GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: POLYPHASE TRANSFORMERS AND ROTATING AC MACHINES
(Code: 3340901)

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

1. RATIONALE

Polyphase (mainly 3 phase) transformers are widely employed in power grids and transmissions lines starting from generating station till the consumer end. Every generating station uses alternators for electricity generation. Induction motors and Synchronous motors are widely used in industries, farms and domestic applications. It is therefore must for electrical engineers to posses knowledge and skills required to operate and maintain 3 phase transformers, induction motors, synchronous motors and alternators. This course attempts to develop these skills into the students.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Operate and Maintain transformers and rotating AC machines.**

3. COURSE OUTCOMES

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

i. Conduct various routine tests on 3 phase transformer.
ii. Operate 3- phase transformers in parallel.
iii. Select a 3- phase or 1- phase induction motor for a given application.
iv. Synchronize an alternator with bus bar or another alternator.
v. Use Synchronous machines for power factor improvement.
vi. Maintain rotating AC machines.

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	4	8	70	30	40	60	200

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **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. Poly Phase Transformer	1a. Justify the advantage of using 3-phase transformer over a bank of 3 single phase transformers 1b. With sketches explain the major parts of the 3-phase transformer 1c. Sketch the different types of connections of 3-phase transformer including vector groups 1d. With sketches the describe the need of parallel operation of 3 phase transformers . 1e. State the maintenance procedure and the transformer oil change process	1.1 Comparison of three phase transformer with bank of three single phase transformers. 1.2 Arrangement of Core and windings in transformer, use of tap changer. Types of losses in transformers. 1.3 Construction - Accessories of 3 phase transformer: Main tank, bushings, conservator with breather, oil level gauge, radiators, buchholz relay, explosion vent, temperature indicators, junction box 1.4 Star delta connections and vector groups 1.5 Cooling of transformer: Natural cooling, Forced cooling 1.6 Parallel operation – Essential and desirable Conditions 1.7 Maintenance of different types of transformers
Unit– II Poly Phase Induction Motors	2a. Explain how a rotational field is produced in a 3 phase induction motor. 2b. Differentiate between squirrel cage and wound rotor induction motor with their salient features. 2c. Explain the torque slip characteristics of squirrel cage and wound rotor induction motor including the generation operation. 2d. Explain various methods of speed control of 3 phase induction motor. 2e. State the maintenance procedure of both squirrel cage and wound rotor induction motor	2.1 Construction, types - Squirrel cage - Single and double cage, Wound rotor 2.2 Working principle with Torque-slip curve, equivalent circuit and phasor diagram 2.3 Torque equation , Starting, running and condition for the maximum torque 2.4 Necessary and types of starters- DOL, Star delta, autotransformer type and rotor resistance starter. 2.5 No load test and Blocked rotor test, Losses and efficiency 2.6 Speed control of squirrel cage and slip-ring inductionmotor 2.7 Maintenance of different types of induction motors
Unit– III Alternator	3a. Explain the working principle of an alternator 3b. Differentiate between turbo generator and hydrogenerators 3c. Derive emf equation 3d. Determine the voltage regulation of an alternator by synchronous impedance method 3e. Synchronize an alternator with infinite bus bar. 3f. State the maintenance requirements of the alternators including the different cooling systems of the alternators	3.1 Principle of working and construction.- Salient and Cylindrical rotor 3.2 Equivalent circuit and phasor diagram 3.3 Voltage regulation by synchronous impedance method, OC, SC characteristics 3.4 Synchronization of alternator with bus bar/alternator 3.5 Cooling system of alternator 3.6 Maintenance of different types of alternators

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit–IV Synchronous Motor	4a. Connect and operate synchronous motor using proper starting method 4b. Improve the power factor of the system using synchronous condenser 4c. State the maintenance requirements of the synchronous motor 4d. Differentiate the features between the synchronous and induction motor	4.1 Principle of working, starting methods 4.2 Equivalent circuit and phasor diagram 4.3 Effect of change in excitation 'V'-curves 4.4 Synchronous condenser 4.5 Hunting and its prevention 4.6 Different torque of a synchronous motor 4.7 Maintenance of synchronous motors
Unit-V Single Phase Induction Motors	5a. Describe the working principle of different types of single phase motors. 5b. Describe the working principle of different types of fractional horse power motors 5c. Troubleshoot single phase induction motor in a ceiling fan/ cooler 5d. State the maintenance requirements of the single phase induction motor	5.1 Working of different types of single-phase induction motors 5.2 Fractional horse power motors 5.3 Speed torque characteristics 5.4 Maintenance of different types of single phase motors

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

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Polyphase Transformer	10	04	04	04	12
II	Polyphase Indcution Motors	16	08	06	04	18
III	Alternator	12	06	05	05	16
IV	Synchronous Motor	10	04	06	04	14
V	Single Phase Induction Motors	8	02	02	06	10
	Total	**56**	**24**	**23**	**23**	**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/PRACTICALS

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 Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
1	I	Identify various accessories of three phase transformer by visiting to nearby substation and draw its sketch with cooling arrangement .	4
2	I	Perform parallel operation on three phase transformer.	4
3	II	Measure the slip of 3-phase Induction motor by using Tachometer and by Stroboscopic method.	4
4	II	Reverse the direction of rotation of a 3-phase IM.	2
5	II	Perform direct load test on three phase induction motor and draw performance curves	4
6	II	Perform no load and blocked rotor test on a three phase induction motor to obtain various parameters. Also construct circle diagram to determine its performance characteristics.	4
7	II	Make connections of DOL starter / star-delta starter / auto transformer / rotor rheostat starter for appropriate three phase induction motor.	8
8	II	Perform speed control of squirrel cage induction motor by: 1. By changing the supply voltage. 2. By changing the applied frequency.	2
9	II	Perform speed control of slip-ring induction motor by: 1. Rotor rheostat control. 2. Injecting an emf from rotor side. 3. operating two motors in cascade connection.	4
10	III	Perform direct loading test on alternator to find out voltage regulation	4
11	III	Find out voltage regulation of alternator by synchronous impedance method for Unity, lagging and leading power factor.	4
12	III	Find out voltage regulation of alternator by ampere turn method for Unity, lagging and leading power factor.	4
13	III	Synchronize a given alternator with bus bar.	2
14	IV	Construct V-curves of synchronous motor at different load conditions to see the effect of variation of excitation	2
15	V	Test the circuit of capacitor start capacitor run single phase induction motor used in a ceiling fan	2
16	V	Perform No load test on single phase induction motor to determine the friction and windage loss	2
		Total Hours	**56**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Prepare journals based on practical performed in laboratory.
ii. Assignments on solving numericals
iii. Prepare chart displaying various accessories of three phase transformer
iv. Prepare/Download a dynamic animation to illustrate the following:
    - Working principle of 3 phase induction motor
    - Working principle of 3 phase alternator
    - Working of different types of 3 phase induction motor starters
v. Carry out a market survey of local dealers for 1-phase Induction motor and compare them on following points:
(a) Rating (b) Method of starting (c) Cost (d) Starting torque and (e) Performance

vi. Download the catalogue of three phase transformer, three phase induction motor, synchronous motor and alternator from websites of reputed manufacturers such as BHEL, SIMENS, CROMPTON, JYOTI, ABB, VOLTAS etc. to learn the latest developments

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

(i) Arrange visit to nearby transformer and induction motor manufacturer/testing facilities

(ii) Show video/animation films to explain functioning of induction motor/synchronous machines/transformers and their accessories.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S. No.	Title of Book	Author	Publication
1.	Electrical Technology Vol. II	B. L. Theraja	S Chand and Co., New Delhi
2.	Electrical Machines	Smarajit Ghosh	Pearson Learning, New Delhi
3.	Electrical Machinery	A.E.Fitzgerald, Charles Kingsley, Jr., Stephen D. Umans	Mc. Graw Hill, New Delhi
4.	Theory and performance of Electrical Machines	J.B.Gupta	S.K. Kataria and sons, New Delhi
5.	Electrical Machines	Ashfaq Hussain	Dhanpat Rai and Company, New Delhi

B) List of Major Equipment/ Instrument with Broad Specifications

i.	Three phase transformer	2KVA, 415V /415V, 50 Hz, 2.8A
ii.	Three phase induction motor	5 HP, 440V, 8.0A, 1400 RPM Squirrel cage type with brake drum arrgangement
iii.	Three phase induction motor	5 HP, 440V, 8.0A, 1400 RPM Slip-ring induction motor
iv.	Synchronous motor	3 HP, 415V, 3-phase, 50Hz, 1500 RPM
v.	DC shunt motor-Alternator set :	5HP,220V, 1500 RPM, 18A, Excitation- 220V DC
vi.	DC shunt motor Alternator	3KVA,415V, 3-phase,3.5A, 1500RPM, Excitation-220V DC
vii.	Single phase induction motor	1 HP, 220 V, 50Hz, 1440 RPM Drum brake with spring balances

C) List of Software/Learning Websites

i. www.sskphdmm.com

ii. www.nptel.iitm.ac.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. H.C. Chawda**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad.
- **Prof. R.D. Panchal**, Lecturer in Electrical Engineering, RC Technical Institute, Ahmedabad

- **Prof. J.C. Gadani,** Lecturer in Electrical Engineering, C.U.Shah Govt.Poly., Surendranagar.

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. (Mrs.) C S Rajeshwari**, Head of Department of Electrical and Electronics Engineering.
- **Prof. Joshua Earnest,** Professor, Department of Electrical and Electronics Engineering.