GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Programmable Logic Controller
(Course Code: 4352403)

Diploma programmer in which this course is offered	Semester in which offered
Power Electronics	5th Semester

1. RATIONALE

PLCs are designed to improve efficiency and productivity in industrial processes. By understanding PLC programming, you can optimize control systems, reduce downtime, and improve overall operational performance. This knowledge enables you to make a significant impact on industrial processes, leading to increased productivity and cost savings for businesses. PLCs are widely used in various industries, such as manufacturing, energy, and process control. As industries continue to automate their operations, the demand for professionals with PLC programming skills is increasing. Overall, a learning of PLC course provides you with valuable skills and knowledge in industrial automation, making you a sought-after professional in a variety of industries.

2. COMPETENCY

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

- **Program, troubleshoot, and maintain PLC systems effectively.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

1. **Explain working of PLC.**
2. **Select appropriate Input-Output Modules.**
3. **Develop Ladder Program for various Logical Conditions.**
4. **Develop Ladder Program for Timers, Counters, Comparison Functions and Mathematical Functions.**
5. **Explain Communication and Networking recommended for Automation.**

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	-	2	4	30	70	25	25	150

(*): For this practical only course, 25 marks under the practical CA has two components i.e. the assessment of micro-project, which will be done out of 10 marks and the remaining 15 marks are for the assessment of practical. This is designed to facilitate attainment of COs holistically, as there is no theory ESE.

***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) that are thesub-components 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'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	To study hardware and software associated with PLC	1	2*
2	To Study Input-Output Modules of PLC and Prepare I/O module chart	2	2*
3	Assemble various modules and component of PLC to make a PLC system.	2	2
4	Execute/Prepare ladder diagram of AND, OR, NOT, NAND, NOR, X-OR, X-NOR gate	3	2*
5	Execute/Prepare ladder diagram for Half-Full Adder and Subtractor.	3	2*
6	Execute/Prepare ladder diagram for any Three combinational circuits.	3	2*
7	Execute/Prepare ladder diagram for any Three logical equations.	3	2*
8	Execute/Prepare ladder diagram for any Three statement-based problems.	3	2*
9	Execute/Prepare ladder diagram for any Three problems based on latching-unlatching and interlock concept.	3	2*
10	Execute/Prepare ladder diagram for any Three statement based logical conditions- for Timer	4	2*
11	Execute/Prepare ladder diagram for any Three statement based logical conditions- for Counter.	4	2*
12	Execute/Prepare ladder diagram for any Three statement based logical conditions- for implementation of Comparison function.	4	2*
13	Execute/Prepare ladder diagram for any Three statement based logical conditions- for implementation of Mathematical function.	4	2
14	Develop ladder diagram for a temperature, level, flow control system	4	2*
15	Execute/Prepare allover ladder diagram for industrial process and control.	4	4
16	Interface personal computers in network using different topology.	5	2*
17	Study Interface of RS232, RS 422, and EIA 485 communication standards for interface in automation.	5	2*
	Total		**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 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.*

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

These 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.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	PLC Trainer Kit PLC: Delta DVP EX2 Series Analog MPU (100 -240VAC) 8 Digital Input: 24VDC, 5mA 6 Digital Output: (< 250VAC, 30VDC) 4 Analog Input: (-10 ~ + 10 V , -20 ~ + 20 Ma) Analog Output: (-10 ~ + 10 V , -20 ~ + 20 Ma) Com Port: Built-in 1 RS-232 and 2 RS-485 ports; Compatible withModbus ASCII/RTU protocol,	4 to 15
2	Different types of application Modules: Traffic Light Module, Vehicle Parking Module, Elevator Lift Module Washing Machine Control Module, Bottle Filler Control Module, Packing Module, Level & Pump Control Module, Fan Control Module, Star/Delta Starter Control Module, Safety Door Control Module, Conveyor Belt Control Module, Stepper Motor Module, DC Motor Control Module	8 to 15
3	Analog, Digital and special I/O Modules	8 to 15

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 instruments and tools.

c) Realize importance of sensors and transducers in electronic circuits.

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 PLC**	1a. Justify the need of PLC in industrial automation. 1b. Write different functions of PLC with its advantages. 1c. Explain Block Diagram and Scan Method of PLC. 1d. List selection criteria for PLC. 1e. Compare the use of PC v/s Relay Control and PLC. 1f. List sector wise various applications of PLC. 1g. Compare any two commercially available PLC from different manufacturer with Delta EX2 series PLC.	1.1 PLC: Introduction, History, Definition, Classification, Advantages, Characteristics, Operation, Block Diagram and functions, Scan Method, Programming Languages. 1.2 Selection Criteria for PLC 1.3 PLC v/s Relay Control 1.4 PC v/s PLC. 1.5 Applications of PLC. 1.6 The IEC Standard for PLC 1.7 Commercially available PLC Brands. 1.8 Delta EX2 Series: Parameters
Unit– II **Input / Output Modules**	2.a Classify I/O modules of PLC. 2.b Sketch the block schematic of I/O system. 2.c Explain the concept of Sinking and sourcing. 2.d Explain Discrete(digital) input and output modules with block diagram. 2.e Write advantages and	2.1 I/O module: Classification, Parallel I/O System, Serial I/O System. 2.2 Sinking and Sourcing in PLC Interfacing 2.3 Discrete input modules: DC input, AC input, Rectifier with filter, Isolation, logic section Spoliations. 2.4 Discrete output modules: operating principles, Specifications. 2.5 Advantages and disadvantages of Output Modules. 2.6 Analog input modules: single ended,

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
	disadvantages of output modules. 2.f Explain Analog input Modules and special I/O Modules with its strengths and limitations.	differential input, specifications. 2.7 Special I/O Modules; Parameters
Unit– III Basic Ladder programming	3a. Draw the ladder diagrams for different logical gates, conditions, logical equations and statements. 3b. Draw the ladder diagrams based on Latching-Unlatching and Interlock concept.	3.1 Ladder diagram: Rules for PLC ladder diagrams, Logic Gates Diagram, Combinational circuit Diagram with the help of Truth Table and Equation, Logical Equation and statement-based diagram 3.2 Programming using Latching- Unlatching and Interlock Concept.
Unit– IV Special Function Programming	4a. Describe characteristics of PLC timer. 4b. Explain the working principle of a PLC timer. 4c. Write function and operation of PLC counter. 4d. Develop Ladder diagram using timer and counter. 4e. Develop Ladder diagrams for the implementation of various comparison functions. 4f. Develop Ladder diagrams for the implementation of various mathematical functions.	4.1 Timers: Classification, Characteristics, Function in PLC, Ladder diagram using timer. 4.2 Counter: Classification, Characteristics, Ladder diagram using counter. 4.3 Ladder Programs using Comparison Function: Equal, Not Equal, Less Than, Less Than or Equal, Greater Than, Greater Than or Equal 4.4 Ladder Programs using Mathematical Function: Addition, Subtraction, Multiplication, Division
Unit– V Communications	5a. Explain different types of communication interface. 5b. Explain various networktopology. 5c. Write advantagesand disadvantages of different network topology.	5.1 Communication interface: Simplex, Half duplex, Full duplex, RS 232- DB-25 connector, DB-9 connector, RS 422, EIA 485 interface. 5.2 Industrial network: Bus topology, Ring topology, Star topology, Tree topology.

***Note**: The UOs need to be formulated at an '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	Unit Title	Teaching	Distribution of Theory Marks

No.		Hours	R Level	U Level	A Level	Total Marks
I.	**Introduction to PLC**	08	06	04	02	12
II.	**Input / Output Modules**	09	04	08	02	14
III.	**Basic Ladder Programming**	08	00	04	12	16
IV.	**Special Function Programming**	12	04	06	10	20
V.	**Communications**	05	02	06	00	08

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:

a) **Compare and analyze any Two Unitary PLC and Any Two Modular PLC Datasheets.**

b) **Observe the output parameter as well waveform using simulation and compare it with practical results.**

c) **Prepare Hazard Analysis report for various materials being generated as Waste in Industrial Automation Fields.**

d) **Use PLC for Interfacing various I/O Modules.**

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.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Use video/animation to demonstrate various interfacing of I/O and Process in PLC.
g) Guide students for reading data sheets.

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 is 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 s/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) **Make any one working module for commercial application to interface with PLC.**

b) **Develop a small application that contain at least 01 sensor, 01 switch and 01 output controllable device to interface with PLC.**

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Programmable Logic Controllers	Frank D. Petruzella	McGraw-Hill Education, 2017 ISBN 978-0-07-337384-3
2	DVP-ES2 / EX2 / EC5 / SS2 / SA2 / SX2 / SE & TP Operation Manual - Programming	Delta Electronics, Inc	Delta Electronics, Inc DVP-0139720-14 2023/02/10
3	Programmable Logic Controllers	W. Bolton	Elsevier Ltd. Sixth edition 2015 ISBN 978-0-12-802929-9
4	Programmable Logic Controllers, Hardware and Programming	Max Rabiee	The GoodHeart-Willcox Company, Inc, Fourth Edition, 2018 ISBN 978-1-63126-932-5
5	Programmable Logic Controllers and Industrial Automation an Introduction	Mitra Madhuchanda Gupta Samarjit Sen	Param International Publishing (India) Pvt. Ltd., New Delhi, Latest edition ISBN 978-81-87972-17-4
6	Practical Guide to Programmable Logic Controllers	AutomationDirect.com	AutomationDirect.com
7	Programmable Controllers Theory and Implementation	L. A. Bryan E. A. Bryan	Industrial Text Company Second Edition ISBN 0-944107-32-X

14. SOFTWARE/LEARNING WEBSITES

a) https://www.electrical4u.com/programmable-logic-controllers/

b) https://dipslab.com/plc-input-output-modules-2/

c) https://instrumentationtools.com/basics-of-plc-programming/

d) https://automationforum.co/plc-learning-series-8-rules-for-ladder-diagram-programming/#:~:text=PLC%20learning%20series%205%3A%208%20Rules%20for%20ladder,address%20can%20be%20used%20as%20inputs%20address%3A%20

e) https://dipslab.com/rules-plc-ladder-diagram-programming/

f) https://www.youtube.com/playlist?list=PL0SiuA-KTuIHFufeksUIsLnk4FzSa4OSN

g) https://www.youtube.com/watch?v=gairfgMphLg&list=PL0SiuA-KTuIHlGEQu22BuobWv4VjBu9hq

h) https://www.youtube.com/watch?v=ETIR_YVqBc0&list=PLjwh8WIIwKDhcB9eFIWra67bL32E8dGeS

i) https://www.youtube.com/watch?v=copaO5k7sDo&list=PLB0MB4KNytIvB8gSiTzM7yY-N2ej4b776

j) https://www.youtube.com/watch?v=EJXaB_tZ5XA

k) https://www.youtube.com/watch?v=zbqrNg4C98U

15. PO-COMPETENCY-CO MAPPING

Semester V	Programmable Logic Controller (Course Code: 4352403)						
	POs and PSOs						
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	**Program, troubleshoot, and maintain PLC systems effectively.**						
Course Outcomes CO 1) Explain working of PLC.	2	1	1	0	1	1	2
CO 2) Select appropriate Input-Output Modules.	2	1	2	2	1	2	2
CO 3) Develop Ladder Program for various Logical Conditions.	2	3	3	3	2	2	2
CO 4) Develop Ladder Program for Timers, Counters, Comparison Functions and Mathematical Functions.	2	3	3	3	2	3	3
CO 5) Explain Communication and Networking recommended for Automation.	2	1	1	2	1	1	3

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

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