GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Power Electronics and Drives
(Course Code: 4350902)

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

1. RATIONALE

Applications of power electronics are used in every field, for example, industrial applications, consumer applications, transportation and aerospace applications. This course address to reduce climate change, pollution and unreliability of energy grids. Power has become one of the most important components of modern life. This has led to the development of smaller, lightweight energy-dense batteries based on converters/inverters to lead the revolution in ESS.

2. COMPETENCY

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

- **Identify power electronic devices and implement different types of Power converters as per functioning of system required with safety.**

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) Compare performance of various power semiconductor devices, along with its protection as per data sheet
b) Recognize different rectifiers and regulators according to device, phases and area of use.
c) Classify inverters and choppers with reference to different parameters and configuration
d) Distinguish the speed control of different motors using various AC and DC drives.

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	5	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 the performance of IGBT	1	2
2	Test the performance of GTO	1	2
3	Test the performance of MCT	1	2
4	Test and plot characteristics of SCR	1	2
5	Build and test Snubber circuits		
6	Test SCR commutating circuits.	1	2
7	Build and test SCR triggering circuit with firing angle control in R and RL series circuit	1	2
8	Compare the ratings and packages of IGBT, GTO, MCT using data sheet.	1	2
9	Simulate of single-phase controlled rectifier and analyze function of flywheel diode for RL load	2	2
10	Wire the three-phase half wave rectifier & test the performance.	2	2
11	Wire the three-phase full wave rectifier & test the performance	2	2
12	Check the performance of six phase half wave rectifier.	2	2
13	Analyze poly phase rectifier circuit performance through simulation	2	2
14	Test the performance of TRIAC for AC load control	2	2
15	Use R-C phase shift network for firing angle Control of single phase controlled rectifier	3	2
16	Test chopper circuits with load.	3	2
17	Simulate chopper circuit, observe and print the various wave forms.	3	2
18	Build/test parallel inverter using two SCRs	4	2
19	Test the Speed control of universal motor using SCR-UJT circuit	4	2
20	Simulate speed control of DC motor using chopper circuits	4	2
22	Simulate Speed control of three-phase induction motor using V/f control	4	2
23	Simulate speed control of single-phase Induction Motor using single phase voltage controller		
			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.*

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

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
Total		**100**

6. 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.	DIAC, TRAIC, SCR, IGBT, GTO and MCT - 5 Nos. each of current rating at least 20 amps or above	5,6,7,8,9
2	Trainer Kits for testing the V-I characteristics of the following - 2 Nos. each: a) DIAC b) TRAIC c) SCR d) Power transistor e) Power MOSFET f) IGBT g) GTO h) MCT	5,6,7,9
3	Trainer kit to check the performance for different types of loads of the following - 2 Nos. each: a) 3-phase uncontrolled half wave rectifier b) 3-phase uncontrolled full wave rectifier	1,2
4	Trainer kit to check the performance using R, RL and RLC Load of the following - 2 Nos. each: **a)** Fully controlled three phase half wave converter **b)** Fully controlled three phase Full wave converter	1,2
5	Trainer kit to check the performance of Three-phase semi-converter using R, RL and RLC Load of the following - 2 Nos.	1,2
6	Chopper Trainer kit to check the performance of the following for different types of loads - 2 Nos. each: a) IGBT Based Chopper Circuit b) Jones Chopper Trainer Circuit c) Morgan Chopper Trainer Circuit	13,14,19
7.	Trainer kit to check the performance for different types of loads of the following - 2 Nos. each: a) Offline inverter b) Online inverter	15, 21
8	Trainer kit to check the performance for different types of loads of the following - 2 Nos. each: a) Class A Load Commutation b) Class B Resonant Pulse Commutation c) Class C Complementary Commutation d) Class D Impulse or Auxiliary SCR commutation e) Class F Line or natural Commutation	12
9	Electric DC Drive Trainer consisting of the following controlling schemes - set: a) Speed control of dc DC shunt motor using single phase fully controlled converter b) Speed control of DC shunt motor using three phase fully controlled converter c) Armature and field control of DC shunt motor	19

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
	d) Speed control of DC shunt motor using SCR dual converter e) Thyristor chopper for DC motor drive f) DC series motor controller using jones chopper	
10	Experimental set up to perform Speed control of a 3 phase WRIM using Kramer drive - 1 set	20
11	Experimental set up to perform Speed control of a 3 phase induction motor using v/f method - 1 set	21
12	Experimental set up to perform speed control of a DC shunt motor using open loop and PID control system through computer interfacing - 1 set	19
13	3 Phase Power Analyzer 3 Nos. with the following specifications: □ 3 phase/1 phase measurement- □ True RMS Voltage 600/1200 V □ True RMS Current 80 A, □ Power measurement (Active, reactive and apparent power),□ Power factor measurement, □ Frequency Measurement, □ RS-232 serial communication, □ LCD display	

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 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 electronic 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 1 **Power Electronic Devices- Characteristics protection and working parameters as per data sheet**	1a. Need of Power Electronic devices, types and application. 1b. Classify Power electronic devices 1c. Explain Construction, working, operation, characteristics, ratings and application of different Power electronic devices. i.e. Power Diode, Transistor, IGBT, SCR, MCT, GTO, Triac Diac, UJT. 1d. Justify need of Protection of power electronic devices 1e. Differentiate various commutation circuits 1f. Understanding data sheet and parameters	1.1 Thyristor family 1.2 Working and characteristics of SCR, IGBT, GTO, MCT, Diac, Triac 1.3 Need of SCR protection- Over voltage, over current, di/dt, dv/dt Heating, 1.4 Need of snubber circuit, heatsink, freewheeling diode. 1.5 Turnoff Methods of SCR- 1.6 Natural and forced commutation. 1.7 Voltage, current and power ratings of SCR
Unit-II **Three phase uncontrolled and Single-phase controlled rectifiers and regulators**	2a. Need of polyphase rectifier 2b. Compare various polyphase uncontrolled rectifier 2c. Differentiate working of single phase halfwave, full wave-controlled rectifiers. 2d. Effect of transformer reactance, PIV. 2e. Compare different single-phase regulators using 1, 2, and 4 diodes and SCR's combination	2.1 compare single phase and 3 phase rectifiers. 2.2 Three phase half wave, full wave uncontrolled rectifier 2.3 Six phase half wave, double star six phase rectifier 2.4 Derive rms current and voltage I_{dc} and E_{dc} for 3 phase half and full wave rectifier. 2.5 Transformer reactance, SUF, controlled rectifier. 2.6 Principle of AC Load control using SCR 2.7 Role of regulators and rectifiers in energy conservation
Unit-III **Choppers Inverters**	3a. Explain working principle D.C. Chopper 3b. Classify Chopper with configuration 3c. Class A, B, C, D E Chopper 3d. Chopper control methods 3e. Jone's Chopper 3f Morgan Choppers 3g. Classification of inverters 3h. Series and Parallel inverters 3i. Voltage control methods of inverter 3j. PWM control in inverter. 3k. Introduction to harmonics	3.1 Working Principle of Chopper 3.2 Configuration of Chopper 3.3 Chopper control 3.4 Principle of Inverter. 3.5 Single phase inverters- series parallel and half and full bridge, square wave, quasi wave inverter. 3.6 Methods of Voltage control in inverter- single pulse, multiple pulse and sine pulse modulation 3.7 Introduction to multilevel inverter- 3 level inverter diode clamped and capacitor clamped 3.8 Basics of Harmonics and power quality in power electronic 3.9 Application of inverter in solar energy using buck boost conversion.
Unit-IV **Electric drives and Control**	4a. Concepts of Electric drives 4b. Power Modulators and motors 4c. 4 Quadrant operation of DC Drives 4d. D C drive using chopper control 4e. Single phase DC drives 4f. Introduction to Cycloconverter 4g. A C drives- Voltage, frequency,	4.1 Block diagram of electric drives 4.2 Different parts of electric drives 4.3 Power Modulators 4.4 AC Drives – Inverter based 4.5 DC Drives- Rectifier and Chopper based 4.6 Cycloconverters -types, application and

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	current control. 4h. Application of Electric Drives in EVs	disadvantages. 4.7 4 Quadrant operation of DC drive 4.8 Speed control of 3phase induction motor using chopper. 4.9 Regenerative braking control in E- Vehicles 4.10 Single phase half semi and full converter drives 4.11 Speed control of Induction motor using various controls- Voltage, frequency V/F control

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	**Power Electronic Devices- Characteristics protection and working parameters as per data sheet.**	12	8	7	5	20
II	**Single phase and three phase uncontrolled and controlled rectifiers and regulators.**	9	6	5	5	16
III	**Inverters, Choppers.**	10	4	8	6	18
IV	**Electronic drives and Control.**	11	4	6	6	16
Total		**42**	**22**	**26**	**22**	**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 Control rectifier, inverter, electrical drives for DC motor, Induction motor.

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 Rectifiers, *inverters, Electrical Drives, FACT devices, Harmonic Filters* 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:

1) Prepare a report on various types of drives used in nearby industries.
2) Prepare chart displaying various Power semiconductor devices and their symbols
3) Simulate following circuits in syllabus and take print out of various wave forms.
   (a) 3 phase half wave rectifier
   (b) 3 phase full wave rectifier
   (c) 6 phase half wave rectifier
   (d) Step up & Step-down chopper circuit
   (e) 1-phase half & full bridge inverter
4) Make a market survey for various types of thyristors available in market.
5) Present a dynamic animations prepared or collected from the internet to illustrate the following:
   (a) Working principle of inverter
   (b) Working principle of PWM inverter
   (c) Working principle of chopper
6) Build 3 phase half wave rectifier circuit & prepare report on it.
7) Build 3 phase full wave rectifier circuit & prepare report on it.
8) Build step up & step-down chopper & prepare report on it.
9) Single phase AC load control using Diac and Triac.
10) Demonstration of commutation circuit for SCR.
11) Single phase inverter using 2 MOSFET and transformer.
12) Square wave inverter using 4 MOSFET, IGBT, Transistor.
13) Overcurrent protection using crowbar circuit.
14) Design of snubber circuit.
15 Speed control of DC Motor using Chopper
16) Speed control of DC motor using 4 diode and 1 SCR
17) Design of Static switch up to 5 Amperes.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1.	Power Electronics	Rashid, Muhammad H.	PHI Learning, New Delhi latest edition
2.	Power Electronics	Gupta, B. R., Singhal V.,	S.K. Kataria and sons, New Delhi
3.	Power Electronics	Singh,M. D. K. Khanchandani, B.	Tata Mc. Graw Hill, New Delhi
4.	Power Electronics	Bimbhra, P.S.	Khanna Publisher, New Delhi latest edition
5.	Power Electronics and its Application	Alok Jain	PENRAM International Publishing
6.	Industries and power Electronics	Rai, H.C.	Umesh Publications. New Delhi latest edition
7.	Fundamentals of electric drives	Dubey, G. K.	Narosa Publishing house New Delhi latest edition
8.	Electric drives- concepts and applications	Subramanyan, V.	Tata McGraw-Hill, New Delhi latest edition

14. SOFTWARE/LEARNING WEBSITES

WEBSITE

(1) www.nptel.iitm.ac.in

(2) www.youtube (lectures on Power electronics)

(3) www.howstuffworks.com

(4) www.alldatasheet.com

(5) MATLAB/SIMULINK

(6) Psim : https://powersimtech.com

(7) Electronics Work bench

(8) www.vlab.co.in

(9) Lectures on GTU portal: https://lectures.gtu.ac.in/listview.aspx?br=09&course=DI

15. PO-COMPETENCY-CO MAPPING:

Semester V	**POWER ELECTRONICS AND DRIVES (Course Code:4350902)**						
	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	**Identify power electronic devices and implement different types of Power converters as per functioning of system required with safety.**						
Course Outcomes CO1: Compare performance of various power semiconductor devices, along with its protection as per data sheet	3	2	2	2	2	-	1
CO2: Recognize different rectifiers and regulators according to device, phases and area of use.	3	2	1	2	2	-	2
CO3: Classify inverters and choppers with reference to different parameters and configuration	3	-	1	2	2	-	2

CO4 : Distinguish the speed control of different motors using various AC and DC drives.	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

S. No.	Name and Designation	Institute	Contact No.	Email
1.	Ms.Chandni Chirag Shah Lecturer Electrical Engg.	A V Parekh Technical Institute Rajkot	7016146890	chandnicshah@gmail.com
2.	Mr Alpesh Mahyavanshi Lecturer Electrical Engg.	G.P. Dahod	9824573878	alpeshmahyavanshi@gmail.com