synchronous impedance method, MMF method, ZPF method and AIEE method, Synchronization : Importance and Methods of synchronization. Operating characteristic, Load angle and Power flow equations, Capability curves, Two reaction model of Salient pole machines, Parallel operation, Load sharing between parallel connected generators, Effect of unequal voltages & unequal percentage impedance, Governor characteristics, Introduction to single phase generators, Slip test for measurement of direct axis and quadrature axis reactance for salient pole machine, Sudden short circuit of Synchronous machine, Hunting of synchronous machines and its prevention.	**20**	**35**
5	**Synchronous Motor:** Methods of starting of synchronous motors, Different torques in Synchronous motor, Stability, Synchronous condenser, Synchronous phase modifiers, V-curves and O-curves of Synchronous motors, **Auto Synchronous Motor:** Construction, principle of operation, equivalent excitation current for various rotor connections, circle diagram.	**5**	**10**
6	**Commutator motors:** Construction and working principle of Schrage motor, Universal motor and Repulsion motor.	**3**	**5**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
20	15	15	10	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Gupta J B, Electrical Machines, S K Kataria Publications
2. Theraja B L, Electrical Technology – Vol II, S Chand Publications
3. Nagrath I J and Kothari D P, Electric Machines, Tata McGraw Hill
4. Ghosh Samarjit, Electrical Machines, Pearson Education
5. Bhimbra P S, Electrical Machinery, Khanna Publishers
6. Say M G, Theory, Performance & Design of A.C. Machines, CBS Publishers.
7. Fitzgerald A.E and Kingsley, Electrical Machinery, Tata McGraw

Course Outcomes:

After learning the course the students should be able to:

1. Explain the construction, working principle, performance and applications of Poly-phase induction motor,
2. single phase motors, synchronous generator (Alternator), synchronous motor and commutator motors.
3. Perform experiments on above machines.
4. Describe the need of these machines in the society.
5. Identify, formulate and solve the numerical problems related to above machines

List of Open Source Software/learning website:

1) Literature available in any laboratory manual of Pharmaceutical Industries.
2) Literature available on internet
3) Medical dictionaries
4) Delnet

List of Experiments: (This is a suggestive list only)

(1) To perform no load and blocked rotor test on a three phase induction motor to find out its performance parameters with the help of (a) Equivalent circuit (b) Circle diagram
(2) To perform direct load test on a three phase induction motor to find out its performance parameters at different load conditions.
(3) To study the construction of a three phase induction motor with the help of a cut section model.
(4) To study about the starters of three phase induction motors.
(5) To study about the speed control methods for three phase induction motors.
(6) To observe and compare the performance of three phase motor with VVVF drive.
(7) To perform no load and blocked rotor test on single phase induction motor to obtain its equivalent circuit.
(8) To study about the induction generator.
(9) To perform the speed control and power factor control of a Schrage motor.
(10) To perform open circuit, short circuit and resistance measurement tests on a synchronous generator (alternator) and to find out its voltage regulation by different methods.
(a) Synchronous impedance method (b) MMF method (c) ZPF method (d) AIEE method
(11) To obtain the direct axis and quadrature axis synchronous reactance of a salient pole machine with the slip test.
(12) To perform the synchronization of two three phase alternators (or one alternator with grid) using different methods. (a) Lamps dark method (b) Two bright one dark method (c) Synchroscope
(13) To obtain the V-curves of a synchronous motor.

Design based Problems (DP)/Open Ended Problem:

(1) List the commonly used rotating electrical machines around us. Identify which application uses which machine.
(2) Identify the common problems/faults in these machines.
(3) Suggest the possible solutions/remedies for these problems

Major Equipment:

Lab set ups of following machines

(1) Squirrel cage induction motor connected to self excited DC generator (with appropriate starter)
(2) Slip ring induction motor connected to self excited DC generator (with appropriate starter)
(3) Single phase induction motor
(4) Cut section models of (a) squirrel cage motor (b) slip ring motor (c) Alternator
(5) DC shunt motor coupled to a three phase alternator - preferably salient pole type (two sets)

(6) Auto synchronous motor
(7) Schrage motor
(8) VVVF drive of suitable rating for the induction motor-generator set.

Digital multimeters, Ameters, Voltmeters, Wattmeters, Digital power meters, Techometers, Synchroscope, Lamp boards, Rheostates, Loading rheostates, DC variable voltage source of minimum 40A, 0 to 240 V rating.

List of Open Source Software/learning website:

Open Source Software:
- LTSpice for circuit simulation,
- KiCAD for CAD application
Web-based tools for design:
- http://www.fairchildsemi.com/support/design-tools/power-supply-webdesigner/
- http://www.ti.com/lsds/ti/analog/webench/overview.page
Circuit Lab:
- https://www.circuitlab.com/editor/
Open source Math Tools:
- http://maxima.sourceforge.net/
- http://www.sagemath.org/
- http://www.scilab.org/
- http://www.gnu.org/software/octave/
Learning website
- http://www.electrical-engineering-portal.com/
- http://nptel.iitm.ac.in/courses.php

Virtual Lab Website

www.vlab.co.in

Active Learning Assignments (ALA) : Preparation of power-point slides: which may include videos, animations, pictures, graphics for better understanding of theory and practical work. The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus can be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of faculty and the department.