GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: AC ROTATING MACHINES
(Code: 3342402)

Diploma Programme in which this course is offered	Semester in which offered
Power Electronics Engineering	4th Semester

1. RATIONALE

Different types of AC machines with power electronic applications are widely used in the industry. It is because of power electronics that renewable energy could make major inroads in the electrical power sector especially in the use of squirrel cage induction generators, wound rotor induction generators, doubly fed induction generators and synchronous generators. Therefore, this course is intended to enable the student understand the facts, concepts, principles and procedure of operation and control of various AC machines used in the industry, which will enable him/her to get employment and work effectively in the industry. These skills developed through this course will help the student to function confidently in his/her career.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Operate different types of AC machines efficiently**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Operate single phase induction motor efficiently
ii. Operate polyphase induction machines efficiently
iii. Operate synchronous machines efficiently
iv. Operate AC commutator machines efficiently
v. Operate AC special machines efficiently

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
4	0	2	6	70	30	20	30	**150**

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I **Single Phase Induction Motor**	1a. Describe working principle of single phase induction motor.	1.1 Single phase induction motor: Construction, working principle, rotating field 1.2 Power developed in single phase single winding induction motor.
	1b. Describe no load and blocked rotor test with sketches and its significance. 1c. Describe the effect of losses in single phase single winding induction motor.	1.3 Blocked rotor test, No load test, Losses in the induction motor
	1d. Describe the starting methods of different types of induction motors 1e. Discriminate between different types of single phase induction motors.	1.4 Starting of Induction Motor 1.5 Types of single phase motors, split phase motor, capacitor-start motor, capacitor-start capacitor-run motor, permanent split capacitor motor, shaded pole motor
UNIT-II **Three Phase Induction Machines**	2a. Explain working principle of three phase induction motor including the phasor diagram. 2b. Define rotor frequency, rotor emf, current and rotor power. 2c. Calculate losses and efficiency of induction motor 2d. Explain the torque-speed and power-slip characteristic of the induction machine. 2e. Describe starting methods of three phase induction motors. 2f. Explain speed control methods of three phase induction motors. 2g. Explain cogging and crawling phenomenon in induction motors.	2.1 Poly phase induction motor: Construction, working principle, power across air gap, torque and output, Phasor diagram 2.2 Rotor frequency, rotor emf, current and power, Losses and efficiency 2.3 Torque-slip and power-slip characteristics 2.4 Starting: starting methods of squirrel-cage and wound rotor motor 2.5 Speed control methods 2.6 Cogging and crawling
	2h. Explain the working principle of squirrel cage induction generator 2i. Differentiate between squirrel cage and wound rotor induction generator 2j. Explain power factor control of squirrel cage and wound rotor induction generator 2k. Explain the working of a doubly fed induction generator	2.7 Squirrel cage induction generator 2.8 Wound rotor induction generator 2.9 Power factor control 2.10 Doubly fed induction generator
UNIT – III **Poly Phase Synchronous Machine**	3a. Explain the working principle of synchronous machine with phasor diagram 3b. Explain the armature reaction 3c. Calculate efficiency of synchronous machine 3d. Explain starting methods of synchronous machine	3.1 Synchronous machine: construction, working principle with phasor diagram characteristics, Armature reaction 3.2 Losses, efficiency, 3.3 Starting methods of synchronous motor

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	3e. Explain need of damper winding and define hunting in synchronous machine. 3f. Explain power factor control of synchronous machine. 3g. Explain V-curve and inverted V-curve for synchronous machine. 3h. Explain the significance of X_d and X_q 3i. Explain the power angle characteristics of cylindrical rotor and salient pole synchronous machine. 3j. Sketch with labels the back-to-back converters used in variable speed synchronous generators widely used in solar and wind energy applications.	3.3 Hunting and damper winding 3.4 V-curve and inverted V-curve 3.5 X_d and X_q 3.6 Power angle characteristics of cylindrical rotor and salient pole synchronous machine
UNIT – IV **Ac Commutator Motor**	4a. Explain construction, working principle, of single phase series motor with phasor diagram.	4.1 Single Phase series Motor: construction, working principle with phasor diagram and application.
	4b. Explain the working of Universal motor with phasor diagram.	4.2 Universal Motor: construction, working principle with phasor diagram
	4c. Describe the salient features of Repulsion motor with phasor diagram. 4d. Differentiate the working principles of various types of Repulsion motors	4.3 Repulsion Motor: construction, working principle 4.4 Various types repulsion motors: repulsion induction motor repulsion start induction motor, compensated repulsion motors, and applications.
UNIT –V **Special Electrical Machines**	5a. Explain the working of Reluctance motor with its characteristics.	5.1 Reluctance Motor: working principle, characteristics and its applications.
	5b. Explain the working of Stepper motor with its characteristics. 5c. Differentiate the working principles of various types of stepper motors. 5d. Explain the working of Hysteresis motor with its characteristics.	5.2 Stepper Motor: construction, working principle, characteristics, 5.3 Various types: variable reluctance, permanent magnet, hybrid stepper motor and applications.
	5e. Explain the working of Hysterisis motor with its torque-speed characteristics.	5.4 Hysteresis Motor: working principle, torque-speed characteristics and applications.
	5f. Explain the working of linear induction motor and its application. 5g. Explain the working of Permanent Magnet AC motor and its application.	5.5 Linear Induction Motor: working principle and applications.
	5h. Explain the working of Permanent Magnet AC motor and its application.	5.6 Permanent Magnet AC motors and applications.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Single Phase Induction Motor.	8	3	5	2	10
II	Three Phase Induction Machine	16	3	11	6	20
III	Poly phase Synchronous Machine	16	3	12	5	20
IV	AC Commutator Motor	7	4	5	0	9
V	Special Electrical Machines	9	5	6	0	11
	Total	**56**	**18**	**39**	**13**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised 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.

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*
Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise (Outcomes' in Psychomotor Domain)	Apprx. Hrs. Required
1	I	Identify the parts of the 3-phase squirrel cage and wound rotor induction motors and different types of single induction motors.	2
2	I	Test the performance of single-phase induction motor.	2
3	II	Use three phase induction motor starters.	2
4	II	Test the performance of 3-phase squirrel cage induction motor.	2
5	II	Test the performance of 3 phase slip ring induction motor.	4
6	III	Test the performance of Synchronous machine.	2
7	III	V and inverted V curve of synchronous motor.	4
8	III	Determin X_d and X_q of a salient pole synchronous machine.	4
9	IV	Test the performance of universal motor.	2
10	IV	Test the performance of Repulsion motor.	2
11	IV	Test the performance of Schrage Motor.	2
12	V	Test the performance of Stepper motor.	2
13	V	Test the performance of Two phase servomotor.	2

S. No.	Unit No.	Practical/Exercise (Outcomes' in Psychomotor Domain)	Apprx. Hrs. Required
14	V	Test the performance of Hysteresis Motor.	2
15	V	Test the performance of Linear Induction Motor.	2
16	V	Test the performance of Permanent Magnet AC motor.	2
Total Hrs (perform practical worth 28 hours so that most units are covered)			**44**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare charts for construction of various AC motors.
ii. Visit power plant for observing controlling action of AC motors.
iii. Compare various AC motors according to its applications.

9. SPECIAL INSTRUCTIONAL STRATEGY (If Any)

Show video/animation films explaining working principles, constructional features, testing and maintenance of different types of AC rotating machines.

10. SUGGESTED LEARNING RESOURCES

A. List of Books

S. No.	Title of Books	Author	Publication
1	Electrical Machines	Kothari D. P. Nagrath I. J.	Tata McGraw-Hill, New Delhi, latest edition
2	Electrical Machinery	Bimbhra P. S.	Khanna Publishers, New Delhi, latest edition
3	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi
4	Electrical Machines	Smarajit Ghosh	Pearson Education, New Delhi, latest edition
5	Text book of electrical technology	Theraja B.L. Theraja A.K.	S.Chand, New Delhi, latest edition
6	Fundamentals of electrical machines	Gupta B.R. Vandana Singhal	New Age, New Delhi, latest edition

B. List of Major Equipment/Materials with Broad Specifications

i. Synchronous motor (3-phase, 415v, 3kva,3.5a,1500 rpm)
ii. Induction motor, 1-phase (55 W max , AC 220V, 50 Hz)
iii. Induction motor, 3-phase (415 V, 50 Hz,5 hp,1500rpm,8A)
iv. Starter(DOL)
v. Rheostat 250/1.5A
vi. SPST switch
vii. Stepper motor (FHP)
viii. Wattmeter 5A/300V LPF10A/75V UPF.

C. List of Software/Learning Websites

i. www.nptel.iitm.ac.in
ii. http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-867-machine learning-fall-2006/

iii. http://www.indiabix.com/online-test/electrical-engineering-test/143
iv. http://freevideolectures.com/Course/3085/Electrical-Machines-I

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. S. A. Patel**, LPE, Dept. of Power Electronics, Dr. S. & S. S. Ghandhy College of Engg. and Technology, Surat.
- **Prof. S. L. Dhoriyani**, LPE, Dept. of Power Electronics, Dr. S. and S. S. Ghandhy College of Engg. and Technology, Surat.

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. A.S.Walkey**, Associate Professor, Department of Electrical and Electronics Engineering
- **Dr. N.P. Patidar**, Professor, Department of Electrical and Electronics Engineering