GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: DC Machines and Transformer
(Course Code: 4332401)

Diploma programmer in which this course is offered	Semester in which offered
Power Electronics	Third

1. RATIONALE

The aim of introducing this course is to impart knowledge of basic energy conversion in transformer and DC machines. Through the study of this course the diploma engineering students will get adequate knowledge of construction, working, classification, troubleshooting, maintenance and performance various types of DC machines and transformer for working in any type of industries.

2. COMPETENCY

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

- **Operate different types of DC machines and transformers.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO 1) Use different types of DC generators.
CO 2) Operate different types of DC motors.
CO 3) Perform routine test on 1-phase transformer.
CO 4) Connect different types of 3-phase transformer for various industrial applications.
CO 5) Maintain various types of DC motor and Transformers.

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	
4	-	2	5	30	70	25	25	150

(*): For this practical only course, 25 marks under the practical CA has two components i.e. the assessment of micro-project, which will be done out of 10 marks and the remaining 15 marks are for the assessment of practical. This is designed to facilitate attainment of COs holistically, as there is no theory ESE.

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

5. SUGGESTED PRACTICAL EXERCISES

*Following practical outcomes (PrOs) that are the sub-components 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'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1.	Identify the parts of D.C. machines, note down the name plate details and interpret it	I	02*
2.	Identify the terminals, and test the field and armature windings of a DC machine for open circuit, short circuit and ground faults using test lamp / megger	I	02*
3.	Perform open circuit test on a separately excited DC shunt generator to plot the magnetization characteristics	I	02*
4.	Obtain External & Internal characteristics of DC Shunt generator.	I	02*
5.	Obtain External & Internal characteristics of DC compound generator.		
6.	Connect, start and run a DC. Motor using a 3 point and or 4 point starter	II	02*
7.	Control the Speed of DC shunt motor by Field Control Method. Plot the graph.	II	02*
8.	Control the Speed of DC shunt motor by Armature voltage control. Plot the graph.	II	02*
9.	Draw the Speed v/s armature current characteristics of a DC shunt motor.	II	02*
10.	Perform speed control of DC Series motor using (i) Armature Control (ii) Field Control.	II	04*
11.	Identify various parts of 1-Phase transformer.	III	02*
12.	Perform OC test on single phase transformer.	III	02*
13.	Perform polarity test on single phase transformer.	III	
14.	Perform SC test on single phase transformer	III	02*
15.	Perform load test on single phase transformer.	III	02*
16.	Perform voltage ration and polarity test on single phase transformer.	III	02
17.	Operate two single phase transformer in parallel.	III	02
18.	Identify various parts of 3-Phase transformer.	IV	02*
19.	Identify various parts of Current and Voltage transformer.	IV	02*
20.	Identify various parts of Pulse transformer.	IV	02*
21.	Perform Scott connection test on 3 phase transformer.	IV	02
22.	Prepare maintenance schedule and troubleshooting chart for DC machine	V	02*
23.	Prepare maintenance schedule and troubleshooting chart for transformer.	V	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
24.	Conduct dielectric strength test on transformer oil.	V	02*
	Minimum 14 Practical Exercises		**28 Hrs.**

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.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	M-G. Set D.C.-D.C. 1/3kW 110/220V D.C. (shunt) with starter. with panel board indicating motor, Generator, meters brought out connections to connecting terminals.	3,4
2	M-G. Set D.C.-D.C. 1/3kW 110/220V D.C. (Compound) with starter. with panel board indicating motor, Generator, meters brought out connections to connecting terminals	5
3	Variac: 3phase (O/P: 0-450V,15A, input: 3ph 400V)and 1-phase(O/P: 0-240V,15Amp, input-230V)	3,4,5,7,8,9,10
4	Wire wound rheostats –assorted ranges.	3,4,5,7,8,9,10, 12,14,15
5	Tachometers- Analog 0-5000 RPM.	3 ,4,5,6,7,8,9,10
6	Portable DC Moving coil ammeter –multirange	3 to 24
7	Portable DC Moving coil Voltmeters - multirange	3 to 24
8	Digital multimeter	3 to 24
9	Cut Section of DC Shunt Motor: Voltage: <100 V	1,2

<table>
<tr><th>S. No.</th><th>Equipment Name with Broad Specifications</th><th>PrO. No.</th></tr>
<tr><td></td><td><table>
<tr><td>Type</td><td>Externally Excited</td></tr>
<tr><td>Torque</td><td><0.20 mNm</td></tr>
<tr><td>Power</td><td><50 W</td></tr>
<tr><td>Current</td><td><100 mA</td></tr>
<tr><td>Commutation</td><td>Brush</td></tr>
</table></td><td></td></tr>
<tr><td>10</td><td><table>
<tr><td colspan="2">Transformer oil testing kit</td></tr>
<tr><td>Capacity</td><td>60KVA</td></tr>
<tr><td>Display</td><td>ANALOG</td></tr>
<tr><td>Frequency</td><td>50HZ</td></tr>
<tr><td>Input Voltage</td><td>220VAC</td></tr>
</table></td><td>24</td></tr>
<tr><td></td><td>400/230V, 50Hz 3-phase transformer with all phase winding terminals brought out for connections output in range of 2kVA to 4kVA</td><td>11,12,13,14,15,16</td></tr>
<tr><td>12</td><td>Two identical 230/115 V, 50 Hz, 1-KVA 1-Phaase transformer</td><td>17</td></tr>
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7. 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 competency.

a) Work as a leader/a team member.
b) Follow safety practices while using electrical power equipment.
c) 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

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level 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 Application and above level)	Topics and Sub-topics
Unit – I DC Generator	1a. Understand the principle of Principles of Electromechanical Energy Conversion.	1.1 Conservation of Energy, Energy stored in Magnetic Field, Forces and torque in magnetic systems, Singly Excited System.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
	1b. Explain working principle of DC generator.	1.2 Basic principle of DC Generator, Fleming's right hand rule.
	1c. Describe the construction of DC Machines with neat sketches.	1.3 Various parts of DC generator: yoke, pole core and pole shoes, armature winding, commutators, brushes, lap and wave winding.
	1d. Classify DC generators with neat diagrams.	1.4 Separately excited, self excited- particularly shunt, series and compound wound type generator.
	1e. Explain the concept of voltage build up and losses.	1.5 E.M.F. equation of generator and various losses in generator.
	1f. Describe various characteristics of DC generator.	1.6 No-load, internal and external characteristics
	1g. List the applications of DC Generator.	1.7 Applications of DC generator.
Unit– II DC Motor	2a. Explain the working principle of DC motor.	2.1 Basic principle of DC motor: Fleming's left hand rule.
	2b. Describe the concept of back emf, voltage equation, torque, speed, losses and efficiency.	2.2 Back EMF and voltage equation, condition for maximum power, torque relation, shaft torque, relation between torque and speed of motor, losses and efficiency.
	2c. Describe the behavior of DC series, shunt and compound motor.	2.3 Different characteristics of DC series shunt and compound motor.
	2d. Describe starters used in DC Motor.	2.4 Need of starter in DC motor, three-point, four point starter, supporting conventional resistance and static power electronics converter control.
	2e. Explain speed control methods of DC Motors.	2.5 Speed control method: armature, field.
	2f. List the applications DC Motors.	2.6 General applications of shunt, series, and compound motor.
Unit – III 1-Phase Transformer	3.a Explain the working principle of Transformer.	3.1 Basic principle: Mutual inductance 3.2 EMF equation, voltage and turns ratio.
	3.b Understand Construction of 1-phase transformer. 3.c Classify the 1-phase transformers based on different criteria.	3.3 Construction: core type and shell type 3.4 Classification: according to o/p voltage, frequency groups, mode of operations, purpose of usage and according to cooling systems.
	3.b Explain the concept of Ideal transformer. 3.c Explain the concept of practical transformer.	3.5 Properties of ideal transformer, Equivalent circuit of ideal transformer. 3.6 Properties of Practical transformer, transformer with winding resistance and leakage reactance. Equivalent circuit of practical transformer.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
	3.d Perform various tests on transformer.	3.7 Transformer test: Open-circuit (No load test), Short circuit test, Polarity test, load (back to back) test.
	3.e Determine the various losses in transformer.	3.8 Transformer losses: Iron (core) loss (hysteresis and eddy current loss), Copper (I^2R) loss, stray loss and dielectric loss.
	3.f Describe the parallel operation of 1-Phase transformer.	3.9 Parallel operation: reasons and advantages, conditions
	3.g Describe operation of 1-phase Variac transformer. 3.h Interpret various parameter of transformer by name plate.	3.10 Variac: working principle, advantages and application. 3.11 Transformer name plate reading includes KVA rating, Voltage Rating, Frequency, Number of Phases, Temperature, Type of Cooling, % Impedance and Reactance, Name of Manufacture, Year of Manufacture.
Unit– IV 3-Phase and Special types of transformer.	4a. Advantages of 3-Phase transformer 4b. Understand the construction of 3-Phase transformer. 4c. Understand labeling of 3-phase transformer terminals	4.1 Advantages over 3 single phase transformer bank. 4.2 Construction: Core type, Shell type. 4.3 Labeling of transformer terminals.
	4d. Explain the three phase transformer connections with sketches.	4.4 3-Phase transformer connections: • Star-Star: 0^o and 180° connections, Problems and solutions. • Delta-Delta: 0^o and 180° connections, Advantages and disadvantages. • Star-Delta: ±30°connections, application and advantages • Delta-Star: ±30°connections, application and advantages • Choice of connections: star/star, delta/delta, star/delta. • Scott connection: three phase to two phase conversation and vice versa, applications. • Input-output voltage and current relations for these connections.
	4e. Perform load tests on 3-Phase transformer.	4.5 Load test on three phase transformer.
	4f. Explain the working of pulse transformer	4.6 Pulse transformer: working with input output waveform, application
Unit– V Maintenance	5a Identify and resolve armature problems in DC machine.	5.1 Armature problems: troubles and remedies of commutators and brush

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
and troubleshooting of DC machine and Transformer.		gear.
	5b Explain factors affecting the life of commutator brush and slip ring.	5.2 Factors affecting the life of commutator brush and slip ring.
	5c Explain the procedure of cleaning and policing the surface of commutator, slip ring and common defects in mica of commutator.	5.3 Procedure of cleaning and policing the surface of commutator & slip ring, common defects in commutators mica and remedies.
	5d Explain the procedure of locating short circuit, earth fault and open circuit in shunt field coil.	5.4 Locate short circuit, earth fault and open circuit in shunt field coil.
	5e Explain the procedure of locating open circuit in armature coils.	5.5 Locate open circuit in armature coils.
	5f State the various troubles with DC motor, their cause and remedies.	5.6 Troubles with DC motor, their cause and remedies.
	5g Explain cause of transformer failures	5.7 cause of transformer failures
	5h Explain need of transformer insulating oil testing.	5.8 Insulating oil: type, features, function benefits of annual testing, Causes of Deterioration, Methods of Dealing with Bad Oil.
	5i Classify various fault types associated with developing gases.	5.9 Fault with developed gases: arcing, corona, sparking, overheating and overheated cellulose.
	5j Explain gas detector relay for transformer	5.10 Buchoz relay: features, working principle, Operation, application.
	5k Explain factors producing the noise in transformer	5.11 Causes of noise in transformer.

***Note**: The UOs need to be formulated at an 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

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.	**DC Generator**	12	3	6	4	13
II.	**DC Motor**	10	3	6	4	13
III.	**1-Phase Transformer**	13	4	8	4	16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
IV.	**3-Phase and Special types of transformer.**	11	3	6	5	14
V.	**Maintenance and troubleshooting of DC machine and Transformer**	10	4	4	6	14
Total		**56**	**17**	**30**	**23**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions 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 vary slightly 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 conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Interpret name plate details of various DC machine and transformer.
b) Make a chart of Classification for DC motor and generator with practical applications.
c) Make a chart of Classification for transformers with practical applications.
d) Undertake a market survey for special purpose DC motors.
e) Undertake a market survey for special types of Transformers.

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/sub topics.
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) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.11***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students for selecting a proper DC motor and transformers for specific applications.
g) Guide students on how to address various issues on speed control of DC motor.

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-project is 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 dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro-project should be about **14-16 (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 Presentation a various types of DC motor and Transformer used in relevant industries.
b) Prepare a report of strategies for installing DC motors.
c) Prepare a report of strategies for installing Transformer.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	A Textbook Of Electrical Technology: Vol 2 AC And DC Machines	Theraja B.L., Theraja A.K..	S. Chand, New Delhi, 2014, ISBN: 978-8121924375
2	Electrical Machines	Nagrath I. J. & Kothari D. P	McGraw Hill Education,2010 ISBN 978-0070699670
3	Electrical Machinery	Bimbhra P.S.	Khanna Publishers,2021 ISBN: 978-9389139105
4	Electric Machines	Husain Ashfaq, Harroon Ashfaq	Dhanpat Rai & Co. 2016 ISBN: 978-8177001662
5	Testing Commissioning Operation & Maintenance of Electrical Equipments	Rao S.	Khanna Publishers,2021 ISBN: 9788174091857
6	Electric motor Maintenance and Troubleshooting.	Augie Hand	McGraw Hill Education, 2011 ISBN: 978-0071763950
7	Electrical Equipment Handbook	Philip Kiameh	McGraw Hill Education, 2011 ISBN: 9780071396035

14. SOFTWARE/LEARNING WEBSITES

a) https://www.vlab.co.in
b) https://nptel.ac.in
c) https://www.classcentral.com
d) https://ocw.mit.edu/courses/6-685-electric-machines-fall-2013/
e) https://www.electrical4u.com/
f) https://www.edx.org/learn/electrical-engineering
g) https://swayam.gov.in/
h) https://shodhganga.inflibnet.ac.in/

15. PO-COMPETENCY-CO MAPPING

Semester II	DC Machine and Transformer Course Code: .....)						
	POs and PSOs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Operate different types of DC machines and transformers.						
CO 1) Use different types of DC generators	2	1	-	2	2	2	1
CO 2) Operate different types of DC motors.	2	1	1	2	2	2	2
CO 3) Perform routine test on 1-phase transformer.	2	2	2	3	3	2	2
CO 4) Connect different types of 3-phase transformer for various industrial applications.	1	1	1	2	1	2	1
CO 5) Maintain various types of DC motor and Transformers.	1	3	2	3	2	3	3

Legend: '**3**' for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1.	Mr. Vinod N. Makwana Lecturer – Power Electronics Department.	Dr. S. & S. S. Ghandhy college of engineering & Technology, Surat	9427386784	makwana_vinodbhai@gtu.edu.in
2.	Mr. Shailesh Dhoriyani, Lecturer – Power Electronics Department.	Dr. S. & S. S. Ghandhy college of engineering & Technology, Surat	9913776990	shailesh.dhoriyani@gmail.com