GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3132407
Semester – III
Subject Name: Electrical Machines and Applications

Type of course: Engineering Science

Prerequisite: Fundamental of Electrical Engineering

Rationale: An Electrical machine is one of the key components of the energy transition from traditional fossil energy to renewable energy. The purpose of this course is to introduce the fundamentals of electrical machines and their applications in drive systems. The students should have an in-depth understanding of energy conversion and understand the principles of the most commonly used machines from a series of theories and lab exercises. The classical theories of electromagnetic energy conversion and electromechanical energy conversion will be introduced first. The induction machines and the synchronous machines will then be treated after introducing the rotational field theories. The drive systems and the mechanical transmission elements will be explained and examples of their applications will be given in the lectures. Different operating modes of the electrical machines will be treated and the thermal characteristics will also be discussed.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Transformers:** Single Phase Transformer: Working principle, Construction, types, EMF equation, Transformer on no load and on load, vector diagram, exact and approximate equivalent circuit, O.C & S.C. test on transformer, regulation of transformer, losses &efficiency, condition for maximum efficiency, All day efficiency, Efficiency curve, Sumpner's test, Auto transformer, Saving of conductor material, Parallel operation, Conditions, Parallel with equal and unequal voltage ratio. 3 Phase transformers: Construction, connections, Scott connection, V-V Connection, Instrument transformers, Current transformers and potential transformers. Application of Transformer	12

2	**Induction Machines:** 3 Phase induction motor: Construction, types, rotating magnetic field, principle of operation, slip, frequency of rotor current, rotor EMF, rotor current, expression for torque, conditions for maximum torque, torque slip characteristics, starting torque in squirrel cage and slip ring motors, effect of change in supply voltage on torque, slip and speed , relation between full load torque and maximum torque, Power stages in induction motor, vector diagram and equivalent circuit, circle diagram, construction and calculation, speed control of 3 phase motor, starting methods for 3 phase induction motors, need for starter and types of starter, applications Single phase motor: Double revolving field theory, starting methods, no load and block rotor test, equivalent circuit, types of single phase motor, applications.	**12**
3	**DC Machines:** DC Generator: Electromechanical Energy Conversion Principal, Constructional features, EMF equation of dc generator, methods of excitation, losses and condition for maximum efficiency, armature reaction, interpoles and compensating winding, commutation, methods of improving commutation, Types and characteristics of separately excited and self excited dc generator. DC Motor: Working principle, force and torque in magnetic field System, voltage equation, condition for maximum power, characteristics, operating characteristics of dc motor, torque equations, starting methods ,need for Starter, 3 point and 4 point starter, speed control methods.	**12**
4	**Synchronous Machine:** Alternator: Basic principle, construction, pitch factor, distribution factor, EMF equation, alternator on load, voltage regulation, synchronous impedance method, MMF method, ZPF method, parallel operation, synchronization of alternator. Synchronous motor: Basic principle, methods of starting, Characteristics and application.	**08**
5	**Introduction to Special Machine:** General construction, Principle, working, characteristics and applications. AC & DC Servo motors. Amplidyne and Metadyne, Printed Circuit Motors, Brushless DC motors, Synchros, Reluctance Motor, Stepper Motor. Linear Induction Motor.	**06**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks

R Level	U Level	A Level	N Level	E Level	C Level
12	23	20	5	5	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create 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 Electrical Machinery: A. E. Fitzgerald, Charles Kingsley.
2 Text of Electrical Technology; Vol - 2; B. L. Theraja, and A. K. Theraja;
3 Electrical Machines: Ashfaq Hussain.
4 Generalized Theory of Rotating Machines: P S Bhimra.
5 Stepping Motors – A Guide to Motor Theory and Practice: P.P. Aearnley.
6 Permanent Magnet and Brushless DC Motors: T. Kenjo and S. Nagamori.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Acquire knowledge about the constructional details, principle of operation, testing and applications of single & three phase transformers.	25
CO-2	Acquire knowledge about the constructional details and principle of operation of three phase and single phase induction motors.	25
CO-3	Acquire knowledge about the constructional details and principle of operation of dc machines.	20
CO-4	Acquire knowledge about the constructional details and principle of operation of alternators and Synchronous motor.	15
CO-5	Acquire the knowledge of fundamentals, construction details and classification of special electrical machines like universal motors, reluctance motors, hysteresis motors, Stepper and Servo Motor.	15

Suggested List of Experiments:

1 To operate two single phase transformers of different KVA ratings in parallel and plot the variation of currents shared by each transformer versus load current.
2 To perform Open Circuit and Short circuit Test on a transformer and find it's efficient and regulation. Speed control of DC Shunt Motor using a) Armature control and b) field control methods
3 To obtain Magnetizing Characteristics, Internal & External Characteristic of Self Excited DC Shunt Generator. Also obtain the critical filed resistance of the machine from magnetizing Characteristics.

4 To conduct direct load test on a D.C. compound generator with a) Shunt field alone b) Cumulative and differential compounding for short and long shunt connections.
5 To obtain Speed-Torque characteristics of DC Series Motor
6 To obtain Speed-Torque characteristics of DC Shunt Motor.
7 To study different starters of D. C. motor.
8 To study different starters of three phase induction motor
9 To perform No load and Block rotor test on induction motor and plot equivalent circuit
10 To Study the effect of Inserting resistance on rotor of Slip ring induction motor.
11 To draw the V curves for synchronous machine.
12 To find the voltage regulation of synchronous machine.
13 To study capacitor start and capacitor run induction motor.
14 To study Characteristics and Construction of Stepper Motor.
15 To Study Construction and Characteristics of Linear Induction Motor

Design based Problems (DP)/Open Ended Problem:

1. To find the applications of various single phases/ three AC and DC motors.
2. Automatic Star Delta Starter by using Relays and Adjustable Electronic Timer for Induction Motor.
3. Direct Current Motor Speed Control through Push Switches.
4. To find suitable application and Control of Stepper Motor or Reluctance Motor.

Major Equipment:

Single & Three Transformer, Single phase and three phase induction motor, synchronous machine, DC Motor, Stepper Motor, Servo Motor, Reluctance and PMBLDC motor.

List of Open Source Software/learning website:

Open source Math Tools: - http://maxima.sourceforge.net/
http://www.sagemath.org/
http://www.scilab.org/
http://www.gnu.org/software/octave/

Learning website:
https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-685-electric-machines-fall-2013/course-notes/
https://nptel.ac.in/courses/108105017/
https://nptel.ac.in/courses/108106072/
http://pwe.vgecg.ac.in/home/semester_iii/dcm-t
http://pwe.vgecg.ac.in/home/semester_v/emec-ii
http://pwe.vgecg.ac.in/home/semester_vi/idc-i

Active learning Assignments (AL) : Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work. The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to 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 the faculty, Department and College on the first slide. The best three works should submit to GTU.