GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Programmable Logical Controllers
(Course Code: 4352002)

Diploma program in which this course is offered	Semester in which offered
Mechatronics Engineering	5th Semester

1. RATIONALE

In previous semesters students have learnt the fundamentals of electronics, digital circuits, and control devices, they are capable to understand and develop a basic circuit. To use this knowledge and programming skill in the field of automation it is also necessary to learn about Programmable Logic Controller. Programmable Logic Controller works as brain of automation system, which can be programmed for desired functions for controlling different machines. The Industries therefore demand for persons having automation knowledge with skill of P.L.C. programming. To cater to the need of Industries and to convert their basic skill in to some advance level.

2. COMPETENCY

The course content should be taught and implemented to develop different skills so that students can acquire the following competency.

- **Programme PLC to execute various machine cycles.**

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

CO-1	Operate PLC.
CO-2	Use of PLC memory & Various Sensors.
CO-3	Use of Boolean algebra to simplify designs.
CO-4	Use of Ladder Logic Functions and advance function for PLC programming.
CO-5	Selection of PLCs for relevant applications.

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	(L+T+P/2)	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

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

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
01	Demonstration of PLC kit and its Simulation Software of LOGOSOFT application in Windows	I	02
02	To Prepare & Run Ladder Logic for AND,OR & NOT Gate	II	02
03	To Study Different Types of Timers & Counters in PLC	III	04
04	To Study the Program of Staircase Light Control with the use of PLC Timer kit	III	04
05	To Study the Program of Water Level Control with of PLC Trainer kit.	III	04
06	To Identify Different Types of Ladder Logic of PLC	III	02
07	Develop ladder programming for a given statement - To on the bulb1 after 5sec of switch1 on. Turn the bulb2 on after the 5 sec of bulb1 on and test.	IV	02
08	Develop ladder programming for a given statement -To on the bulb after 5sec of switch off. Turn the bulb2 off after the 5 sec of bulb1 on and test.	IV	02
09	PPT on Various Topics Given by Course Coordinator	I to V	02
10	Develop ladder programming for a given statement -To operate four bulbs in series and test.	IV	04
Total (Hours)		**-**	**28**

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 representative list**.**

II. Care must be taken in assigning and assessing the study report as it is a Second-year study report. The study report, data collection, and analysis report must be assigned to a group. A teacher has to discuss the type of data(which and why)before the group starts 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 %
Experimentation/performance type PrOs (PrOs Number: 2,3,4,5,6,7,8,9,10 &11)		

1	Knowledge	30
2	Quality of Report	30
3	Participation	20
4	Punctuality	20
Total		**100**
For Demonstration type PrOs (PrOs Number: 1&12)		
1	Knowledge	20
2	Procedure follows	30
3	Observation Skill	20
4	Conclusion/ Summary	10
5	Quality of Report	10
6	Punctuality	10
Total		**100**

Sample rubrics Performance Indicators for the PrOs

Demonstration type PrOs (PrOs Number 1 &12)					
Criteria	**%**	**10**	**9-8**	**7-6**	**5**
Knowledge	30%	Students give the correct answers 90% or more	Student give the correct answers between 70-89%	Student give the correct answers between 50-69%	Student give the correct answers less than 50%
Quality of Report	30%	Neat Handwriting, figure, and table. Complete labeling of figure and table.	Only formatting is not proper (Location of figures/tables, use of pencil and scale)	A few required elements (labeling/ notations) are missing	Several require elements (content in paragraph, labels, figures, tables) are missing
Participation	25%	Excellent focused attention in the exercise	Moderately focused attention on exercise	Focused limited attention in the exercise	Participation is minimum
Punctuality	15%	Timely Submission	Submission late by one laboratory	Submission late by two laboratories	Submission late by more than two laboratories

Experimentation/performance type PrOs (PrOs number 2,3,4,5,6,7,8,9,10 & 11)					
Criteria	**%**	**10**	**9-8**	**7-6**	**5**

Knowledge	20%	Student give the correct answers 90% or more	Student give the correct answers between 70-89%	Student give the correct answers between 50-69%	Student give the correct answers less than 50%
Procedure follows	30%	Student follow all the procedure with precaution in a logical order	Student follow all the procedure with some precaution in a logical order	Student follow all the procedure without precaution in a logical order	Student follow all the procedure without precaution in an illogical order
Observation Skill	20%	Excellent focused attention in the exercise	Moderately focused attention on exercise	Focused limited attention in the exercise	Participation is minimum
Conclusion/ Summary	10%	Student concept is mostly clear	Student concept is partly clear	Student concept is somewhat clear	Student concept is not clear
Quality of Report	10%	Neat Handwriting, figure, and table. Complete labeling of figure and table.	Only formatting is not proper (Location of figures/tables, use of pencil and scale)	A few required elements (labeling/ notations) are missing	Several require elements (content in paragraph, labels, figures, tables) are missing
Punctuality	10%	Timely Submission	Submission late by one laboratory	Submission late by two laboratories	Submission late by more than two laboratories

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

Sr. No.	Equipment Name
1.	PLC Trainer 4VDC , minimum 12 I/O ,TTL OR RELAY TYPE 2PTO-100KHZ min. (optional (Inbuilt)), Minimum 10-timer and counter. 4 Analog I/O.
2.	Sensor ---- Proximity (Inductive , Capacitive ,Photoelectric) Limit Switch.
3.	Programming Software – LOGOSOFT PLC

7. AFFECTIVE DOMAIN OUT COMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the COs mentioned above and PrOs. More could be added to fulfill the development of this course competency.

a. Work as a leader/team member.

b. Follow safety practices.

c. Follow ethical practices

d. Maintain tools and equipment

e. Practice environment-friendly methods and processes.(Environment related)

The ADOs are best developed through 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' in1st year

II. 'Organization Level' in 2nd year.

III. 'Characterization Level' in 3rd year.

8. UNDER PINNING THEORY

Based on the higher level UOs of Revised Bloom's taxonomy formulated for developing COs and competency, the primary underpinning theory is given below. If required, more such UOs could be included by the course teacher to focus on attaining COs and competency.

Unit	Unit Outcomes (UOs) (4to6 UOs at different levels)	Topics and Sub-topics
Unit – I **Introduction to PLC**	1a. What is PLC? 1b.Types of PLC? 1c.Describe hardware components of PLC. 1d.Explain the block diagram of PLC.	1.1 Principles of operation of PLC 1.2 PLC verses computer 1.3 PLC hardware components 1.4 Scan time of a cycle. 1.5 Industrial PLC. 1.6 Applications of PLC
Unit– II **PLC Memory and Logical Sensor**	2a. Explain different types of memories available for PLC. 2b. PLC input and output. 2c. PLC programming languages.(LAD, FBD, SFC etc) 2.1 2d.Distinguish between various data files: User Bits Memory, Timer Counter Memory, PLC Status Bits, User Function Control Memory, Integer Memory, Floating Point Memory 2.2 2e.Use addresses for locations in memory. 2.3 2f.Distinguish between Switches, TTL, Sinking and sourcing, Connection of switch	2.1 Memory Address. 2.2 Program Files. 2.3Data files: User Bits Memory, Timer Counter Memory, PLC Status Bits, User Function Control Memory, Integer Memory, Floating Point Memory 2.4 Sensor wiring: Switches, TTL, Sinking and sourcing, Connection of switch 2.5 Human/ product Presence Detection Sensors: Reed Switch, Optical Sensor, Capacitive Sensor, Inductive Sensor

	2.4 2g. Distinguish the various types of human/product presence detection sensors interfacing and calibration 2.5 2h. Select sensors for a given application	
Unit-III **Boolean Logic Design and Timers, Counter, Latch Concept**	3a. Explain logic design for a given application 3b. Simplify designs with Boolean algebra. 3c. Use timers, latch and counters in various designs 3d. Use counter as per requirement Apply latch in ladder logic	3.1 Boolean algebra: Rules of Boolean Algebra, Logic Design for a given application 3.2 Common Logic Forms: Complex gate forms, Multiplexer. 3.3 Timers: On-delay timer, Off-delay timer, Retentive timer. 3.4 Counters: Up-Counters, Down-Counter, Up-Down Counter. 3.5 Master Control Relay.
Unit-IV **Ladder Logic Function and Advance Function**	4a. Explain various programme control instructions (Mathematical, logical, move, data conversion). 4b. Manipulate the data for various applications 4c. Develop ladder logics for a particular design 4d. Develop programmes for given applications.	4.1 Data handling Function: Move Function, Mathematical Function, Conversion Function 4.2 Logic Function: Comparison of Value, Boolean Function 4.3 List Function: Shift registers, Stacks, Sequencer 4.4 Program Control: Branching and Looping.
Unit-V **Selecting PLC**	5a. State the criteria for selection of PLC 5b. Select right PLC for a given application / software. 5c. Prepare the specifications of a PLC	5.1 PLC selection criteria. 5.2 PLC specifications 5.3 PLC Advantages & Disadvantages

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 to PLC	03	04	04	00	08
II	PLC Memory and Logical Sensor	11	06	06	06	18
III	Boolean Logic Design and Timers, Counter, Latch Concept	10	07	07	08	22
IV	Ladder Logic Function and Advance Function	12	06	06	04	16
V	Selecting PLC	06	02	02	02	06
Total		**42**	**25**	**25**	**20**	**70**

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

10. SUGGESTED STUDENT ACTIVITIES

Sr. No.	Activity.
1.	Prepare journals based on practical performed in laboratory.
2.	Assignments on solving Boolean algebra.
3.	Prepare/Download a dynamic animation to illustrate the following: a) Working principle of Timer b) Working principle of Counter c) Working of different types Ladder logic.
4.	Carry out a market survey of local dealers for PLC and compare them on mentioned points: (a) Rating (b) Memory (c) Cost (d) Programming language and (e) Performance
5.	Download the catalogue of PLC from websites of reputed manufacturers such as SIEMENS, FATEK, DELTA, ABB, and OMRON etc. to learn the latest developments.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

Programmable logic Controllers being a most important subject of Mechatronics , teachers are expected to lay considerable stress on understanding the basic concepts, principles, and applications. For this purpose, teachers are expected to give simple problems in the classroom and provide tutorial exercises to develop the necessary knowledge for comprehending the basic concepts and principles. As far as possible, teaching the subject is supplemented by demonstrations and practical work in the laboratory using various PLC Simulation Softwares.

12. SUGGESTED MICRO-PROJECTS

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-projects are group-based (groups 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 must maintain a dated workdiaryconsistingofindividualcontributionstotheprojectworkandgiveaseminarpresentationbefore submission. The duration of the micro project should be about**14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit a micro-project by the end of these semester to develop the industry-oriented COs.

A representative 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 or using suggested student activity.

A representative list of micro-projects is given here. The concerned faculty could add similar micro-projects in any form (chart/presentation/report/model):

1. Assignments on solving Boolean algebra.
2. Prepare/Download a dynamic animation to illustrate the following:
   a) Working principle of Timer
   b) Working principle of Counter
   c) Working of different types Ladder logic.
   d) Prepare a Chart on Different Topics given by PLC Faculty member.

1. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication
1	Programmable Logic Controller,5th Edition	John W. Webb and Ronald A. Reis	PHI Learning, New Delhi
2	Programming Language Concept	Peter sestoft	Springer
3	Automating Manufacturing System	Hugh Jack	McGraw Hill, New Delhi
4	A practical Handbook to PLC	Alireza H. Fassih	New Generation publication
5	Programmable Logic Controllers,5th Edition	W. Bolton	Newnes

13. SOFTWARE/LEARNINGWEBSITES

List of Software/Learning Websites

i. *www.plcs.net*
ii. *www.automation.siemens.com*
iii. *www.abb.co.in*
iv. www.ia.omron.com

14. PO-COMPETENCY-COMAPPING

Semester- V	Programmable Logical Controllers						
Semester- V	POs						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7
Competency &CourseOutcomes	Basic & Discipline-specific knowledge	Problem Analysis	Design/development of solutions	Engineering Tools, Experimentation & Testing	Engineering practices for society, sustainability & environment	Project Management	Life-long Learning
Competency	Select, operate and maintain fluid machinery based on fluid laws and characteristics.						
CO-1 Operate PLC.	2	---	---	1	1	---	2
CO-2 Use of PLC memory & Various Sensors.	2	1	---	1	1	1	1

CO-3 Use of Boolean algebra to simplify designs.	1	2	3	--	---	2	2
CO-4 Use of Ladder Logic Functions and advance function for PLC Programming.	1	2	2	---	--	1	2
CO-5 Selection of PLCs for relevant Applications.	2	----	---	---	1	2	2

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

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE(GTU Resource Persons)

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Harsh G. Tailor Lecturer(Mechatronics Engg)	B. & B. Institute of Technology, Vallabh Vidyanagar	9408365148	tailor.harsh4@gmail.com
2	Dr.R.D.Patel Head, Mechanical	B. & B. Institute of Technology, Vallabh Vidyanagar	9825523982	rakeshgtu@gmail.com

BOS Resource Persons

Sr. No.	Name and Designation	Department	Contact No.	Email
1.	Dr. S. H. Sundarani, BOS (Chairman HOD Mechanical Engg.)	Government Polytechnic Ahmadabad	9227200147	gpasiraj@gmail.com
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