GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: PLC & Industrial Automation
(Course Code: 4351109)

Diploma Program in which this course is offered	Semester in which offered
Electronics & Communication Engineering	5th Semester

1. RATIONALE

Automation is the need of current era. With the advancements in the field of AI and computer science, automation in the industry has evolved very much in this decade and it became a part of our day to day life now. Different types of automation systems are used for automatic and optimum control of different electrical and non-electrical parameters. Automation is the current need in the field of electronics, mechatronics, process control and smart home. So Diploma Engineers should be able to maintain them. This requires the thorough knowledge and practical skills. Diploma engineers should know very well about logical control action fundamentals. Hence this curriculum has been designed so that the students will be able to explain the construction, working and applications of various logical control strategies for automation.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different typesof skills so that students are able to acquire following competency:

- Use PLC for industrial automation systems.

3. COURSE OUTCOMES

CO1. Identify components for logical process control in automation applications.

CO2. Connect peripherals with the PLC for automation applications.

CO3. Develop basic PLC programmes for automation applications.

CO4. Develop advanced PLC programmes for automation applications.

CO5. Maintain PLC in various automation applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	CA	ESE	CA	
3	0	2	4	70	30*	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
ESE - End Semester Examination; **CA** - Continuous Assessment.

5. SUGGESTED PRACTICAL EXERCISES

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

Sr. No.	*Unit No.*	*Practical Exercises (Outcomes' in Psychomotor Domain)*	*Approx. Hrs. Required*
1.	*I*	*Identify continuous, discrete and composite control Systems.*	*2*
2.	*I*	*Connect direct digital control for a process.*	*2*
3.	*I*	*Connect data logger to a process.*	*2*
4.	*I*	*Identify components of SCADA.*	*2*
5.	*II*	*Prepare PLC specification for given situation for automation.*	*2**
6.	*II*	*Identify various modules and component of PLC hardware.*	*2**
7.	*III*	*Assemble various modules and component of PLC to make a PLC system.*	*2*
8.	*IV*	*Use relay as a switch to make circuit ON.*	*2*
9.	*IV*	*Implement NOT, AND & OR logic using relay(s).*	*2**
10.	*IV*	*Implement NAND & NOR logic using relay(s).*	*2**
11.	*IV*	*Implement EX-OR & EX-NOR logic using relay(s).*	*2**
12.	*IV*	*Identify programming formats and proper construction of ladder diagrams of given PLC.*	*2*
13.	*IV*	*Build NOT, AND & OR logic using ladder diagram with the help of PLC.*	*2**
14.	*IV*	*Build NAND & NOR logic using ladder diagram with the help of PLC.*	*2**
15.	*IV*	*Build EX-OR & EX-NOR logic using ladder diagram with the help of PLC.*	*2**
16.	*V*	*Develop ladder diagram to prepare latching relay.*	*2**
17.	*V*	*Develop ladder to switch ON motor for given condition*	*2*
18.	*V*	*Wire given temperature control system for automation.*	*2**
19.	*V*	*Wire given counting system for automation.*	*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. Care must be taken in assigning and assessing study report as it is a first year study report. Study report, data collection and analysis report must be assigned in a group. Teacher has to discuss about type of data (which and why) before group start their market survey.

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	Prepare the experimental setup and documentation of the program/application	25
2	Operate /Program the PLC correctly	30
3	Follow safe practices measures	10
4	Record observations/Output of PLC correctly	15
5	Interpret the results and conclude	20
Total		100

6. MAJOR EQUIPMENTS/ INSTRUMENTS REQUIRED

These are major equipment 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.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Computer with latest configuration with Windows Operating System and licensed/Free simulator software and internet connection	All
2	PLC trainer kit with 8 or 16 analog and digital input/output cards	All
3	D.C. power supply 12V and 24 V	All
4	Multi-meter, Breadboard, patch cord.	All
5	Encoder	19
6	Limit switch , proximity switch	All
7	Temperature sensor	18

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.

b) Follow ethical practices.

c) Follow safety precautions.

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)	Topics and Sub-topics
Unit – I Introduction to automation systems	1a. Justify the need of automation 1b. Describe different industrial controllers 1c. Process control techniques. 1d. Explain the working of data logger, DDC, SCADA system 1e. Explain the working of variable frequency AC drive	Introduction to automation and process control Basic block diagram of control system open loop and closed loop control system Different types of industrial controllers On-Off, P, PI, PD, PID controllers and their time equation and response Continuous Process Control Discrete-state Process Control Composite Process Control Block diagram of data logger, DDC, SCADA systems Advantages of data logger, DDC, SCADA systems Scope of automation in industry. Block diagram and working of variable frequency AC drive
Unit – II PLC Architecture and applications	2a. Draw Block diagram of PLC. 2b. Describe PLC architecture. 2c. Explain the working of PLC. 2d. List the steps to configure the PLC. 2e. List out peripherals for PLC 2f. Draw basic symbols used for PLC. 2g. Describe selection criteria for PLC. 2h. State advantages and Disadvantages of PLC. 2i. List out PLC applications in industries and automation Systems.	Introduction to PLC with its block diagram Configuration of PLC (Different components of modular PLC) Architecture and working of PLC PLC peripherals PLC symbols Selection criteria of PLC Advantages and disadvantages ofPLC PLC applications

Unit – III **PLC peripherals and wiring**	3a. Describe analog input /output module for PLC. 3b. Describe digital input /output module for PLC. 3c. Explain and Interface peripheral devices to PLC via analog/digital input/output module (including wiring) 3d. Draw connection diagram to Connect the switching deviceswith PLC. 3e. Describe the isolation technique. 3f. Draw and explain Isolated and non- isolated input wiring to PLC.	Analog input/ output module Digital input/ output module Connection of different peripheral devices to PLC **Input devices :** Pushbutton, Limit switch, proximity switch, level switch, and optical encoder. **Output Devices:** Relay, solid state relay, contactor, solenoid valve, and AC drive PLC power connection (wiring). Advantages of isolation and Different Isolation technique Isolated and non-isolated input/output wiring with PLC.
Unit – IV **Basic PLC programming**	4a.Describe general programmingprocedure. 4b.List special key board and display functions of hand-heldprogrammer 4c.List the steps to upload ON-line, Off-line program by hand-held programmer 4d.List the steps for Programming sequence of PLC. 4e.Describe the legal (proper) /illegal (improper) PLC ladder diagram 4f.List the important scanningconsiderations for PLC. 4g.List the corrective steps to betaken in case of PLC operational fault. 4h. Develop Relay based logical functions. 4i.Develop Ladder logic for NOT, AND, OR, NAND, Ex-OR, Ex-NOR logic.	Introduction to General PLC Programming Procedures. Programming equipment- Laptop and Hand held programmer and its connection to PLC Programming sequence of PLC PLC Ladder Diagrams Process scanning consideration PLC operational faults, troubleshooting procedure and corrective steps to rectify it. Realize NOT, AND, OR, NAND, NOR, Ex-OR, Ex-NOR logic using relay logic and ladder logic.

Unit – V Advanced PLC programming and applications	5a.Develop ladder logic for given Boolean algebraic equation. 5b.Develop Ladder logic for holding contact. 5c .Develop ladder logic for simple and complex branching ladder rung. 5d.Develop ladder logic for ON-OFF temperature control using timer and limit switches 5e .Develop Ladder logic for Counter 5f. Develop Ladder logic for timers	Boolean algebraic equation. Holding (latching relay) contact. Serial, Parallel and Nested branching in ladder rung. Temperature control using PLC ladder logic. Up , Down and Up/down Counter timers

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	Introduction to automation systems	07	02	06	02	10
II	PLC architecture and applications	08	02	04	08	14
III	PLC peripherals and wiring	08	02	04	08	14
IV	Basic PLC programming	10	02	04	12	18
V	Advanced PLC programming and applications	09	02	04	08	14
Total		**42**	**10**	**22**	**38**	**70**

Legends: R = Remembrance; **U** = Understanding; **A** = Application and above levels (Revised Bloom's taxonomy)

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 poster of PLC based automation system.
c) Mini project for industrial application using PLC.

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 is 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 automation in industrial and domestic applications.
f) Introduce automation of E-waste recycling plant among the students.
g) Guide students on how to address issues on environment and sustainability using PLC based automation.

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 industrial 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 working model of traffic light control using PLC.

b) Make a working model of elevator using PLC.

c) Make a working model of Automatic Car Parking System-multi Level.

d) PLC Based Automatic Bottle Filling Application.

e) PLC Based Door Open and Closing System.

f) PLC Based Automatic Counting System.

g) PLC Based Level Control System.

h) PLC Based Automatic Mixing Applications.

i) PLC based bottle counting system.

j) Collect specifications of PLC from different manufacturers and prepare a market survey report.

k) PLC based E-waste handling plant

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication
1	Programmable logic Controllers Principles and applications	John w. Webb Ronald A Reis	PHI Learning,
2	Programmable logic Controllers Programming methods and applications	John R Hackworth Frederick D. Hackworth Jr.	Pearson
3	Process Control Principles and applications	Surekha Bhanot	Oxford University press
4	Instrumentation engineer's handbook	B.G Liptak	Chilton Book Co., Philadelphia
5	Process control Instrumentation technology	Curtis D Johnson	PHI pvt. Ltd.
6	Modern Power Electronics and AC Drives	Bimal k bose	PHI Pvt. Ltd.

14. SOFTWARE/LEARNING WEBSITES

1) www.control.com
2) www.ourinstrumentationgroup.com
3) www.plcs.net
4) www.seimens.com
5) www.triplc.com
6) https://instrumentationtools.com
7) theautomationblog.com
8) www.plccompare.com
9) www.plcdev.com
10) www.plcprogramming.com
11) https://plcmanual.com/
12) https://plcacademy.com
13) https://realpars.com/plc
14) www.plcgurus.net
15) https://app.plcsimulator.online/
16) https://forumautomation.com/t/top-free-plc-simulator-software/2789
17) http://plcladdersimulator.weebly.com/
18) Learn PLC SCADA Android Application

15. PO-COMPETENCY-CO MAPPING

Semester V	PLC & INDUSTRIAL AUTOMATION (Code: 4351109) (Programme Elective-II)

	POs						
Competency & Course Outcomes	**PO1 Basic & Discipline specific knowledge**	**PO2 Problem Analysis**	**PO3 Design/ development of solutions**	**PO4 Engineering Tools, Experimentation & Testing**	**PO5 Engineering practices for society, sustainability & environment**	**PO6 Project Management**	**PO7 Life-long learning**
Competency Course outcome	Use PLC for industrial automation systems.						
CO1) Identify components for logical process control in automation	2	2	-	2	-	-	2
CO2) Connect peripherals with the PLC for automation applications.	3	2	2	3	-	2	2
CO3) Develop basic PLC programmes for automation applications.	3	3	3	3	-	1	2
CO4) Develop advanced PLC programmes for automation applications.	3	3	3	3	-	1	2
CO5) Maintain PLC in various automation applications.	3	3	-	3	1	2	2

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
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