GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2022)

Semester – IV

Course Title: Industrial Power Control

(Course Code: 4341706)

Diploma program in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	4th semester

1. RATIONALE

In the present industrial scenario, role of the industrial power control instrumentation is becoming more important day by day. More advanced, precise and complex power control circuits and techniques are being employed in industry. Diploma engineers should therefore be able to identify, classify, troubleshoot and maintain the different industrial power control instrumentation systems. Therefore, this course has been designed so that students will learn to identify, select, wire, build, test, troubleshoot and maintain different types of industrial instrumentation circuits and components.

Nowadays all the modern electrical machines are controlled by power electronics devices and methods. The function of power electronics is to process and control the electric power by supplying voltage and current in a form that is optimally suited to the load. With the advancement of power electronics devices the conventional control and relays are now replaced by electronic control and relays, employing solid state power semiconductor devices. This course is therefore designed so that the diploma engineers will be able to use power electronics for controlling AC and DC power in various applications. Essential theoretical and practical knowledge to use power electronics to control electrical machines in commercial and industrial sector will be achieved by this course.

2. COMPETENCY ('Program Outcome' according to NBA Terminology)

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 different types of industrial power control instrumentation system.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be undertaken in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domains to demonstrate the following course outcomes:

a) Describe construction and working of various power semiconductor devices.
b) Illustrate various triggering, commutation and protection circuits for SCR.
c) Describe construction and working of various power converters.
d) Illustrate various industrial and commercial applications of power electronics devices.

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 sub-components of the COs.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Obtain V I characteristic of SCR.	1	4
2	Obtain V I characteristic of DIAC.	1	4
3	Obtain V I characteristic of TRIAC.	1	4
4	Obtain V I characteristic of UJT.	1	2
5	Obtain V I characteristic of PUT.	1	2
6	Obtain V I characteristic of MOSFET.	1	4
7	Obtain V I characteristic of IGBT.	1	4
8	Test function of opto-isolator as switch.	2	2
9	Test function of RC gate triggering circuit.	2	2
10	Test function of UJT based pulse gate triggering circuit for triggering of SCR.	2	2
11	Test function of Class A commutation circuit for SCR.	2	2
12	Test function of Class D commutation circuit for SCR.	2	2
13	Test function of Class F commutation circuit for SCR.	2	2
14	Test function of half wave controlled rectifier with resistive load.	3	2
15	Test function of full wave controlled bridge rectifier with resistive load.	3	2
16	Test function of parallel inverter.	3	2
17	Test function of series Inverter.	3	2
18	Test function of bridge type Inverter.	3	2
19	Test function of step up chopper.	4	2
20	Test function of step up/down chopper.	4	2
21	Test function of single phase mid point type cyclo-converter.	4	2
22	Test function of single phase bridge type cyclo-converter.	4	2
23	Test speed control of A.C. Motor using DIAC-TRIAC.	5	2
24	Test D.C motor speed control using chopper.	5	2
25	Test speed control of Stepper motor.	5	2
26	Test D.C Static switch.	5	2
27	Make Battery charger for E-vehicles.	5	2
28	Test Over voltage detection using UJT.	5	2

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. Above practical list is given with assumption that all practicals will be performed on dedicated test kit but if test kits are not available then faculty can make students build test circuit on breadboard / PCB and use word BUILD and TEST in PrO or faculty can use various simulation software for the same and make appropriate changes in PrO.

*iii. 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 experimental setup confidently and correctly	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.

i. Trainer Kits for testing the V-I characteristics of the following - 2 Nos. each:
   a) DIAC
   b) TRAIC
   c) SCR
   d) Power MOSFET
   e) IGBT
   f) UJT
   g) PUT

ii. 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) Armature and field control of DC shunt motor
   c) Speed control of DC shunt motor using SCR dual converter
   d) Thyristor chopper for DC motor drive

iii. i. Function Generator: Sine, square, triangle Wave etc. with frequency range 10 Hz to 100 kHz

iv. ii. DC power supply: -30 →0→+30 V with at least 1A current capacity.

v. iii. Dual channel CRO: At least 20MHz or higher

vi. iv. Multi meter: Capable of measuring AC and DC current, voltage and resistance.

vii. v. Electrical tool kit: Maintenance of trainer boards.

viii. vi. Circuit/Trainer board/ Demonstration modules: For performing relevant practical's with inbuilt power supply

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 fulfil the development of this competency.

a) Work confidently as a leader/a team member.
b) Regularly follows safety practices while using electrical appliances.
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	Major Learning Outcome	Topics and Sub topics
Unit 1 **Power semiconductor Devices.**	**1a**. Introduction and history of power electronics development. **1b**. Describe construction and working of various power semiconductor devices with the help of sketches. **1c**. Analyze V-I characteristics of various power semiconductor devices. **1d**. Enlist applications of various power semiconductor devices. **1e**. Compare various power semiconductor devices. **1f**. Enlist advantages and limitations of various power semiconductor devices.	1.1 Industrial electronics devices : 1.1.1 Silicon controlled rectifier (SCR) 1.1.2 DIAC 1.1.3 TRIAC 1.1.4 Metal oxide semiconductor field effect transistor (MOSFET) 1.1.5 Insulated gate bipolar transistor (IGBT) 1.1.6 Unijunction Transistor (UJT) 1.1.7 Programmable unijunction transistor (PUT) 1.1.8 Opto-isolator
Unit 2 **SCR : Triggering, Commutation and Protection.**	**2a**. Define various terminologies of thyristor family (SCR). **2b**. Explain two transistor analogy of SCR and derive mathematical relation between anode current and gate current. **2c**. Justify need of triggering, commutation and protection circuits for SCR. **2d**. Explain various triggering	2.1 Terminologies : On state voltage, Forward break over voltage, Peak inverse voltage, Forward dv/dt rating, Gate trigger voltage, On state current, di/dt rating, Holding current, Latching current, Gate current, Minimum gate current, Maximum gate

	methods / turn on methods of SCR with circuit diagram (No mathematical equation). **2e**. Explain various commutation / turn off methods of SCR with circuit diagram (No mathematical equation). **2f**. Explain various protection circuits for SCR.	current, Turn on time, Turn off time. 2.2 Triggering methods of SCR : 2.2.1 Forward voltage triggering 2.2.2 Radiation triggering 2.2.3 Thermal triggering 2.2.4 dv/dt triggering 2.2.5 Gate triggering 2.2.5.1 DC gate triggering 2.2.5.2 AC gate triggering 2.2.5.3 Pulse gate triggering 2.3 Commutation methods of SCR (Natural and Forced commutation) : 2.3.1 Class A 2.3.2 Class B 2.3.3 Class C 2.3.4 Class D 2.3.5 Class E 2.3.6 Class F 2.4 Protection for SCR : 2.4.1 Snubber circuit 2.4.2 Freewheeling Diode / Flyback diode 2.4.3 Heatsink
Unit 3 **Controlled rectifier and Inverter**	**3a**. Justify need of various types of power converter. **3b**. Classify various types of power converter. **3c**. Explain working of various types of single phase controlled rectifier with circuit diagram and waveforms. (No mathematical equations) **3d**. Explain working of various types of single phase inverter with circuit diagram and waveforms. (No mathematical equations) **3e**. Enlist applications of Controlled rectifier and Inverter.	3.1 Need of various power converter. 3.2 Classify various power converter. 3.3 Single phase Controlled rectifier 3.3.1 Half wave controlled rectifier with resistive load. 3.3.2 Half wave controlled rectifier with R-L load. 3.3.3 Half wave controlled rectifier with R-L load with freewheeling diode. 3.3.4 Full wave controlled rectifier with resistive load. 3.3.5 Full wave controlled bridge type rectifier with resistive load. 3.3.6 Applications of controlled rectifier. 3.4 Single phase inverter. 3.3.1 Series inverter

		3.3.2 Parallel inverter 3.3.3 Bridge type inverter 3.3.4 Applications of Inverter.
Unit 4 **Chopper and Cyclo-converter**	**4a**. Illustrate concept of PWM and duty cycle with mathematical equation. **4b**. Explain basic block diagram / circuit of chopper. **4c**. Explain working of various types of choppers with circuit diagram and waveforms. (Give mathematical relation between input voltage and output voltage, no need to derive the relation) **4d**. Enlist applications of chopper. **4e**. Explain working of various types of Cyclo-converters with circuit diagram and waveforms. (No mathematical equations) **4f**. Enlist applications of cyclo-converter.	4.1 PWM and duty cycle. 4.2 Basic block diagram of chopper. 4.3 Single phase chopper 4.3.1 Step up chopper 4.3.2 Step up-down chopper 4.3.3 Applications of chopper 4.4 Single phase Cyclo-converter using SCR 4.4.1 Step up mid point type cyclo-converter with resistive load. 4.4.2 Step down mid point type cyclo-converter with resistive load. 4.4.3 Step up bridge type cyclo-converter with resistive load. 4.4.4 Step down bridge type cyclo-converter with resistive load. 4.3.5 Applications of cyclo-converter.
Unit-V **Industrial and Commercial Applications of Power Electronics Devices**	**5a**. Describe Speed control of D.C. Motor using armature voltage control with circuit. **5b**. Describe stator voltage speed control for single phase induction motor with circuit. **5c**. Describe stepper motor drive circuit. **5d**. Illustrate application of SCR as A.C. Switch and D.C. static switch. **5e**. Describe function of single-phase AC power control circuit using DIAC-TRIAC with neat diagram. **5f**. Describe function of DC power control circuit using SCR with UJT in triggering circuit with circuit diagram and waveform. **5g**. Describe function of control circuit for temperature measurement system. **5h**. Describe function of control circuit for level measurement system.	5.1 Concept of electric drive 5.1.1 D.C motor drives 5.1.2 A.C. Motor drives (Induction motor) 5.1.3 Stepper motor drive 5.2 Static Switches 5.2.1 Single phase A.C. Switches 5.2.2 D.C. Switches 5.3 Power control 5.3.1 DC power control using SCR and UJT. 5.3.2 Single phase AC power control using DIAC-TRIAC. 5.4 Industrial applications 5.4.1Temperature control 5.4.2 Liquid level control 5.4.3 Induction heating 5.4.3.1 Basic concept of Induction heating. 5.4.3.2 Applications of Induction heating. 5.5 Commercial application

	5i. Explain basic bock diagram of induction heating. **5j**. Explain basic block diagram of battery charger for E-vehicles.	5.5.1 Battery charging of E-vehicles.

***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 QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Power semiconductor Devices	8	06	04	04	14
II	SCR : Triggering, Commutation and Protection	8	04	06	04	14
III	Controlled Rectifiers and Choppers	8	02	06	06	14
IV	Inverter and Cyclo-converter	8	02	06	06	14
V	Industrial and commercial Application of Power Electronics Devices	10	04	04	06	14
	Total	**42**	**18**	**26**	**26**	**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.*

10. 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. Do assignments related to theory topics.
iii. Download datasheets of various power semiconductor devices and obtain values of various parameters and note it down in practical journal if required.
iv. Troubleshoot various power electronics applications like motor drives, power converters etc.
v. Visit library and collect information from various magazines on recent developments in power electronics and it's applications and make report of that.
vi. Visit relevant industries to get practical knowledge and field experience and realize importance of power electronics.
vii. Take up a small technical project based on any advance theory topic.
viii. Repair faulty house hold applications like fan regulator, power supplies (i.e. SMPS) and make list of faults and procedure of repair.
ix. Students can join various channels / pages of power electronics on social media and conduct group discussion on learned topics.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Show video/animation film to demonstrate the working principles, constructional features, testing and maintenance of different types of power control devices.
ii. Use flash/animations to explain the working of different industrial applications of power electronics (i.e. motor drives, power converter).
iii. Arrange Industrial Visit for students (chemical industries, petroleum industries, production industries, Manufacturing industries, Automobile industries, Power Industries)
iv. Ask students to explore internet about recent developments in field of power electronics and prepare seminar presentations on relevant topics.
v. Give mini technical projects based on advance theory topics.
vi. Arrange expert lectures of instrumentation engineers working in industries.

12. SUGGESTED MICRO-PROJECTS

Take up a small technical projects based on any advance theory topic.

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at 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 he/she 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 a dated work diary consisting of individual contributions 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 a micro-project by the end of the semester to develop the industry oriented COs.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication
1	Power Electronics	Bimmhra B S	Khanna Publication,New Delhi
2	Power Electronics	Singh M D and Khanchandani K.B.	TMH Publication,New Delhi
3	Power Electronics and Its Applications	Jain Alok	Penram International Publication, New Delhi
4	Industrial Electronics and Control	Bhattacharya S K and Chatterjee S.	TMH Publication,New Delhi
5	Power Electronics	Rashid, Muhammad H.	PHI Learning, New Delhi latest edition
6	Industrial Electronics and Control	Paul Biswanath	PHI Learning New Delhi
7	Power Electronics-Devices, Circuits, Systems and Applications	Rai Harish C.	Galgotia Publication,New Delhi

14. List of Software/Learning Websites

www.nptel.iitm.ac.in. www.howstuffworks.com www.allaboutcircuits.com

www.electronicshub.org www.alldatasheet.com https://www.falstad.com/circuit/
(online circuit simulator)

www.youtube.com (Lectures on power electronics)

Simulation softwares :

MATLAB/SIMULINK.
Electronics Work bench.
MULTISIM.
Proteus.
Scilab.
Caspoc.

15. PO-COMPETENCY-CO MAPPING

Semester IV	Industrial Power Control (Course Code: 4341706)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ develop-ment of solutions	PO 4 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 industrial power control instrumentation systems.						
CO1: Describe construction and working of various power semiconductor devices.	2	-	-	2	-	-	-

CO2 : Illustrate various triggering, commutation and protection circuits for SCR.	2	1	1	2	1	-	-
CO3 : Describe construction and working of various power converters	2	1	1	2	1	-	-
CO4 : Illustrate various industrial and commercial applications of power electronics devices.	3	1	1	2	1	1	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

Member – Board of Studies (GTU), Electrical and Allied branches

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