GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-V

Course Title: Special Electrical Machine
(Course Code: 4350906)

Diploma programmer in which this course is offered	Semester in which offered
Electrical Engineering	5th Semester

1. RATIONALE

Due to research and development the specialized electrical machines have been developed for specialized applications. They play an important role in industries such as production, processing, fabrications and renewable energy applications, etc. Some special electrical machines have higher efficiency, small size and useful for specific applications. This course refers to such machines which have not been considered in the earlier semesters. The most significant development in recent years in the allied area of motor control also plays an important role. Essential efforts are made in this course to familiarize the students with advanced technology in such machines which is a necessary to maintain them.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain different types of special electric machines.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Use different types of transformers efficiently for various applications.
b) Maintain different types induction machines for different applications.
c) Maintain different types synchronous machines for different applications.
d) Maintain different types of fractional horse power motors.
e) Maintain various types of Small specialized electric machines.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken

during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the subcomponents of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Test polarity of current transformer.	I	02*
2.	Test polarity of potential transformer.	I	02*
3.	Test ratio of potential transformer.	I	02*
4.	Identify the various parts of a squirrel cage induction Generator (SCIG).	II	02*
5.	Dismantle a small SCIG.	II	02
6.	Operate the squirrel cage induction motor as a SCIG to Test the performance.	II	02
7.	Identify the various parts of a wound rotor induction Generator (WRIG).	II	02*
8.	Dismantle a small WRIG.	II	02
9.	Operate the wound rotor induction motor as a WRIG to Test the performance.	II	02
10.	Identify the various parts of a doubly-fed induction Generator (DFIG).	II	02*
11.	Dismantle a small DFIG.	II	02
12.	Operate the DFIG to test the performance.	II	02
13.	Identify the various parts of a wound rotor synchronous generator(WRSG)	III	02*
14.	Test &Assemble a WRSG.	III	02
15.	Operate the WRSG to test the performance.	III	02
16.	Identify the various parts of a permanent magnet synchronous generator(PMSG)	III	02*
17.	Dismantle a PMSG.	III	02
18.	Operate the PMSG to test the performance.	III	02

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
19.	Dismantle/assemble/test a Hysteresis motor	IV	02*
20.	Dismantle/assemble/test a Permanent magnet motor	IV	02*
21.	Dismantle/assemble/test a Reluctance motor	IV	02*
22.	Dismantle/assemble/test a Switched reluctance motor	IV	02
23.	Dismantle/assemble/test a Stepper motor and its types.	V	02*
24.	Dismantle/assemble/test a Synchros	V	02*
25.	Dismantle/assemble/test a Servomotors	V	02*
26.	Dismantle/assemble/test a Repulsion motor	V	02
TOTAL (perform any practical worth 28hours from above depending upon the availability of resources so that most units are covered)			**28**

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*
ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Experimental setup, Procedure and conduction by following safety practices.	40
2	Conceptual clarity	30
3	Interpretation of Results and Ethical values.	30
Total		**100**

5. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to use in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Current transformer	1
2.	Potential transformer	2,3
3.	Squirrel Cage Induction Generator: Air cooled, three phase,3/5kW,400V, 50Hz.-	4,5,6
4.	Wound Rotor Induction Generator: Air cooled, threephase,3/5kW,400V,50Hz.	7,8,9
5.	Doubly fed Induction Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz	10,11,12
6.	Wound Rotor Synchronous Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz.	13,14,15
7.	Permanent Magnet Synchronous Generator: Air cooled, three phase, 3/5 kW, 400V, 50 Hz	16,17,18
8.	Hysteresis motor	19
9.	Permanent magnet motor	20
10.	Reluctance motor	21
11.	Switched reluctance motor	22
12.	Stepper motors of different types	23
13.	Synchros	24
14.	Servomotor	25
15.	Repulsion motor	26

6. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

a. Work as a leader/a team member (while doing a micro-project).
b. Follow safety practices while using D.C. and AC supply and electrical equipment.
c. Work as a group member (while performing experiments and taking readings)
d. Practice environmentally friendly methods and processes. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Special Transformer Types	1a. Explain with sketches the various connection diagrams a power and distribution transformer 1b. Describe the features of a welding transformer 1c. Differentiate between a audio transformer, isolation transformers and microphone transformers 1d. Distinguish between current and potential transformers 1e. Distinguish between constant current and constant voltage transformers 1f. Describe the test & maintenance procedure of all the above mentioned special transformers	1.1 Different types of connections of power and distribution transformers 1.2 Welding transformers 1.3 Isolation transformer 1.4 Pulse transformer 1.5 Audio transformers and microphone Transformers 1.6 Instrument transformers : current transformers and potential transformers 1.7 Constant Voltage Transformer (CVT) and Constant Current Transformer (CCT) 1.8 Maintenance procedure
Unit– II Special Induction Machines	2a. Explain the working principle of dual winding squirrel cage induction generator with sketches 2b. Describe the phenomenon of cogging and crawling in induction machines. 2c. Explain working principle of soft starters with sketches 2d. Justify the need for reactive power compensation for squirrel cage induction generators. 2e.Explain the working principle of wound rotor induction generator with sketches 2f. Explain the working principle	2.1 Dual winding Squirrel cage induction generator 2.2 Soft starters 2.3 Reactive power compensation 2.4 Wound rotor induction generator(WRIG) 2.5 Doubly fed induction generator(DFIG) 2.6 Brushless doubly fed induction generator(BDFIG) 2.7 Magnetic Levitations 2.8 Linear Induction motor 2.9 Maintenance procedure

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	of doubly fed induction generator with sketches 2g. Explain the working principle of brushless doubly fed induction generator 2h. Explain magnetic levitation principle 2i. Principle, advantages & application of linear induction motor 2j. Describe the maintenance procedure of all the above mentioned special induction machines	
Unit– III Special Synchronous Machines	3a. Explain the working of wound rotor synchronous generator used in renewable energy applications with sketches. 3b. Explain the working of wound rotor synchronous generator used in direct- drive wind turbines with sketches. 3c. Explain the working of permanent magnet synchronous generators used in direct drive large wind turbines with sketches 3d. Explain the working of permanent magnet synchronous generators used in direct drive small wind turbines with sketches 3e. Describe the test & maintenance procedure of all the above mentioned special synchronous machines	3.1 Wound rotor synchronous generators for renewable energy applications. 3.2 Wound rotor synchronous generators in large and small direct- drive wind turbines. 3.3 Permanent magnet synchronous generators in large and small direct-drive wind turbines. 3.4 Maintenance procedure.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit–IV Fractional Horse Power Motors	4a. Describe the concept of FHP motor sand their applications 4b. Explain the working of hysteresis motor with sketches and application 4c. Explain the working of permanent magnet motors and their applications 4d. Differentiate the working principles of Reluctance motor and Switched reluctance motor with sketches and application. 4e. Describe the test & maintenance procedure of all the above mentioned fractional horse power motors	4.1 Fractional horse power(FHP)motor 4.2 Hysteresis motor 4.3 Permanent magnet motor 4.4 Reluctance motor 4.5 Switched reluctance motor 4.6 Maintenance procedure
Unit-V Special Machines	5a. Explain the working principle of different types of stepper motors. 5b. Explain working principle of a Servomotor with sketches and application 5c. Explain working principle of synchros with sketches and application 5d. Explain working principle of resolvers with sketches and application. 5e. Explain working principle of a Repulsion motor with sketches and application. 5f. Describe the test & maintenance procedure of all the above-mentioned special motors	5.1 Stepper motor and its types. 5.2 Servomotors 5.3 Synchros 5.4 Resolvers 5.5 Repulsion motor 5.6 Maintenance procedure

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Special Transformer Types**	08	04	06	04	14
II	**Special Induction Machines**	08	03	06	03	12
III	**Special Synchronous Machines**	06	00	06	06	12
IV	**Fractional Horse Power Motors**	08	04	04	08	16
V	**Special Machines**	12	04	06	06	16
Total		**42**	15	28	27	70

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidence for their (student's) portfolio which may be useful for their placement interviews:

a) Present seminar on various topics from course content
b) Prepare nameplate of Special Electrical Machines

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4 means*** different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) Show animation/ video related to course content.
e) Co-relating the importance of content of this course with other courses/ practical applications. (e.g. importance of a content course or whole course related to Special Machines, Transmission and Distribution of Electrical Power, Energy Conservation, Microcontroller, Switchgear and Protection etc. and in practical industrial &/ domestic applications.
f) Introduce E-waste recycling technology among the students.
g) Guide students on how to address issues on environment and sustainability

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **12-14** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Make a impedance matching amplifier by using audio transformer.
b) Make a working model of automatic power factor correction by using instruments transformer and capacitor bank.
c) Make a working model of soft starter with contactor.
d) Prepare a chart of wound rotor synchronous generator applications.
e) Make a small robot using stepper motor.
f) Collect specifications of special machine and prepare a market survey report.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Electrical Technology Vol.II	Theraja,B. L.	SChand andCo., NewDelhi
2	Wind Power Technology	Earnest, Joshua	PHILearning,New Delhi,2014
3	Fundamentals of Electrical Engg.	Mehta,V.K.	S Chand and Co.,NewDelhi
4	Electrical Machines	Ghosh,Smarajit	Pearson Learning, NewDelhi
5	Electrical Machinery	Fitzgerald, A.E. CharlesKingsley, Jr., StephenD.Umans	Mc.Graw Hill,NewDelhi
6	Theory and performance Of Electrical Machines	Gupta, J.B.	S.K.Kataria and sons, New Delhi
7	Electrical Machines	Hussain, Ashfaq	DhanpatRai and Company, NewDelhi

14. SOFTWARE/LEARNING WEBSITES

WEBSITE

i. http://www.learnabout-electronics.org/ac_theory/transformers04.php
ii. http://www.tpub.com/celec/5.htm
iii. http://www.wisegeek.com/what-is-a-fractional-horsepower-motor.htm
iv. www.sskphdmm.com
v. www.nptel.iitm.ac.in
vi. www.electricalandelectronics.org
vii. www.allaboutcircuits.com
viii. www.nmbtc.com

15. PO-COMPETENCY-CO MAPPING:

Semester V	Special Electrical Machine (Course Code:4350906)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solution	PO4 Engineering Tools, Experimen-tation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Maintain different types of special electric machines**						
Course Outcomes **CO1** Use different types of transformers efficiently for various applications.	3	2	2	1	2	-	2
CO2 Maintain different types induction machines for different applications.	3	2	2	2	2	-	2
CO3 Maintain different types synchronous machines for different applications.	3	2	1	1	-	-	2
CO4 Maintain different types of fractional horsepower motors.	3	2	1	2	1	-	2
CO5 Maintain various types of Small specialized electric machines.	3	2	-	1	2	-	2

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Vaishnavi V. Rupawala Lecturer Electrical Engg.	SSGP, Surat	9687618385	vvr.ssg@gmail.com
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