GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Basics of Industrial Automation
(Course Code: 1334101)

Diploma programme in which this course is offered	Semester in which offered
Automation & Robotics	3rd Semester

1. RATIONALE

This course has designed for diploma students through which they can learn basic to intermediate theory of industrial automation using programmable logic controllers and others control system. In the present global scenario of manufacturing, industries are moving towards complete automation. Small and medium scale industries are in the phase of switching to PLC and SCADA technology for the data acquisition and control. Therefore, it is necessary for engineers to have knowledge of both PLC and other technology. A diploma holder in the automation industry is required to install, troubleshoot, program & modify PLCs and PLC-controlled systems. This course attempts to provide basic knowledge of these technologies to develop operational competency. Hence this course is foundation for the engineers who want to further specialize in the Industrial automation field.

2. COMPETENCY

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

- ✓ **Understand Basic Components Of Industrial Automation Systems.**

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:

CO1: Describe the basic concept of industrial automation system.
CO2: Explain the basic principal, components and architecture of PLC system.
CO3: Describe the fundamental concepts of PLC programming.
CO4: Learn various basic programming functions to create control strategies using PLC.
CO5: Study different components of an industrial automation system.

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	4	5	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	Introduction of automation and various types of system.	I	2
2	Learn the basics Basic components of automation system.	I	4*
3	Identify continuous, discrete and composite control system.	I	2*
4	Sketch PLC based automation system with example.	I	2
5	Learn the basics and hardware components of PLC.	II	2*
6	Identify various modules and component of PLC hardware.	II	2
7	Identify various peripherals which are interface with PLC.	II	2
8	Determine the No. of digital I/O & Analog I/O of given PLC.	II	2*
9	Draw wiring Diagrams for Digital Input (DI) and Digital Output (DO) signals for PLC.	II	2
10	Draw wiring Diagrams for Analog Input (AI), and Analog Output (AO) signals for PLC.	II	2
11	Study different types of programming language for PLC.	III	4
12	Demonstrate procedure for Ladder diagram Preparation, downloading and running status of PLC.	III	2
13	Describe the sequence of program scanning in PLC.	III	2
14	Study Memory Mapping and I/O addressing for PLC.	III	2
15	Develop ladder logic to test functionality of basic logic gates	III	4*
16	Draw ladder diagram for given Boolean expression.	III	2*
17	Develop ladder diagram to prepare latching relay.	III	2
18	Draw basic ladder logic symbols for PLC.	III	2
19	Implementation of simple ladder logic program using timer. 1) On delay timer 2) Off delay timer 3) Retentive timer	IV	4*
20	Implementation of simple ladder logic program using Counter 1) Up Counter 2) Down Counter.	IV	2*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
21	Simulate ladder logic for Industrial application on UP counter.	IV	2
22	Simulate ladder logic for Industrial application on Retentive timer.	IV	2
23	Simulate Industrial application of Arithmetic Function for plc.	IV	2
24	Simulate Industrial application of Comparison Functions.	IV	2*
25	Simulate Industrial application of Logical Functions.	IV	2
26	Implement a simple ladder logic to test the START/ STOP logic for two inputs and one output.	IV	2*
27	Develop ladder program for pulse counting using limit switch/proximity sensor and counter function.	IV	2
28	Write and implement ladder logic program to blink LED using timer.	IV	2
29	Simulate ladder logic for traffic light control system using timer.	IV	2
30	Develop ladder logic to convert Celsius to Fahrenheit using arithmetic function.	IV	4*
31	Use of various functions in SCADA simulation editors to develop simple project. (Use InTouch or other editor.)	V	4*
32	Design ON/OFF switch in SCADA. (Use InTouch or other editor.)	V	2
33	Study the basic components of RTU in automation system.	V	4
34	Study architecture of Distributed control system.	V	4*
35	Study various software (Editor) for designing screen of HMI.	V	4

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.	5,12 to 32
2	Computer system with latest operating system.	5,12 to 32
3	PLC, SCADA trainer kit.	5,12 to 32
4	DCS ,HMI ,RTU MODULE/KIT	32 TO 35
5	Digital and analog module.	5,6,8,26
6	Level, flow, proximity and limit switch.	5,7,26
7	License/Free copy of ladder logic editor.	5,12 to 30
8	Simulator software for virtual simulation.	4,12,34,35
9	Level, flow, pressure control trainer kit.	7,27
10	DC motor, solenoid valve, relay and other switching devices.	7,27

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 to Industrial Automation**	**1a.** Define Industrial automation. **1b.** List Benefits of Industrial Automation. **1c.** Describe Types of automation system. **1d.** Explain Basic components of automation system. **1e**. Explain need of automation in Industries. **1f**.List challenges of automation in industry. **1g**.Describe different industrial process techniques. **1h.** State Application of PLC based automation system.	**1.1** Definition of Industrial Automation. **1.2** Objective of Industrial Automation. **1.3** Benefits of Industrial Automation **1.4** Types of automation system 1. Fixed automation. 2. Programmable automation. 3. Flexible automation. **1.5** Basic components of automation system. PLCs, Sensors, Actuators, HMI, Control system, Communication networks, Software & Programming. **1.6**. Various industrial process technique. a) Continuous Process. b) Discrete-state Process. c) Composite Process. **1.7** Applications of PLC based Automation system.
Unit II **Fundamental of PLCs.**	**2a.** Explain working of PLC. **2b.** Draw block diagram of PLC. **2c.** Describe PLC architecture. **2d.** Describe PLC components. **2e**. List various types of PLCs. **2f**. Describe analog input /output module for PLC. **2g**. Describe digital input /output module for PLC. **2h.**List out peripherals for PLC. **2i**. Draw interfacing diagram to connect switching devices with PLC. **2j**. List selection criteria for PLC. **2k**.State Advantages and limitations of PLC.	**2.1** Introduction of PLC. **2.2** Architecture & Working of PLC. **2.3** Working of PLC hardware components. **2.4** Types of PLCs **2.5** Peripherals devices of plc. Input Devices: Pushbutton, Limit, level proximity switch & other input devices. Output Devices: Relay, SSR, contactor, solenoid valve and other output devices. **2.6** Different types of I/O modules. **1.** Analog Input/output module. ▪ AC / DC input module **2.** Digital Input/output module. ▪ AC/DC Output module **2.7** I/O modules interfacing diagram. **2.8** Selection Criteria of PLC. **2.9** Advantages and limitations of PLC.
Unit III **PLCs Programming Technique.**	**3a**. Explain types of PLC Programming Language. **3b**. Describe PLCs scan sequence. **3c**. Explain Memory mapping of PLC.	**3.1** PLC Programming Languages. a. Ladder Logic (LAD) b. Functional Block Diagram (FBD) c. Sequential Functional Chart (SFC) d. Structured Text (ST)

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	3d. Describe I/O addressing of PLC. **3e**. Describe common types of registers used in PLC. **3f**.Develop ladder logic for all logical gates. **3g**.Develop ladder logic for given Boolean algebraic equation. **3h**. Develop Ladder logic for holding contact. **3i.** Explain simple and complex branching in ladder logic. **3j**. Differentiate proper and improper ladder logic diagram. **3k.** Draw basic symbols used in ladder logic programming.	**3.2** Program scan sequence. **3.3** Memory mapping of PLC. **3.4** I/O addressing of PLC. **3.5** Types of Register use in PLC a. Holding (Data) registers b. Input/output registers c. Status Registers d. Control registers **3.3** Ladder logic of basic Logic Gates. **3.4** Boolean algebra using ladder logic. **3.5** Holding (latching relay) contact. **3.6** Simple and complex branching in Ladder logic. **3.7** Ladder logic Symbols of PLC.
Unit-IV **Basic functions and Application of PLC.**	**4a**. Describe various timers use in PLC programming. **4b**. Describe various counters use in PLC programming. **4c**. Explain arithmetic function with example. **4d**. Explain comparison functions with one example. **4e**.Draw ladder logic using various logical function block with example. **4f.** Develop ladder logic for LED blinking using timer. **4g.** Develop ladder to count no of box pass on belt using counter. **4h.**Develop ladder logic to convert Celsius to Fahrenheit using arithmetic function. **4i.**Develop ladder logic for two way switch logic.	**4.1** ON Delay timer, Off Delay timer, Retentive timer, Non-retentive timer **4.2** UP Counter, Down Counter. **4.3** PLC arithmetic functions. • Addition, • Subtraction, • Multiplication, • Square Root, • Division, **4.4** PLC comparison function. • Equal, • Not equal, • less than , less than or equal • greater than, greater than or equal **4.5** PLC logical function. **4.6** LED blinking using various timers. **4.7** Object counting using counter function. **4.8** Temperature unit conversion using arithmetic function.
Unit-V **Basic Components Of Automation System.**	**5a**. Describe function of RTU. **5b**. List importance of RTU. **5c**. Describe function of SCADA. **5d**. Draw block diagram of SCADA. **5e**. Discuss benefit of SCADA in automation. **5f**. Write Short notes on DCS. **5g**. Draw architecture of DCS. **5h**. State application of DCS in automation system. **5i**. State application of HMI in	**5.1** Definition of RTU (Remote terminal unit). a. Function of RTU. b. Importance of RTU in automation. **5.2** Introduction of SCADA. a. Basic diagram of SCADA system. b. Benefit of SCADA in automation. **5.3** About DCS (Distributed control system) a. Architecture of DCS. b. Application of DCS in automation. **5.4** Introduction of HMI.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	automation system. **5j**.Pros and Cons of HMI.	a. Benefit of Human Machine Interface. b. Disadvantage of HMI. c. Application of HMI in automation.

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 Industrial Automation.	06	02	08	00	10
II	Fundamental of PLCs.	10	05	12	00	17
III	PLCs Programming Technique.	12	03	12	05	20
IV	Basic functions and application of PLC.	08	00	08	05	13
V	Basic Components Of Automation System.	06	00	10	00	10
Total		**42**	**10**	**50**	**10**	**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.
d) Prepare list for practical applications of DCS and SCADA in various industries.
e) Make list of various industries based on implemented automation system and also specify the sub process if more than one system is implemented.

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) PLC Based Door Open and Closing System.
d) PLC Based Automatic Counting System.
e) PLC Based ON/OFF type Level Control System.
f) PLC based Automatic Dam Shutter Control System.
g) Collect specifications from different manufacturers of PLC /DCS/SCADA and prepare a market survey report.
h) Create a model of small robotic arm that can pick up objects from one location and place them in another location using manual control.
i) PLC based home automation system model.
j) PLC based railway crossing system.

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	Distributed Computer Control for Industrial automation	Dobrivoje Popovic and Vijay Bhatkar.	Marcel Dekker Inc.,1990
5	Process control Instrumentation technology	Curtis D Johnson	PHI pvt. Ltd.
6	Overview of Industrial Process Automation	KLS Sharma	Elsevier Publication
7	Programmable Controllers	Thomas A. Hughes	ISA
8	SCADA-Supervisory Control and Data Acquisition System	Stuart A. Boyer	ISA publication (3rd Edition)

14. SOFTWARE/LEARNING WEBSITES

- www.plcs.net
- www.triplc.com
- https://instrumentationtools.com/dcs-plc-rtu/
- theautomationblog.com
- https://engineerscommunity.com/
- www.plcdev.com
- www.plcprogramming.com
- https://plcmanual.com/
- https://electrical-engineering-portal.com/scada-dcs-plc-rtu-smart-instrument
- https://engineeringhulk.com/rtu-remote-terminal-unit-definition-functions-importance/
- https://instrumentationtools.com/distributed-control-systems-dcs/
- https://automationcommunity.com/human-machine-interface/
- www.plcgurus.net
- http://www.kronotech.com/

15. PO-COMPETENCY-CO MAPPING:

SEMESTER III	**BASICS OF INDUSTRIAL AUTOMATION (Course Code: 1334101)**						
	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	**Understand Basic Components Of Industrial Automation Systems.**						
CO1	3	-	-	-	-	-	-
CO2	3	2	2	1	-	-	-
CO3	3	2	3	3	-	2	2
CO4	3	2	3	3	1	2	2

CO5	3	-	-	2	-	-	1

*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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