GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

Branch: Electrical Engineering / Renewable Energy

Subject Code: DI04000201

Subject Name: Industrial Automation & Control

w. e. f. Academic Year:	2025-26
Semester:	4th
Category of the Course:	MOPEC

Prerequisite:	Knowledge of Basic Electrical Engineering, Basic Electronics, Digital Electronics, Electronics Measurement and Instruments
Rationale:	Industrial automation is essential for modern industries to achieve efficiency, quality, and large-scale production. This course introduces students to the basics of automation, focusing on PLCs, SCADA, sensors, and robots. It emphasizes practical applications, problem-solving, and hands-on skills to prepare students for Industry 4.0 and careers in automation-driven sectors.

Course Outcomes: After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level*
01	Explain the need, benefits, and types of industrial automation systems along with their applications.	R,U, A
02	Identify PLC hardware modules, input/output devices, and demonstrate basic PLC programming concepts.	R,U
03	Develop and implement ladder logic programs for timers, counters, arithmetic, and industrial applications.	U, A
04	Implement PLC-based automation solutions for motor control, process control, and material handling applications.	U, A
05	Analyze SCADA/DCS architectures and demonstrate their role in supervisory control, communication, and process monitoring.	U, A

**Revised Bloom's Taxonomy (RBT)*

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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA(M)	PA(I)	ESE(V)	
2	0	2	3	70	30	20	30	150

Unit No.	Content	No. of Hours	% of Weightage
1.	**Unit 1: Fundamentals of Industrial Automation & Control** 1.1 Automation in Production Systems: Definition, objectives, need and benefits in industries (e.g., automobile assembly, packaging, renewable energy). 1.2 Basic Elements of Automation: Sensors, controllers, actuators, feedback loops, communication lines. 1.3 Types of Automation Systems: • Fixed automation (transfer lines, dedicated equipment). • Programmable automation (batch manufacturing, CNC). • Flexible automation (robots, reconfigurable systems). 1.4 Industrial Control Systems Overview: Roles and applications of PLC, HMI, SCADA, DCS, and Drives in modern production.	4	12%
2.	**Unit 2 – PLC Fundamentals & Hardware** 2.1 PLC Architecture & Modules: CPU, memory, power supply, digital/analog I/O, communication modules, control modules. 2.2 Input & Output Devices: Push buttons, selector switches, limit switches, proximity sensors, relays, contactors, solenoid valves, SSR, analog sensors (temperature, flow, pressure). 2.3 Programming Basics: • PLC Scan Cycle – input scan, program execution, output update. • Programming Languages (as per IEC 61131-3 standard): Ladder Diagram (LD), Functional Block Diagram (FBD),Structured Text (ST), Sequential Function Chart (SFC). 2.4 PLC I/O Addressing and Wiring: Input/output address mapping, rules for slot addressing, examples with actual PLC families (Siemens,	8	24%

	Allen Bradley, Delta, Mitsubishi). 2.5 Introduction to PLC Software Tools: Simulation and programming environments (LOGO Soft, TIA Portal, RSLogix, WPLSoft etc.)		
3.	**Unit 3 – PLC Programming Techniques** PLC Programming for various functions with ladder logic implementation: • Interlocking and Latching – Motor forward/reverse interlocking, motor start/stop push button latching. • Timing Functions – On-delay timer (conveyor delayed start), Off-delay timer (exhaust fan run-on), Retentive on-delay timer (oven heating cycle), Pulse timer (automatic stamping). • Counter Functions – Up-counter (bottle counting), Down-counter (item packing from 100 to 0), Up-Down counter (people entry/exit counting). • Arithmetic and Logical Functions – Addition (total power consumption), Subtraction (stock after dispatch), Multiplication (production units per cycle), Division (average speed), AND (safety interlock), OR (alarm activation), NOT (safety guard condition). • Analog input/output handling - temperature sensor input, analog actuator output	8	24%
4	**Unit 4 – Industrial Applications of PLC** Case Studies with Ladder Logic Implementation: • DOL starter for induction motor • Water level controller for automatic tank filling • Temperature ON/OFF control (heater/fan). • Bottle filling system using sensors and solenoid valve • Conveyor sorting system.	6	24%
5.	**Unit 5 – Supervisory Control and Data Acquisition System (SCADA)** 5.1 Industrial Communication Protocols: Ethernet/IP, Modbus, Profibus. 5.2 Human Machine Interface (HMI): Importance, role in safety, examples of operator panels. 5.3 SCADA Introduction: Architecture, block diagram, operator station, RTU/PLC integration, benefits. 5.4 DCS Concepts: Features, architecture, typical applications in process industries	4	16%
	Total	**30**	**100%**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20 %	**30 %**	**45 %**	**5%**	**00**	**00**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Reference Books:

1. "Programmable Logic Controllers: Principles and Applications" – John W. Webb & Ronald A. Reis (Prentice Hall), 5th Edition, ISBN-13: 978-8120323087.
2. "Introduction to Programmable Logic Controllers", Gary Dunning, latest edition
3. Overview of Industrial Process Automation, KLS Sharma, Elsevier Publication
4. "Industrial Automation and Control" – S.K. Singh (Tata McGraw-Hill).
5. "Programmable Logic Controllers" – Madhuchhanda Mitra & Samarjit Sen Gupta (PHI Learning).
6. "Introduction to PLCs" – Gary Dunning (Cengage)
7. "Handbook of industrial automation," Richard L. Shell and Ernest L. Hall, (CRC press)
8. "Fundamentals of Industrial Instrumentation and Process Control" – S.K. Singh (Tata McGraw-Hill).
9. "Programmable Logic Controller and Industrial Automation" – R.K. Rajput (Laxmi Publications).
10. "Industrial Automation: Hands-on" – Frank Lamb (McGraw Hill).
11. "SCADA: Supervisory Control and Data Acquisition" – Stuart A. Boyer, 4th Edition, ISBN-13: 978-1941546178
12. Practical SCADA for Industry, David Bailey, Elsevier Publication
13. Distributed Computer Control for Industrial Automation, Vijay P. Bhatkar

(b) Open-Source Software and Website:

PLC Simulation & Programming

1. OpenPLC (https://www.openplcproject.com)
    - Open-source PLC platform supporting IEC 61131-3 languages (LD, ST, FBD).
    - Can simulate PLC programs and run on Arduino, Raspberry Pi, PC.

2. PLC Ladder Simulator 2 (Android App)
    - Mobile-based ladder logic simulator.
    - Useful for basic programming practice without hardware.
3. LDmicro (http://cq.cx/ladder.pl)
    - Free ladder diagram compiler for microcontrollers.
    - Supports simple automation projects on PIC/AVR.
4. Do-more Designer (AutomationDirect) – Free version for simulation.
    - Useful for practicing PLC programming with no hardware required.

SCADA & HMI Simulation

1. ScadaBR (http://www.scadabr.com.br)
    - Open-source SCADA software (Java-based).
    - Supports Modbus, OPC, BACnet.
2. Rapid SCADA (https://rapidscada.org)
    - Free, open-source SCADA system.
    - Supports Modbus, OPC, SNMP, BACnet, MQTT protocols.
3. Ignition Edge (Inductive Automation)
    - Lightweight SCADA/HMI solution for small projects

Websites for Learning & Practice

1. PLC Ladder Tutorials – PLCDev (https://www.plcdev.com)
    - Tutorials, examples, and learning resources for ladder programming.
2. Automation Forum (https://automationforum.co)
    - Community-driven discussions on PLC, SCADA, and industrial automation.
3. PLC GURU (https://plcguru.com)
    - Free tutorials and blogs on PLC programming concepts.
4. Electronics Tutorials – PLC Section (https://www.electronics-tutorials.ws/logic/programmable-logic-controllers.html)
    - Beginner-friendly PLC and logic circuit tutorials.

Suggested Course Practical List: Each week includes One lab sessions (2 hours).

Sr. No.	Practical Outcome/Title of experiment	Unit/ CO	Approx. Hours required
1	Identification & wiring of digital input and output devices with PLC.	2	2
2	Wiring of analog input devices (e.g., temperature sensor, potentiometer) with PLC.	2	2
3	PLC I/O addressing exercise using Siemens / Allen Bradley / Mitsubishi software tools.	2	2
4	Connect PLC to PC and test execution of ladder programs for basic logic operations using two input switches and one output indicating lamp.	2	2
5	Develop and implement a ladder logic program for motor start/stop with latching.	3	2
6	Implement forward and reverse motor control with interlocking in ladder logic.	3	2
7	Develop/Test a program for conveyor delayed start using on-delay timer.	3	2
8	Design and implement an exhaust fan overrun control using off-delay timer.	3	2
9	Implement oven heating cycle control using retentive timer using ladder logic.	3	2
10	Develop/Test a Ladder program to blink LED/lamp.	3	2
11	Develop/Test a bottle counting system using up-counter.	3	2
12	Implement a packing countdown system using down-counter.	3	2
13	People entry/exit counting system using up-down counter.	3	2
14	Implement safety interlock using AND/OR/NOT functions	3	2
15	Implementation of DOL starter for induction motor using PLC.	4	2
16	Design and implement automatic water level controller with tank filling using PLC.	4	2
17	Design of bottle filling system using sensors and solenoid valves.	4	2
18	Conveyor sorting system based on object size or color sensor.	4	2
19	Familiarization with SCADA software interface	5	2

Subject In-charge can add performance experiment only

List of Laboratory/Learning Resources Required:

1. IEC 1131-3 compatible PLC with programming Software and interfacinghardware, user manual, (complete PLC Trainer system)
2. Input and Output devices for PLC: like Lamp, DC Motor, Proximitysensors, Thermocouple/RTD, Red, green, yellow LEDs, Stepper Motor, limit switches, push button, Potentiometer.
3. Nano PLC, Mini PLC, Micro PLC with analog and Digital I/0, memory, peripheral interfaces.
4. Ladder logic simulator, Pico soft Simulator. Logixpro simulator, TIA Portal with PLCSIM, Simple EDA tools(open source).
5. Servomotor, DC motor, AC motor, steeper motor.
6. SCADA software: like Ellipse/FTVSE/Wonderware/Step7.
7. Digital Multimeter (% Digital Multimeter): 4000 counts large LCD display with auto/manual range, No Power OFF under natural operation,Data Hold, Max/Min value Hold Capacitance, Frequency/Duty Cycle
8. Different types of Electrical wires and Cables, cable Ferrule, Lugs, Gland, tags, switches, socket, light sources/lamps, Contactor, Push button, insulating & conducting materials, etc.

Suggested Activities for Students:

Beyond classroom and laboratory learning, the following student-centered co-curricular activities are suggested to help enhance the achievement of various course outcomes. Students should work in groups to complete these activities and prepare a report of about 5 pages for each.

1. Conduct an internet survey to identify leading manufacturers of PLC, SCADA, DCS, HMI, and other industrial automation tools, and list them along with their brand names.
1. Refer to operating manuals of PLCs from reputed manufacturers and prepare a step-by-step procedure for using a PLC in a specified application.
2. Create a PowerPoint presentation on various PLC troubleshooting techniques.
3. Prepare a list of safety precautions to be followed during the installation of a PLC system.
4. Download and present animated videos from the internet explaining any theoretical topic related to the course.
5. Compile a list of available analog and digital input/output devices commonly used in the market.
6. Prepare guidelines outlining the steps to be followed for configuring available SCADA software.

Suggested Project List: Suggested Project List as given below:

Suggestive list of micro projects is given here. Similar projects could be added by the concerned faculty:

1. Automatic Street light controller: Prepare a PLC based system to control the street light as per the intensity of natural light.
2. Automatic agriculture irrigation system: Prepare a PLC based system to control drip irrigation.
3. Railway gate automation: Prepare a PLC and SCADA based system to open or close the proto type railway gate automatically.
4. Home automation: Implement the versatile automation system for home that can automate any three home appliances.
5. Bottle filling station: Prepare a PLC and SCADA based system for proto type bottle filling station.
6. Troubleshoot the Faulty Equipment/Kit available in automation Laboratory.

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