GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)

Semester-V

Course Title: Programmable Logic Controller

(Course Code: 4351702)

Diploma programme in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	5th Semester

1. RATIONALE

This course has designed for diploma students through which they can learn basic to intermediate theory & basic programming concepts of programmable logic controllers. PLCs are used in many industrial and commercial processes. A diploma holder in the industry is required to install, troubleshoot, program & modify PLCs and PLC-controlled systems. Looking at the industrial applications of PLCs in modern industry, this course finds its usefulness in the present curriculum.

2. COMPETENCY

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

- Programme and operate PLC for various types of industrial automation system.

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills should be taught to acquire different learning out comes in cognitive, psychomotor and affective domain for the achievement of the following CO's:

a) Describe basic components of PLC and logical process in automation system.

b) Interface analog and digital input / output module with PLC.

c) Explain the basic concepts of PLC & ladder logic.

d) Use of timer, counter and other intermediate programming functions.

e) Develop basic entry-level applications and troubleshooting of PLC.

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 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	Identify continuous, discrete and composite control system.	I	2*
2	Identify various modules and component of PLC hardware.	I	2
3	Learn the basics and hardware components of PLC.	I	4
4	Sketch PLC based automation system with example.	I	2
5	Identify various peripherals which are interface with PLC.	II	2
6	Draw basic ladder logic symbols for PLC.	II	2
7	Determine the No. of digital I/O & Analog I/O of given PLC.	II	1
8	Draw wiring Diagrams for Digital Input (DI) and Digital Output (DO) signals for PLC.	II	2
9	Draw wiring Diagrams for Analog Input (AI), and Analog Output (AO) signals for PLC.	II	2
10	Describe the method of program scanning in PLC.	III	2
11	Study Memory Mapping and I/O addressing for PLC.	III	2
12	Implement a simple ladder logic program using digital inputs and outputs for PLC.	III	2*
13	Develop ladder logic to test functionality of basic logic gates.	III	2
14	Develop ladder logic to realize S-R flip-flop	III	2
15	Develop ladder logic to realize J-K flip-flop	III	2
16	Develop ladder diagram to prepare latching relay.	III	2*
17	Draw ladder diagram for given Boolean expression.	III	2
18	Implementation of simple ladder logic program using timer. 1) On delay timer 2) Off delay timer 3) Retentive timer	IV	2*
19	Implementation of simple ladder logic program using Counter 1) Up Counter 2) Down Counter	IV	2
20	Simulate ladder logic for Industrial application on UP counter.	IV	2
21	Simulate ladder logic for Industrial application on Retentive timer.	IV	2
22	Simulate Industrial application of Arithmetic Function for plc.	IV	2
23	Simulate Industrial application of PLC Data Transfer Functions.	IV	2

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
24	Simulate Industrial application of Comparison Functions.	IV	2*
25	Simulate Industrial application of PLC Skip and MCR Functions.	IV	2
26	Simulate Industrial application of PLC Sequencer Function.	IV	2
27	Simulate Industrial application of PLC Shift Register.	IV	2
28	Write and implement ladder logic program to blink LED using timer.	V	2*
29	Simulate material handling elevator operation on PLC simulator. Draw connection details for the same process.	V	2
30	Write and implement ladder logic program to on-off the DC motor using PLC	V	2
31	Implement traffic light control system using PLC.	V	2*
32	Simulate Bottle filing process on PLC simulator. Draw connection details for the same process.	V	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. *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	Conceptual clarity.	20
2	Experimental setup, Procedure and conduction by following safety practices.	50
3	Interpretation of Results and Ethical values.	30
Total		**100**

***** *Weightage of particular PrO may vary as per experiments.*

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	D.C. power supply, Multi-meter, Breadboard, patch cord.	12 to 32
2	Computer system with latest operating system.	12 to 32
3	PLC trainer kit.	12 to 32

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
4	8 Digital input/output PLC with SMPS & required cables.	3,12 to 32
5	Digital and analog module.	3,4,5,7
6	Level, flow, proximity and limit switch.	3,4,5,7
7	License/Free copy of ladder logic editor.	12 to 32
8	Simulator software for virtual simulation.	12 to 32
9	Level, flow, pressure control trainer kit.	1,2,3, 12 to 32
10	DC motor, solenoid valve, relay and other switching devices.	3,4,5,32

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 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:

a. 'Valuing Level' in 1st year.
b. 'Organization Level' in 2nd year.
c. '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 the development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on the attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit I **Introduction of PLCs.**	**1a.** Describe different process control techniques. **1b.** List various Brands of PLCs available in the market. **1c.** Draw block diagram of PLC. **1d.** Describe PLC architecture. **1e**. Explain working of PLC. **1f**. List selection criteria for PLC. **1g**. State Application of PLC in Industry. **1h.** State Advantages and limitations of PLC. **1i.**Explain need of automation.	**1.1** Introduction of various process control. a) Continuous Process Control. b) Discrete-state Process Control. c) Composite Process Control. **1.2** Introduction of PLC. **1.3** Architecture of PLC. **1.4** Working of PLC. **1.5** Selection Criteria of PLC **1.6** Application of PLC in the Industry. **1.7** Advantages and limitations of PLC. **1.8** Need of Automation in Industries.
Unit II **Peripherals and Interfacing**	**2a.** List out peripherals for PLC. **2b**. Draw basic symbols used in PLC. **2c**. Describe interfacing of peripheral with I/O modules. **2d**.Describe analog input /output module for PLC. **2e**. Describe digital input /output module for PLC. **2f**. Draw interfacing diagram to connect switching devices with PLC.	**2.1** Peripherals devices of plc, **Input Devices**: Pushbutton, Limit switch, proximity switch, level switch, and other sensing devices. **Output Devices**: Relay, solid state relay, contactor, solenoid valve, and other controlling devices. **2.2** Ladder logic Symbols of PLC. **2.3** Analog Input/output module. 1. AC input module 2. DC input module **2.4** Digital Input/output module. 1. AC Output module 2. DC Output module **2.5** PLC Input/output interfacing diagram.
Unit-III **Basic of Programming techniques**	**3a**.Describe common types of registers used in PLC. **3b**. Describe module addressing for PLC. **3c**.Explain basic plc programming Language. **3d**.Describe general	**3.1** Program scan & memory organization. a. PLC operation & program sequence. b. PLC Memory Mapping and I/O addressing for (Allen-Bradley PLC). c. Types of Register use in PLC (Holding, Input, Output register).

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	programming procedure. **3e**.Develop ladder logic for all logical gates. **3f**. Develop ladder logic for R-S and J-K flip flop. **3g**.Develop Ladder logic for holding contact. **3h**.Explain simple and complex branching of ladder rung. **3i**.Develop ladder logic for given boolean algebraic equation. **3j**.Write difference between proper and improper PLC ladder diagram.	**3.2** PLC Programming Languages. a. Ladder Logic (LAD) b. Functional Block Diagram (FBD) c. Sequential Functional Chart (SFC) d. Structured Text (ST) e. Instruction List (IL) **3.3** Ladder diagram of all Basic Logic Gates. **3.4** Ladder diagram of S-R & J-K flip flop. **3.5** Holding (latching relay) contact. **3.6** Concept of simple and complex branching in Ladder logic. **3.7** Boolean algebra law using ladder language.
Unit-IV **Advance Programming functions**	**4a**. State types and instructions of timing functions used in PLC. **4b**.Describe PLC ON delay and OFF delay timer. **4c**. State types and instructions of PLC counter functions. **4d**.Describe UP & Down Counter **4e**.Describe arithmetic and comparison functions. **4f**. Describe working of Skip, Master Control Relay (MCR) and Jump To Label functions. **4g**.Describe PLC sequencer. **4h**.Describe Sequencer output, and Sequencer load functions. **4i**. Describe working of data handling instruction. **4j**. Describe working of Bit Shift Right and Bit Shift Left function functions.	**4.1** ON Delay timer, Off Delay timer, Retentive timer, Non-retentive timer **4.2** UP Counter, Down Counter, UP-Down Counter **4.3** PLC arithmetic functions. (Addition, Subtraction, Multiplication, Square Root, Division, Negative) **4.4** PLC comparison function (Equal, Not equal, less than, greater than or equal, limit test function) **4.5** Skip, Master Control Relay (MCR), Jump To Label. **4.6** Sequencer output (SQO) and Sequencer load (SQL) instruction. **4.7** Data handling instructions: Move, Block Move, Table Move, Register Move. **4.8** Bit Shift Right and Bit Shift Left function.
Unit-V **Application and Troubleshooting**	**5a**. Draw PLC-based automation system for a given application with I/O interfacing. **5b**. Develop a Ladder Logic for application mentioned from para 5.2 to 5.6 of given topics. **5c**. Identify Input and Output interfacing devices for given	**5.1** PLC-based automation system. **5.2** High-Low level control of the tank. **5.3** LED blinking using various timers. **5.4** DC motor control using PLC.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	PLC based application. **5d**. Prepare event of sequencing using real-world examples. **5e**. State troubleshooting procedure for PLC.	**5.5** Two-way traffic lights system. **5.6** material handling elevator **5.7** Troubleshooting procedure of PLC.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction of PLCs	10	10	5	0	15
II	Peripherals and Interfacing.	5	5	5	0	10
III	Basic of Programming Techniques.	9	3	7	5	15
IV	Advance Programming functions.	12	5	5	10	20
V	Application and Troubleshooting.	6	1	3	6	10
Total		**42**	**24**	**25**	**21**	**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 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) Show animation/ video related to course content.
d) Co-relating the importance of content of this course with other practical application.
e) Industrial visit for practical exposure.
f) Quiz competition across intercollege branch students.

g) Organize workshop on PLC programming by expert from industry.

h) 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:

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

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
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	Programmable Logic Control: Principles And Applications	NIIT	PHI EEE edition
7	Programmable Controllers	Thomas A. Hughes	ISA

14. SOFTWARE/LEARNING WEBSITES

- www.control.com
- www.plcs.net
- www.seimens.com
- www.triplc.com
- https://instrumentationtools.com
- theautomationblog.com
- www.plccompare.com
- www.plcdev.com
- www.plcprogramming.com
- https://plcmanual.com/
- https://plcacademy.com
- https://realpars.com/plc
- www.plcgurus.net

15. PO-COMPETENCY-CO MAPPING:

Semester V	PROGRAMMABLE LOGIC CONTROLLER **(Course Code : 4351702)**						
	POs						
Competency & Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
	Basic & Discipline specific knowledge	Problem Analysis	Design/ development of solution	Engineering Tools, Experimentation & Testing	Engineering practices for society, sustainability & environment	Project Management	Life-long learning
Competency	Programme and operate PLC for various types of the industrial automation system.						
CO1	3	-	-	-	-	-	-
CO2	3	2	1	1	-	-	-
CO3	3	2	3	3	-	1	2
CO4	2	1	-	3	-	-	3

Semester V	PROGRAMMABLE LOGIC CONTROLLER **(Course Code : 4351702)**						
	POs						
Competency & Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**
	Basic & Discipline specific knowledge	Problem Analysis	Design/ development of solution	Engineering Tools, Experimentation & Testing	Engineering practices for society, sustainability & environment	Project Management	Life-long learning
Competency	Programme and operate PLC for various types of the industrial automation system.						
CO5	2	3	3	3	2	2	3

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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

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