GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Industrial Electronics
(Course Code: 4331103)

Diploma programme in which this course is offered	Semester in which offered
Electronics and Communication Engineering	Third

1. RATIONALE

Exposure to application oriented electronic circuits commonly used in the industries is very essential for students of Electronics and Communication Diploma Engineering. This course will enable the students to understand the construction, working, and applications of various types of power electronic components like SCR, DIAC, TRIAC, IGBT and applications based circuits such as fan regulator, photo-electric relay, AC/DC power controller, Poly phase rectifier, Inverters etc. Hence study of this course will enable the students to test and troubleshoot the Industrial electronic circuits and components.

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:

- **Maintain the industrial electronic equipments.**

3. COURSE OUTCOMES (COs)

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

a) Choose relevant thyristor for the given application.
b) Troubleshoot AC&DC power control circuits employing thyristors.
c) Troubleshoot inverter and chopper.
d) Use photoelectric devices in relevant applications.
e) Use different types of timers in specific applications.
f) Maintain induction heating and dielectric heating equipment.

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) that are the sub-components of the 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	Plot V/I Characteristics of SCR and determine latching current and holding current.	1	2*
2	Plot V/I Characteristics of DIAC and determine the break over voltage.	1	2*
3	Plot V/I Characteristics of TRIAC.	1	2*
4	Construct a relaxation oscillator using UJT and from the waveform measure the oscillation frequency.	1	2*
5	Plot Characteristics of Opto-Isolator.	1	2
6	Perform RC phase shift control of UJT triggered SCR.	2	2*
7	Perform the operation of commutation on SCR.	2	2*
8	Demonstrate dv/dt limitation of SCR.	2	2
9	Observe the output waveform of half wave controlled rectifier with R load, RL load, and freewheeling diode and measure the firing angle and conduction angle and the load voltage.	3	2*
10	Observe the output waveform of full wave controlled rectifier with R load, RL load, and freewheeling diode and measure the firing angle and conduction angle and load voltage.	3	2*
11	Test Half controlled bridge rectifier with filter.	3	2
12	Measure efficiency of Poly phase Rectifier.	3	2
13	Test the operation of universal chopper.	3	2*
14	Test the operation of series Inverter.	3	2*
15	Measure Load/Line regulation of SMPS.	4	2
16	Test the performance of given UPS.	4	2
17	Perform the AC power control using DIAC and TRIAC.	4	2*
18	Demonstrate solar photo voltaic power generation.	4	2
19	Obtain Characteristics of LASCR.	4	2
20	Test Light operated Relay/Photo-electric switch.	4	2*
21	Implement On-delay timer using IC-555.	4	2*
22	Perform Sequential Timer operation using IC-555.	4	2
23	Implement Delay timer using SCR.	4	2
24	Implement Programmable Timer IC-XR2240.	4	2
25	Measure Speed of DC shunt motor controlled by open loop–close loop control system.	5	2*
26	Measure Speed of Universal Motor controlled by SCR/TRIAC.	5	2*
27	AC Single phase Servomotor FW/REV control.	5	2
28	Perform the speed control of BLDC motor using the BLDC driver circuit.	5	2
	Total (perform sufficient number of practical from above for 28 hours)		56

Note

*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.*

*i. 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

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

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Trainer kit for SCR, DIAC, TRIAC, UJT, Opto- Isolator.	1,2,3,4,5
2	Trainer kit for RC phase shift control of SCR.	6
3	Trainer kit for commutations of SCR.	7
4	Trainer kit for demonstrate dv/dt limitation of SCR.	8
5	Trainer kit for controlled rectifiers, poly phase rectifiers, Inverters and Choppers	9,10,11,12,13, 14
6	Trainer kit for SMPS and UPS.	15,16
7	Trainer kit for AC power control using DIAC and TRIAC.	17
8	Trainer kit for demonstration of solar photo voltaic power generation.	18
9	Trainer kit for LASCR and photo electric relay.	19,20
10	Trainer kit for IC-555 timer, sequential timer and other timers.	21,22,23,24
11	Trainer kit for speed control of AC/DC motor, universal motor, servomotor, BLDC motor	25,26,27,28
12	Variable Power supply (0-30 V, 0-2 A, digital display)	1 to 28
13	Digital multimeter	1 to 28
14	Cathode Ray Oscilloscope(CRO)(Dual trace 20 MHz)	4,6,7,9,10,11, 21,22,23,24
15	Function generator	1,3,7,17,21,22
16	Consumables component: SCR S104, TYN604, DIAC DB32, TRIAC BT136, 2N2646, MOC3011, MOC3031, PC817, MCT2E, IC555/556, XR2240 and bread board.	1,2,3,4,5,6,7,8, 9,10,17,21,22

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 and electronics high power appliances.
c) Practice environmental 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 Introduction to Thyristors	1a. Describe working &constructional features of SCR, DIAC, TRIAC, SCS, SIT, GTO, LASCR, LATRIAC, POWER MOSFET, IGBT, and MCT with the help of characteristic curve. 1b. Draw the characteristic curve of SCR, DIAC, TRIAC, SCS, SIT, LASCR, LATRIAC, GTO, POWER MOSFET, IGBT, and MCT. 1c. List applications of SCR, DIAC, TRIAC, SCS, SIT, LASCR, LATRIAC, GTO, POWER MOSFET, IGBT and MCT. 1d. Explain working of SCR using two transistor analogy. 1e. Describe construction & working of Opto-Isolators, Opto-TRIAC, Opto-SCR, and Opto-transistor. 1f. Draw characteristics of Opto- Isolators, Opto-TRIAC, Opto-SCR, Opto-transistor 1g. List industrial applications of Opto-Isolators, Opto-TRIAC, Opto-SCR, and Opto-transistor. 1h. Explain the working of Solid state relay using Opto-SCR, Opto-transistor.	1.1 Industrial electronics devices : SCR, DIAC, TRIAC, SCS, SIT, GTO, LASCR, LATRIAC, POWER MOSFET,IGBT, MCT 1.2 Triggering devices: UJT, PUT 1.3 Opto electronic devices: Opto-TRIAC, Opto-SCR, Opto-transistor, Opto-Isolators, and Opto-Coupler. 1.4 Solid state relay using Opto-TRIAC, Opto-SCR, Opto-transistor.

Unit – II Turn on and Turn off methods of Thyristor	2a. Explain the turn ON methods of thyristor (SCR) - triggering methods. 2b. Explain the turn OFF methods of SCR-commutation techniques of SCR. 2c. State the method to protect SCR against over current. 2d. State the method to protect SCR against over voltage. 2e. Design the snubber circuit for SCR. 2f. State the importance to provide the gate protection to SCR.	2.1 Triggering methods of SCR 2.2 Commutation techniques of SCR 2.3 Thyristor protection: Over current protection, Over voltage protection, Snubber circuit, Gate protection.
Unit– III Power Converters	3a. Compare single-phase and Poly-phase rectifier circuits. 3b. Describe the applications of Poly-phase rectifiers. 3c. Explain working of three-phase H.W. & three-phase F.W. rectifiers. 3d. Describe the applications of Series, Parallel and bridge type Inverters. 3e. Explain the Principle & working of Chopper circuits. 3f. Describe the applications of Chopper. 3g. Describe the working of UPS & SMPS with the help of block diagram. 3h. List the applications and technical specifications of UPS & SMPS. 3i. Compare different types of Battery and charging Technology 3j. Describe the working of solar Photovoltaic (PV) based power generation with the help of block diagram.	3.1 Single phase rectifiers and poly phase rectifiers 3.2 Single phase control rectifier using SCR 3.3 Poly phase rectifiers 3.4 Inverters: Series, Parallel and bridge Inverters 3.5 Chopper 3.6 UPS : online &offline 3.7 SMPS 3.8 Battery charging Technology 3.9 Solar Photovoltaic (PV) based power generation
Unit – IV Industrial Electronics Applications	4a. Explain use of SCR as a static switch 4b. Describe function of single phase AC power control circuit using DIAC-TRIAC. 4c. Draw schematic circuit for the above application. 4d. Describe function of DC power control circuit using SCR with UJT in triggering circuit. 4e. Draw schematic circuit for the above application. 4f. Select the appropriate photoelectric devices for switching in power control application. 4g. Design delay timer and sequential	4.1 SCR as a static switch 4.2 Single phase AC power control using DIAC-TRIAC. 4.3 UJT Triggered SCR power control. 4.4 Photo electric relay/switch using LDR, LASCR, photodiode. 4.5 Timer circuits using SCR and timer ICs. 4.6 Induction heating 4.7 Dielectric heating

	timer circuits. 4h. Describe the working principle of Induction heating. 4i. List merits-demerits of Induction heating. 4j. State the procedure of Spot welding 4k. Describe the working principle of Dielectric heating. 4l. List merits-demerits of Dielectric heating.	
Unit– V Solid State Controls	5a. Explain AC/DC Drives Basic Concept. 5b. Explain the working of Solid State Controls for the various types of motors i.e. Series, Shunt, Universal, Servo and Stepper motor, BLDC motor and its driver circuit. 5c. Use of hall effect sensors in bldc driver circuit 5d. List AC/DC drives applications. 5e. Explain the working of VFD(Variable Frequency Drive) 5f. Draw the block diagram of Programmable Logic Control (PLC) and explain the function of each block.	5.1 AC/DC Drive control (Basic Concept) 5.2 Single phase DC shunt motor and its speed control using thyristors. 5.3 Single phase Induction motor(AC motor) and its speed control using thyristors-TRIAC 5.4 Universal motor and its speed control 5.5 Stepper motor – construction, working and its applications 5.6 Servo motor - construction, working and its applications. 5.7 BLDC motors- construction, working, its applications and driver circuits, Hall effect sensor. 5.8 AC/DC Drive applications- steel rolling mills, Textile mills, machine tools, cement Industries. 5.9 VFD - construction, working 5.10 Programmable Logic Control – block diagram, working, advantages, applications.

***Note**: The UOs need to be formulated at the '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	Introduction to Thyristors	7	8	4	3	15
II	Turn on and Turn off methods of Thyristor	5	2	4	4	10

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
III	Power Converters	12	4	5	6	15
IV	Industrial Electronics Applications	8	3	6	6	15
V	Solid State Controls	10	6	4	5	15
Total		**42**	**23**	**23**	**24**	**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:

i. Find Specifications and package of SCR, DIAC, TRIAC, UJT, PUT, POWER MOSFER, IGBT, and MCT from datasheet.
ii. Find Specifications and package of Opto-TRIAC, Opto-SCR, Opto-Transistor, and Opto-coupler from datasheet.
iii. Collect specification of commercially used UPS, Inverter, and SMPS in syllabus.
iv. Find Specifications and package of IC-555, IC-556, and IC-XR2240 from datasheet.
v. Find Specifications and package of DC shunt motor, Induction motor, Universal motor, and Servo motor, BLDC motor from datasheet.

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 on how to address issues on environment and sustainability
g) Guide students for using data manuals.

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 are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become

problem solver so that she/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, 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 total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student 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) Fan regulator using TRIAC/DIAC
b) Light operated Relay-/Street Light Control.
c) Water Level Controller.
d) Home Appliances Automation.
e) Automatic Door control and counting of persons.
f) Cyclic Timer usingIC555
g) Star-Delta timerusingIC555
h) Solid State Relay using Diac-Triac
i) SCR Firing using UJT.
j) Arm ROBOT using Stepper Motor.
k) Tone burst modulation usingIC556
l) Project on XR2240
m) SMPS based on IC7840
n) Projects on MOC3011
o) Projects on MOC3031
p) Zero cross detector using PC817
q) Battery charger using SCR

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Industrial Electronics and Control	S. K. Bhattacharya & S.Chatterjee	McGraw Hill Education, july 2017, ISBN-13 978-0074624777
2	Industrial Electronics	G.K. Mithal & Maneesha Gupta	Khanna publishers, January 1987 ISBN-13 978-8174091093
3	Industrial and Power Electronics	Harish C. Rai	Umesh Publication, ISBN-13 978-8188114146
4	Thyristor Engineering	M.S. Berde	Khanna publishers, 1997 ISBN-13 978-9387394100
5	Electronics in Industry	George M. Chute Robert D. Chute	McGraw-Hill Education,1979 ISBN-13 978-0070662254
6	Power Electronics | Devices, Circuits and Applications	M.H. Rashid	Pearson Education ISBN-13 978-8120345317
7	Industrial electronics Manual	Paul Zbar	McGraw Hill Education,1990 ISBN-13 978-0070728226

14. SOFTWARE/LEARNING WEBSITES

Common website for Industrial electronics:

i.	Datasheets:	http://www.epanorama.net/links/searchlinks.html#datasheets
ii	Thyristor:	http://www.epanorama.net/links/componentinfo.html#thyristor http://en.wikipedia.org/wiki/Thyristor
Iii	SCR:	http://www.allaboutcircuits.com
Iv	Opto-Electronics:	http://www.epanorama.net/links/lights.html#dimmer
V	Opto-isolator:	http://en.wikipedia.org/wiki/Opto-isolator
Vi	Solid State Relay	http://en.wikipedia.org/wiki/Solid-state_relay
vii	UPS:	http://www.epanorama.net/links/psu.html
viii	PLC:	http://www.epanorama.net/links/automation.html#plc http://en.wikipedia.org/wiki/Programmable_logic_controller
Ix	Motors:	http://www.epanorama.net/links/motorcontrol.html
x	AC/DC motors:	http://en.wikipedia.org/wiki/Motor
xi	Stepper motor:	http://en.wikipedia.org/wiki/Stepper_motor
xii	Universal motor:	http://en.wikipedia.org/wiki/Universal_motor
xiii	Servo motor:	http://en.wikipedia.org/wiki/Servomotor
xiv	Universal motor:	http://en.wikipedia.org/wiki/Universal_motor
Xv	Servo motor:	http://en.wikipedia.org/wiki/Servomotor
xvi	BLDC motor	Brushless DC electric motor - Wikipedia
xvii	Induction heating:	http://en.wikipedia.org/wiki/Induction_heating
xviii	Dielectric heating:	http://en.wikipedia.org/wiki/Dielectric_heating
xix	Solar PV power generation	https://www.eajournals.org/wp-content/uploads/Solar-Pv-Power-Generation.pdf

- https://www.tutorialpoint.com
- https://www.circuitstoday.com
- https://www.electrical4u.com
- https://nptel.ac.in

15. PO-COMPETENCY-CO MAPPING

Semester III	**Industrial Electronics**						
	Pos						
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 *"Solve basic circuit problems using circuit laws and network theorems."*							
CO a) Choose relevant thyristor for the given	3	2	2	2	-	2	1

application							
CO b) Troubleshoot AC & DC power control circuits employing thyristors	3	2	2	3	2	3	2
CO c) Troubleshoot inverter and chopper	3	2	2	3	2	3	2
CO d)Use photoelectric devices in relevant applications	3	2	2	2	-	2	1
CO e)Use different types of timers in specific applications	3	2	2	2	1	2	1
CO f) Maintain induction heating and dielectric heating equipment	3	1	1	1	2	2	1

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	K R Vadalia, Hod EC	G P Rajkot	9879330253	krvadalia@gmail.com
2	T R Parmar, Hod EC	G P Vadnagar	9898318759	tus1973har@gmail.com
3	R C Parmar, Lecturer EC	G P Palanpur	9974338709	rhl.gp2016@gmail.com

BoS Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Dr. A S Pandya, Principal BoS Chairman Electrical & Allied Branches	AVPTI, Rajkot	9426201171	aspandya22@rediffmail.com
2.	Dr. S N Sampat, I/c Principal BoS Member-EC	GGP, Surat	9033777389	snsampat@gmail.com
3.	Shri U V Buch, LEC BoS Member-EC	GP A'bad	9825346922	uvbuch@gmail.com