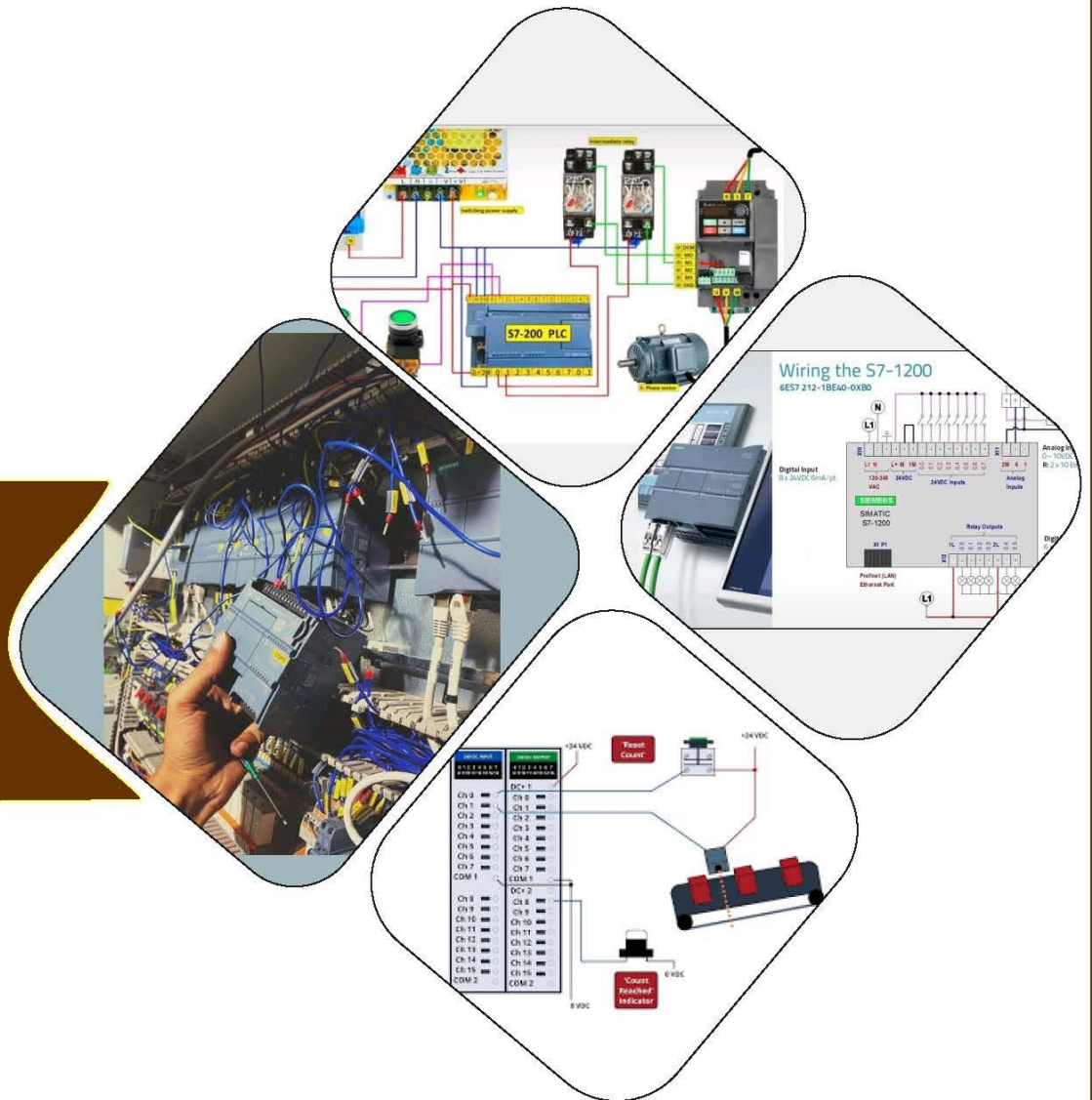


SCHEME :K

Name : _____
Roll No.: _____ Year : 20 ____ 20 ____
Exam Seat No. : _____

LABORATORY MANUAL FOR AUTOMATION & PLC (316334)



ELECTRONICS ENGINEERING GROUP



**MAHARASHTRA STATE BOARD OF
TECHNICAL EDUCATION, MUMBAI
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)**

VISION

To ensure that the Diploma Level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

QUALITY POLICY

We, at MSBTE, are committed to offer the best-in-class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation evaluation and monitoring system along with adequate faculty development Programs.

CORE VALUES

MSBTE believes in the followings:

- Skill development in line with industry requirements.
- Industry readiness and improved employability of Diploma holders.
- Synergistic relationship with industry.
- Collective and cooperative development of all stake holders.
- Technological interventions in societal development.
- Access to uniform quality technical education.

A Laboratory manual

for

Automation and PLC

(316334)

Semester – VI

(EJ/EK/ET/EX)



**Maharashtra State
Board of Technical Education, Mumbai**

(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)



**Maharashtra State
Board of Technical Education, Mumbai**
(Autonomous) (ISO 21001:2018) (ISO/IEC 27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai – 400051.



**MAHARASHTRA STATE BOARD
OF TECHNICAL EDUCATION
Certificate**

This is to certify that Mr./Ms.
Roll No. Of Sixth Semester of Diploma in
of Institute
(Code:) has attained pre-defined practical outcomes (PROs)
satisfactorily in course **Automation and PLC (316334)** for the
academic year 20..... to 20..... as prescribed in the curriculum.

Place:

Enrollment No.:

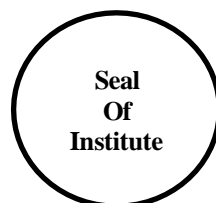
Date:

Exam Seat No.:

Course Teacher

Head of Department

Principal



Preface

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curricula for engineering diploma programs with outcome-based education as the focus and accordingly, a relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work, making each teacher, instructor and student realize that every minute of the laboratory time needs to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a '*vehicle*' to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'K' scheme laboratory manual development team designed the practicals to *focus* on the *outcomes*, rather than the traditional age-old practice of conducting practical's to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the predetermined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through the procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student- centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Microwave engineering plays a crucial role in the design and development of communication system, antennas, waveguides, and microwave devices. Simultaneously, radar system are integral to defense, weather forecasting, navigation, and traffic management. Understanding the principles behind the operation of microwave components and radar system is essential for aspiring engineers in the field of electronics, communication, and applied system.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Program Outcomes (POs)

Following program outcomes are expected to be achieved through the practical of the course.

PO1: Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the broad-based Electronics Engineering group program problems.

PO2: Problem analysis: Identify and analyze well-defined Electronics Engineering group program problems using codified standard methods.

PO3: Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of Electronics Engineering group program systems components or processes to meet specified needs.

PO4: Engineering Tools, Experimentation and Testing: Apply modern Electronic Engineering group program tools and appropriate technique to conduct standard tests and measurements.

PO5: Engineering practices for society, sustainability and environment: Apply appropriate Electronics Engineering group program technology in context of society, sustainability, environment and ethical practices.

PO6: Project Management: Use Electronics Engineering group program management principles individually, as a team member or a leader to manage projects and effectively communicate about well- defined engineering activities.

PO7: Life-long learning: Ability to analyze individual needs and engage in updating in the context of Electronics Engineering group program technological changes.

List of Industry Relevance Skills

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

1. Ability to identify, test, and select industrial sensors, actuators, and PLC hardware components.
2. Skill in wiring and interfacing field I/O devices (digital/analog) with PLC modules safely and correctly.
3. Competence in developing and debugging ladder logic programs for logic operations and automation tasks.
4. Capability to design PLC-based automation solutions using timers, counters, interlocks, and application logic.
5. Proficiency in configuring and troubleshooting industrial communication protocols such as Modbus, Profibus, and Ethernet/IP.

Practical - Course Outcome matrix

Course Level Learning Outcomes (COs)						
CO1 - Identify different components of automation system						
CO2 - Interface the given I/O device with PLC module.						
CO3 - Develop ladder logic program for various logic gates and Boolean equations.						
CO4 - Develop ladder logic program for given application.						
CO5- Use the relevant communication protocol for specific automation system.						
Sr. No.	Title of the Practical	CO 1	CO 2	CO 3	CO 4	CO 5
1.	*Identification of components of automation trainer kit available in the laboratory.	✓	–	–	–	–
2.	*Interface given I/O devices with PLC.	✓	✓	–	–	–
3.	Interface I/O devices with PLC in virtual lab	✓	✓	–	–	–
4.	Sourcing and sinking connection of I/O devices with discrete I/O module.	–	✓	–	–	–
5.	*Test functionality of various logic gates using ladder diagram.	–	–	✓	–	–
6.	*Develop ladder program for 4:1 Multiplexer.	–	–	✓	–	–
7.	* Test the functionality of latching using basic relay type instructions in ladder diagram.	–	–	✓	–	–
8.	Develop a ladder program for sequential ON-OFF control of lamps/motors.	–	–	✓	–	–
9.	*Develop a ladder program to process analog signal.	–	–	✓	–	–
10.	Develop ladder program to control the direction (Clockwise and Anticlockwise) of stepper moto.	–	–	✓	✓	–
11.	Develop ladder program for traffic light control system using virtual lab simulator	–	–	✓	✓	–
12.	Develop ladder program to sort metallic and non-metalic objects	–	–	✓	✓	–
13.	Develop Sequential Function Chart (SFC) to sort metallic and non-metalic objects	–	–	✓	✓	–
14.	*Develop ladder program for automatic car parking system.	–	–	✓	✓	–
15.	Interface and test PLC with profibus and profinet network protocol.	–	–	–	–	✓
16.	*Develop SCADA graphic screen and integrate with PLC to perform the sequential ON-OFF control of Lamps/motors.	–	–	–	–	✓

Guidelines to Teachers

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain prior concepts to the students before starting of each practical.
3. Involve students in the performance of each experiment.
4. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
5. Teachers should give opportunities to students for hands-on experience after the demonstration.
6. Teacher is expected to share the skills and competencies to be developed in the students.
7. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected of the students by the industry.
8. Finally give practical assignments and assess the performance of students based on tasks assigned to check whether it is as per the instructions.
9. Teacher is expected to refer complete curriculum document and follow guidelines for implementation
10. At the beginning of the practical which is based on the simulation, teacher should make the students acquainted with any simulation software environment.

Instructions for Students

1. Listen carefully to the lecture given by the teacher about course, curriculum, learning structure, skills to be developed.
2. Organize the work in the group and make a record of all observations.
3. Do the calculations and plot the graph wherever it is required in the practical
4. Students shall develop maintenance skills as expected by industries.
5. Student shall attempt to develop related hand-on skills and gain confidence.
6. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual
7. Student should develop the habit to submit the practical on date and time.
8. Student should prepare well while submitting a write-up of exercise.

Content Page

List of Practical's and Progressive Assessment Sheet

Sr. No.	Title of the practical	Page No.	Date of performance	Date of submission	Assessment marks (25)	Dated sign. Of teacher	Remarks (if any)
1	*Identification of components of automation trainer kit available in the laboratory.						
2	*Interface given I/O devices with PLC.						
3	Interface I/O devices with PLC in virtual lab						
4	Sourcing and sinking connection of I/O devices with discrete I/O module						
5	*Test functionality of various logic gates using ladder diagram.						
6	*Develop ladder program for 4:1 Multiplexer.						
7	* Test the functionality of latching using basic relay type instructions in ladder diagram.						
8	Develop a ladder program for sequential ON-OFF control of lamps/motors						
9	*Develop a ladder program to process analog signal						
10	Develop ladder program to control the direction (Clockwise and Anticlockwise) of stepper moto						
11	Develop ladder program for traffic light control system using virtual lab simulator						
12	Develop ladder program for traffic light control system using virtual lab simulator						
13	Develop Sequential Function Chart (SFC) to sort metallic and non-metalic objects						
14	*Develop ladder program for automatic car parking system						
15	Interface and test PLC with profibus and profinet network protocol						
16	*Develop SCADA graphic screen and integrate with PLC to perform the sequential ON-OFF control of Lamps/motors						
Total							

Note: Out of above suggestive LLOs –

- '*' Marked Practical's (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

Practical No.1: Identification of components of automation trainer kit available in the laboratory.

I. Practical Significance

A PLC is an industrial computer used to control automation processes like machinery, assembly lines, and power plants. The PLC Trainer Kit has a PLC unit with input and output terminals. It includes input devices like push-to-ON switches and toggle switches, which send signals to the PLC. Output devices like lamps and hooters operate according to the PLC's control logic. All input/output devices are connected to PLC through input and output lines.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

Identify different components of automation system.

IV. Laboratory Learning Outcomes

LLO 1.1 Identify the components of automation system available in laboratory.

V. Relevant Affective domain related Outcomes

1. Demonstrate working as a leader or a team member.
2. Follow ethical practices.
3. Follow safety practices.
4. Practice good housekeeping.
5. Maintain tools and equipment

VI. Relevant Theoretical Background

Input Sensors/devices send signals to the PLC through input lines. The PLC executes the ladder logic program to process these signals. Based on the instruction of ladder program, the PLC generates corresponding output signals, which activate the connected output devices.

PLC accepts signals from input devices like push buttons, limit switches, proximity and photo sensors, and temperature sensors. Input signal from input device can digital signals (ON-24V/OFF-0V) and analog signals (0–10V, 4–20mA). PLC digital output signals are used to drive a relay, which then controls higher power output devices like motors, pumps, or heaters safely

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

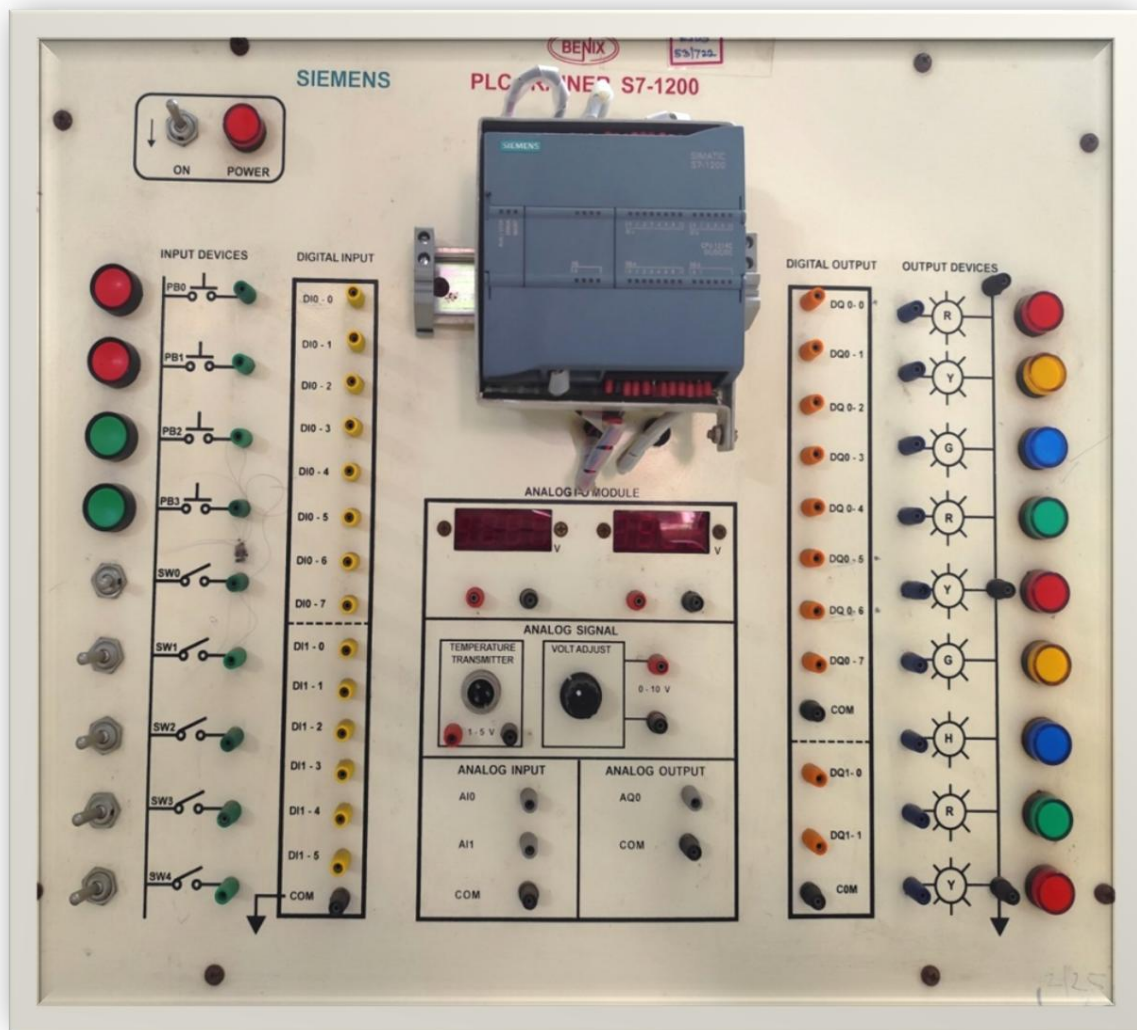


Fig. 1.1: Automation Trainer Kit

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 1.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: 1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer/Laptop	PC preloaded with required PLC software (TIA Software for Siemens PLC) and I/O communication facility.	1

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.

X. Suggested Procedure

1. Switch OFF the PLC Trainer Kit and observe it physically to identify its main components safely.
2. Identify the PLC module (Siemens S7-1200) on the trainer kit, note its Digital/Analog input to and Digital/Analog output terminals, communication ports (RJ45), and power supply section.
3. Observe and identify all input devices such as push buttons, toggle switches, DC voltage generator, and DC voltmeter provided on the kit.
4. Identify the output components such as indicator lamps, Hooter.
5. Use connecting wires to connect input devices to the PLC input terminals, and connect output devices to the PLC output terminals.
6. Ensure that a PC or Laptop with pre-installed PLC programming software (e.g., Siemens TIA Portal) is available for PLC programming and interfacing.
7. Open TIA Portal, create a new project, and add PLC device.
8. Configure PLC communication and open OB1 program block.
9. Select Ladder Diagram editor, insert I/O instructions, and assign addresses.
10. Develop control logic, compile the program, and download to PLC.
11. Switch PLC to RUN mode, monitor online, and verify operation

XI. Resources used during performance

Table 1.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

XIII. Observation Table

Table 1:3 Specification of PLC Trainer

Sr. No.	Name of PLC Trainer-Make	Specification
1	PLC Trainer Make.....	Digital Inputs
		Analog Inputs
		Digital Outputs
		Analog Outputs
		Rated DC Output Voltage
		Communication Port Type
		Available Input Devices
		Available Output Devices

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Successful installation of Packet Tracer	10%
2	Identification of Packet Tracer Simulator components	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Create a simple network topology	10%
2	Demonstrate device configuration and connections	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.2: Interface given I/O devices with PLC.

I. Practical Significance

To implement real-time applications in industrial automation, a variety of field devices are employed for tasks such as temperature monitoring, object detection, and level measurement. The signals from these input devices are processed by the PLC, which then generates appropriate control signals to operate actuators and execute the required task. For successful operation, all field devices must be properly wired and correctly programmed with the PLC. This experiment enables students to develop essential wiring and interfacing skills, preparing them to connect and configure different types of field devices with suitable PLC modules for industrial applications.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcomes

- Identify different components of automation system.
- Interface the given I/O device with PLC module.

IV. Laboratory Learning Outcome

1. LLO 2.1 Interface input output devices with PLC and test the output for various inputs.

V. Relevant Affective domain related Outcomes

- 1) Promotes discipline, ensures precision in wiring, fosters accuracy during programming as well as documentation of automation systems.
- 2) Builds a sense of responsibility, promotes safety consciousness while managing PLC hardware as well as field devices.

VI. Relevant Theoretical Background

- Introduction to PLC
 1. A Programmable Logic Controller (PLC) is an industrial digital computer designed to control manufacturing processes or machinery. It performs logical, sequential, timing, counting, and arithmetic control functions through user-defined programs stored in memory.
 2. PLCs are widely used in automation systems because of their reliability, ease of programming, and ability to interface with various input/output (I/O) devices.
- Concept of I/O Interfacing
 1. Interfacing refers to establishing a communication link between the field devices (sensors and

actuators) and the PLC.

2. Input Devices send real-world signals to the PLC (e.g., push buttons, limit switches, sensors).
3. Output Devices receive control signals from the PLC to perform actions (e.g., lamps, relays, solenoids, motors).
4. The PLC reads input signals through its input module, processes the logic based on the control program, and sends the corresponding control signals through its output module.

➤ Types of I/O Signals

• Digital (Discrete) Signals:

Represent ON/OFF or HIGH/LOW states (e.g., 24V DC or 0V).

Examples: Push button, proximity sensor, limit switch, indicator lamp, relay.

• Analog Signals:

Represent variable values such as voltage (0–10V) or current (4–20mA).

Examples: Temperature sensor, pressure transducer, speed controller.

➤ PLC I/O Modules

- 1) **Input Module** – Converts incoming field signals to logic levels compatible with the PLC's CPU.
- 2) **Output Module** – Converts CPU control signals into voltage or current suitable for actuators.

Table 2.1 Typical List of I/O Devices

Type of Device	Device	Function
Input	Push Button	Start/stop command
Input	Limit switch	Detects mechanical position
Input	Proximity sensor	Detects object presence
Output	Indicator Lamp	Visual status indication
Output	Relay	Controls high-power load
Output	Solenoid valve	Controls fluid flow

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

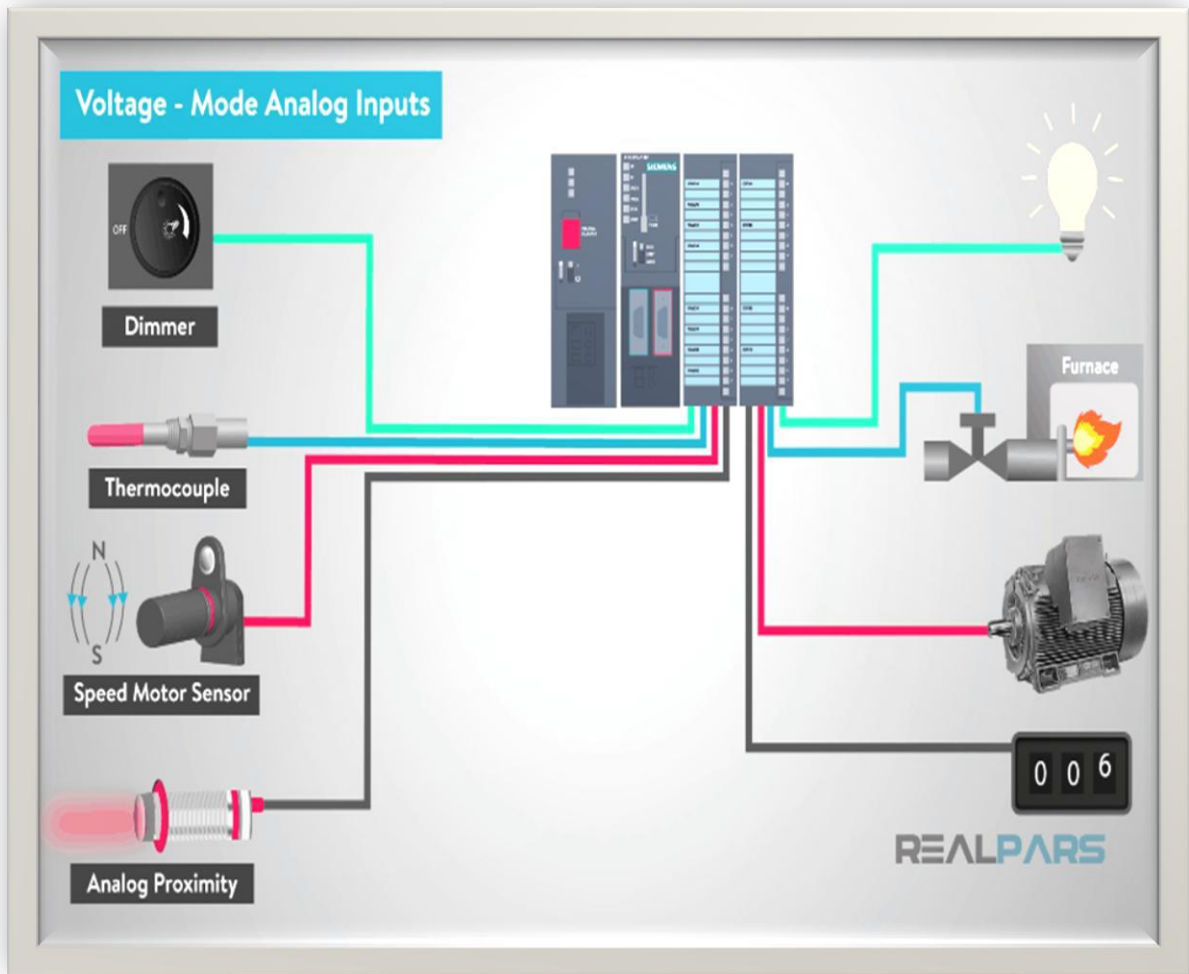


Fig. 2.1: I/O device interfacing with PLC
(Source: Courtesy of REALPARS)

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 2.2

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: SIEMENS S7-1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1 Experimental kit
2	Computer/Laptop	PC preloaded with required PLC software (TIA Software for Siemens PLC) and I/O communication facility.	1
3	Input output devices	Toggle Switch	1
		Push button (Push to ON)	1
		Push button (Push to OFF)	1
		Sensor (Object detector)	1
		Relay (Electromechanical SPST, SPDT etc.)	1
	Neon Bulb	1	

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.
4. Use correct grounding and wiring practices.
5. Do not connect or disconnect devices when PLC is powered ON.
6. Verify addressing and signal polarity before operation.

X. Suggested Procedure

1. Identify the I/O devices (digital or analog).
2. Connect input devices to the PLC input terminals (common and signal).
3. Connect output devices to the PLC output terminals.
4. Configure I/O addresses in the PLC software (e.g., I0.0, Q0.0).
5. Develop and download the ladder logic or control program.
6. Test the operation to verify correct response between input actions and output responses.

XI. Resources used during performance

Table 2.3

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: Digital input: Digital Outputs: Analog Inputs: Analog Outputs: External Power Supply: Memory:	
2	Computer/Laptop	Computer/Laptop Configuration: Programming software used:	
3	Input output devices	1) 2) 3) 4) 5)	

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

XIII. Observation Table

Table 2.4

Sr. No.	Field Device Interfaced	Type Input/output	Address	Operating mode Analog/Digital	Function of Device
1					
2					
3					
4					
5					

XVIII. Suggested references for further reading

Table 2.5

Sr. No.	Link / Portal / VLab	Description
1	Frank D. Petruzella Programmable <i>Logic Controllers</i> , 5th Edition McGraw-Hill Education, 2016. ISBN: 978-0073373843	Reference Book
2	https://youtu.be/IEd1OM5JQPs?si=qDue2ImdtZv3pKAa	PLC I/O basics PLC Input and Output Signal Digital Analog signal Explained I/O Module of PLC

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Successful installation of GNS3	10%
2	Identification of GNS3 Simulator components	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Create a simple network topology	10%
2	Demonstrate device configuration and connections	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.3: Interface I/O devices with PLC in virtual lab

I. Practical Significance

Interfacing I/O devices with a PLC in a virtual lab lies in providing a safe, cost-effective, and realistic platform to understand industrial automation systems. It allows learners to simulate real-world conditions by connecting virtual sensors, switches, and actuators to a PLC, helping them visualize and test how inputs and outputs interact through control logic. This hands-on experience enhances understanding of PLC programming, troubleshooting, and system behaviour without the risk of damaging physical equipment. Moreover, it enables flexible experimentation, performance analysis, and skill development essential for real industrial applications.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcomes

- CO 1. Identify different components of automation system.
- CO 2. Interface the given I/O device with PLC module.

IV. Laboratory Learning Outcome

LLO 3.1 Interface input output devices with PLC and test the output for various inputs in virtual lab.

V. Relevant Affective domain related Outcomes

1. Promotes discipline, ensures precision in wiring, fosters accuracy during programming as well as documentation of automation systems.
2. Builds a sense of responsibility, promotes safety consciousness while managing PLC hardware as well as field devices.

VI. Relevant Theoretical Background

- A Programmable Logic Controller (PLC) is an industrial digital computer designed to control and automate electromechanical processes such as machinery operation, assembly lines, and robotic systems. It operates based on input and output (I/O) interfacing, where input devices like sensors, switches, and push buttons send signals to the PLC, which processes them according to the programmed logic, and output devices such as motors, lamps, and relays execute the desired actions.
- The PLC continuously scans inputs, executes the control program (usually written in ladder logic), and updates outputs accordingly. Interfacing I/O devices enables the PLC to interact with the external environment, making automation possible.
- In a virtual lab environment, these I/O operations are simulated using software tools that replicate

the behavior of real sensors and actuators. This allows learners to understand signal flow, logic processing, and control system operation safely and efficiently while reinforcing theoretical concepts of digital logic, control systems, and industrial automation.

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

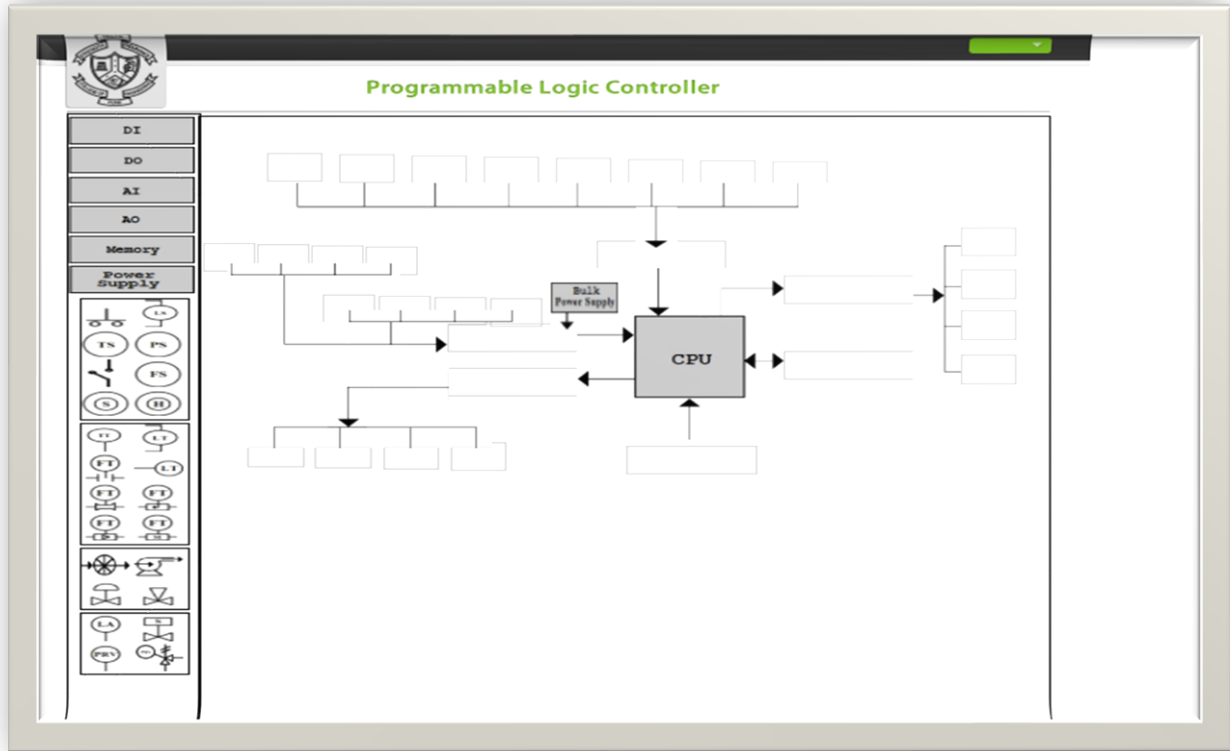


Fig. 3.1: Virtual lab setup for Input output interfacing
(Courtesy: <https://www.vlab.co.in/>)

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 3.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Computer/Laptop	Minimum Intel i3 or equivalent processor, 4 GB RAM (8 GB recommended), Windows 10 or above / Linux OS. Internet connection to access virtual lab simulator.	1

IX. Precautions to be followed

1. Ensure the virtual PLC simulator and I/O modules are correctly configured before starting.
2. Follow the logical connections between inputs and outputs as per the circuit diagram.
3. Verify ladder logic or control program before running the simulation.
4. Monitor input/output status continuously to detect errors early.
5. Save your work regularly to prevent loss due to crashes.
6. Use step-by-step simulation modes to test the program gradually.

X. Suggested Procedure

1. Open virtual lab software.
2. Select PLC Lab.
3. Open list of experiments tab.
4. Click on hardware and software of PLC.
5. Read related theory concepts carefully and appear for pretest.
6. Follow given procedure to perform simulation.
7. Take printout final simulation and stick in given space.

XI. Resources used during performance

Table 3.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

XIII. Observation Table

Table 3.3

Sr.No.	Observations	Remark
1	Virtual simulation software used	
2	Number of input devices available in V. Lab.	
3	Unidirectional Section includes	
4	Bidirectional section includes	

XIV. Results

.....

XV. Interpretation of results

.....

XVI. Conclusions and Recommendations

.....

XVII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

1. Interface discrete and analog field devices in automation system with reference to a simple application.
2. List various I/O devices with their types based on operating signals also give function of each device.

XVIII. Suggested references for further reading

Table 3.4

Sr. No.	Link / Portal / VLab	Description
1	Frank D. Petruzella Programmable <i>Logic Controllers</i> , 5th Edition McGraw-Hill Education, 2016. ISBN: 978-007337384	Reference Book
2	https://plc-coep.vlabs.ac.in	

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Identification of topology	10%
2	Observation and documentation	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Drawing of network diagram	10%
2	Explanation of working topology	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.4: Sourcing and sinking connection of I/O devices with discrete I/O module.

I. Practical Significance

Sourcing and sinking are methods of connecting digital input and output devices with a PLC. In a PLC system, the input and output field devices connect with the processor via the I/O modules. A sinking input device is a device that provides a path to ground (0V) when it activated. Its “sinks” current from the PLC input module.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

CO2 - Interface the given I/O device with PLC module.

IV. Laboratory Learning Outcome

LLO 4.1 Test sinking and sourcing concept indiscrete I/O module.

V. Relevant Affective domain related Outcomes

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment

VI. Relevant Theoretical Background

➤ **Sinking type Input Module Connection:**

In the Sinking type input device connection of PLC, the current flow into the PLC from input device or Power supply unit. The current flows from the positive terminal of the power supply → input device → PLC input terminal → negative of power supply.

➤ **Sourcing type Input Module Connection:**

In the Sourcing Mode input device connection of PLC, the current flows out of the PLC to input device or Power supply unit. The current flows from PLC input terminal → input device → negative terminal of the power supply

➤ **Sinking Output Device:**

The current flows from the device into the PLC output. PLC receives current from the device to operate it. Current flow: +V of power supply → Output device → PLC output terminal → 0V (ground)

➤ **Sourcing Output Device:**

The current flows from the PLC output to the device. PLC supplies current to operate the device. Current flow: PLC output terminal → Output device → 0V (ground) of power supply

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

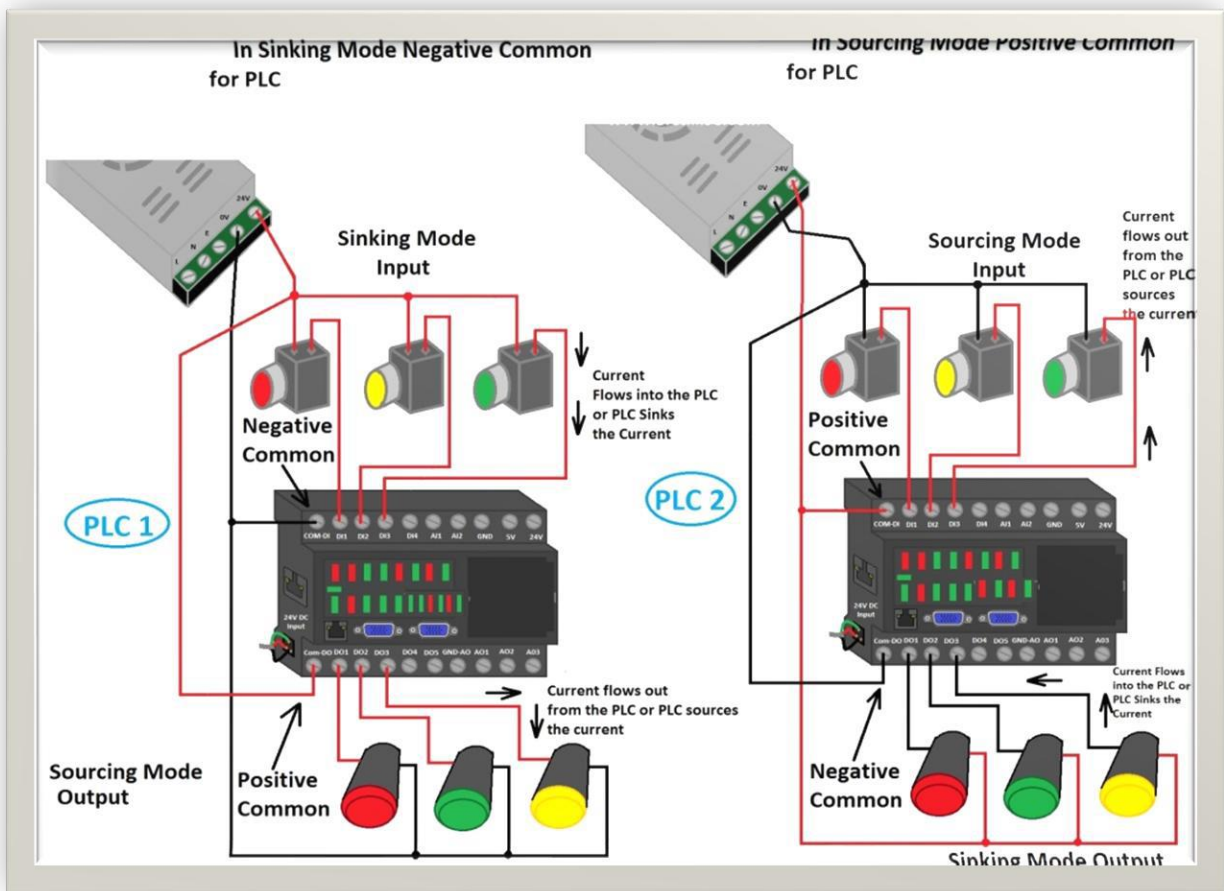


Fig. 4.1: Sinking and Sourcing connection of field devices

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 4.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: 1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Push to ON Switch	Operating Voltage: 24 V, Current Rating: 15-50 mA	1
3	Lamp/Indicator (RYB)	Operating Voltage: 24 V, Current Rating: 15-50 mA	1
4	Connecting Wires	Connecting Wires for Connection of Push Buttons and Lamp with PLC	

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.

X. Suggested Procedure

1. Switch OFF the PLC Trainer Kit when wiring the input/ output devices (Push Button/Lamp) with PLC.
2. For a Sinking type Input Module Connection, The Negative terminal from the power supply is connected to the common input terminal of the PLC, and all the input devices (here push-button switches) are connected to the positive terminal of the power supply.
3. For sinking type Output Module Connection, Negative terminal from the power source is connected to the common output terminal of the PLC and all Lamps other terminal are connected to the positive terminal of the power source.
4. For Sourcing type Input Module Connection positive terminal from the power supply is connected to the common input terminal of the PLC. And all the input devices (here push-button switches) are connected to the negative terminal of the power supply.
5. For Sourcing type Output Module Connection positive terminal from the power source is connected to the common output terminal of the PLC and all the loads are connected to the negative terminal of the power source.

XI. Resources used during performance

Table 4.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.

XIII. Observation Table

Table 4.3

Sr. No.	Device	Connection with Power supply and PLC	
1	Push Button	Sinking types Input device	Terminal-1 of Push Button Connected to..... Terminal-2 of Push Button Connected to.....
		Sourcing types Input device	Terminal-1 of Push Button Connected to..... Terminal-2 of Push Button Connected to.....
2	Lamp	Sinking types Output device	Terminal-1 of Lamp/Indicator Connected to..... Terminal-2 of Lamp/Indicator Connected to.....
		Sourcing types Output device	Terminal-1 of Lamp/Indicator Connected to..... Terminal-2 of Lamp/Indicator Connected to.....

XIV. Results

.....

XVIII. Suggested references for further reading

Table 4.4

Sr. No.	Link / Portal / VLab	Description
1	https://ied-nitk.vlabs.ac.in/exp/exp-interface-to-plc-nitk/theory.html	Virtual Lab link
2	https://www.realpars.com/blog/sinking-output?utm_source=chatgpt.com	Video demonstration on Sinking and sourcing concept
3	https://cdn.automationdirect.com/static/specs/sinksources.pdf	Pdf document on Sinking and sourcing concept

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Identification and Selection of Tools/Devices	10%
2	Selection of proper devices and cables in Cisco Packet Tracer	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Successful simulation of mesh topology	10%
2	Proper connectivity verification using ping command	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.5: Test functionality of various logic gates using ladder diagram

I. Practical Significance

Industrial automation often requires specific sequence of operations, which achieve by implementing the logic in PLC program. Logic gates are used to process signals from sensors/inputs to decide output actions. This Practical will enable the students to use basics logic gates for the efficient hardware implementation using PLC.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

CO3 - Develop ladder logic program for various logic gates and Boolean equations.

IV. Laboratory Learning Outcome

LLO 5.1 Test functionality of logic gates using ladder diagram.

V. Relevant Affective domain related Outcomes

- Follow safety practices.
- Practice good housekeeping.
- Maintain tools and equipment

VI. Relevant Theoretical Background

A Programmable Logic Controller (PLC) functions on the principles of digital logic, There are only two possible states: 1 (ON) and 0 (OFF). Within the PLC, logical decisions are performed using logic gates; PLC accepts one or more input signals and generates a single output determined by a defined logical relationship among the inputs. Logic gates such as AND, OR, NOT, NAND, NOR, and XOR can be easily implemented using Ladder Logic programming in a PLC.

Each gate is created using input contacts (representing logic inputs) and output coils (representing logic outputs). By arranging contacts in series or parallel, the PLC executes logical operations similar to electronic gates. For example, series contacts perform **AND logic**, while parallel contacts perform **OR logic**. The PLC scans inputs, processes the programmed logic, and controls the output accordingly.


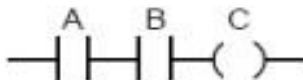
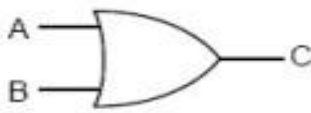
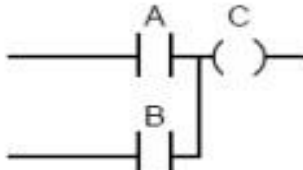
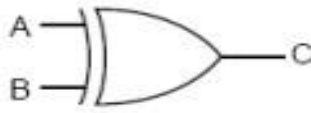
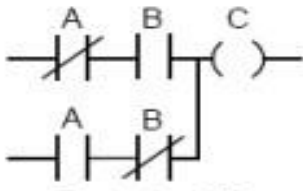

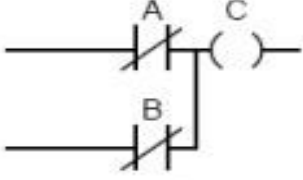
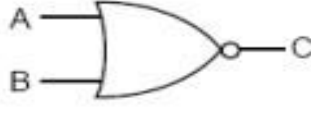
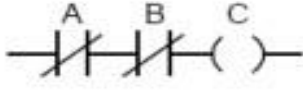
Logic Diagram	Truth Table	Ladder Diagram															
 <p>AND Gate</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	A	B	C	0	0	0	0	1	0	1	0	0	1	1	1	 <p>AND Equivalent Circuit</p>
A	B	C															
0	0	0															
0	1	0															
1	0	0															
1	1	1															
 <p>OR Gate</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	A	B	C	0	0	0	0	1	1	1	0	1	1	1	1	 <p>OR Equivalent Circuit</p>
A	B	C															
0	0	0															
0	1	1															
1	0	1															
1	1	1															
 <p>Exclusive-OR Gate</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table>	A	B	C	0	0	0	0	1	1	1	0	1	1	1	0	 <p>Exclusive-OR Equivalent Circuit</p>
A	B	C															
0	0	0															
0	1	1															
1	0	1															
1	1	0															
 <p>NAND Gate</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table>	A	B	C	0	0	1	0	1	1	1	0	1	1	1	0	 <p>NAND Equivalent Circuit</p>
A	B	C															
0	0	1															
0	1	1															
1	0	1															
1	1	0															
 <p>NOR Gate</p>	<table border="1"> <thead> <tr> <th>A</th> <th>B</th> <th>C</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>1</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>0</td> </tr> </tbody> </table>	A	B	C	0	0	1	0	1	0	1	0	0	1	1	0	 <p>NOR Equivalent Circuit</p>
A	B	C															
0	0	1															
0	1	0															
1	0	0															
1	1	0															

Table No: 5.1 Logical Diagrams, Truth Table and Ladder Diagram for Various Logical Gates

VII. Circuit diagram / block diagram / flowchart
A. Suggestive Block Diagram

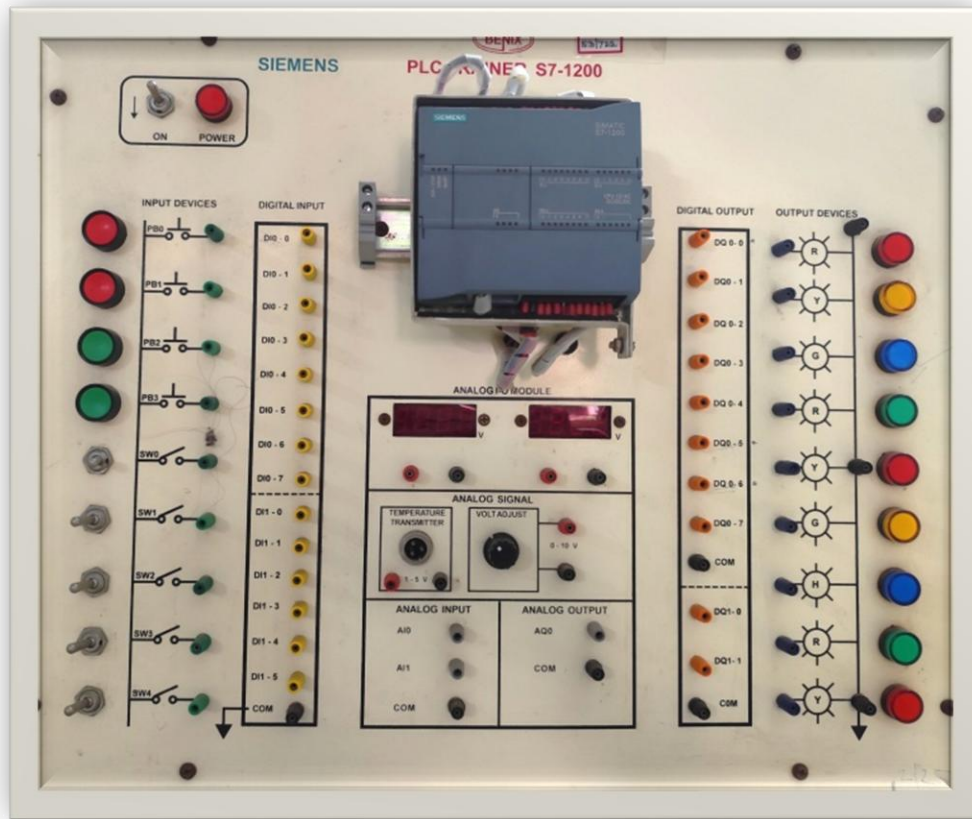


Fig. 5.1: Automation Trainer Kit for analysing operation of logic gates

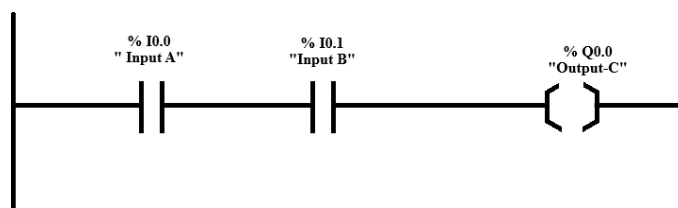


Fig. 5.2 AND Logic

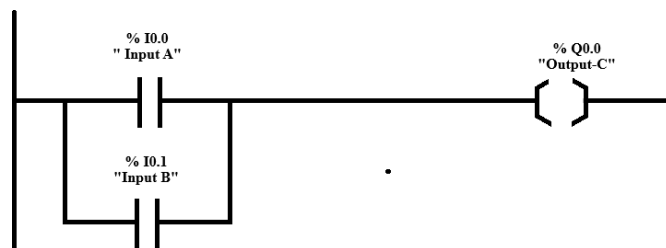


Fig. 5.3 OR Logic

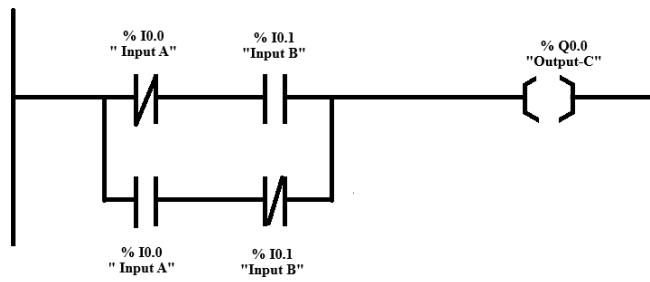


Fig. 5.4 EX-OR Logic

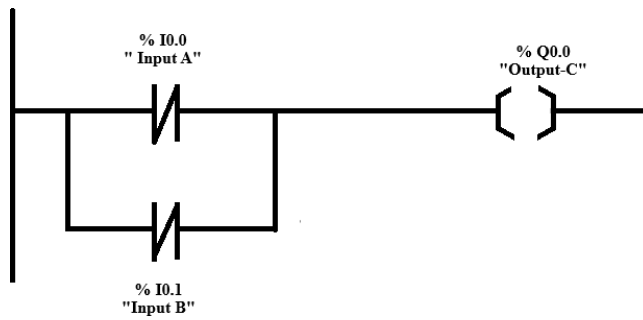


Fig. 5.5 NAND Logic

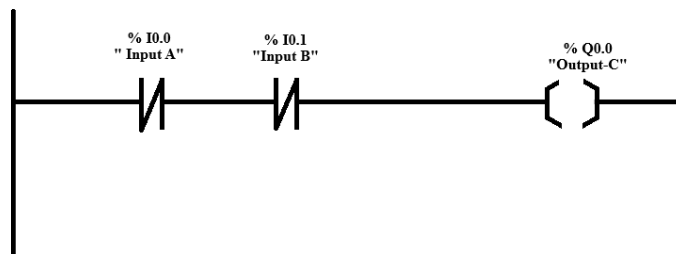


Fig. 5.6 NOR Logic

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 5.2

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: 1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer /Laptop	Computer or laptop with pre-installed PLC software	1
3	Push to ON Switch (ON/OFF)	Operating Voltage: 24 V, Current Rating: 15-50 mA	1
4	Lamp/Indicator (RYB) (ON/OFF)	Operating Voltage: 24 V, Current Rating: 15-50 mA	1
5	Connecting Wires	Connecting Wires for Connection of Push Buttons and Lamp with PLC	

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.

X. Suggested Procedure

1. Open TIA Portal PLC software and create a new project.
2. Add a new PLC device and select the correct CPU model.
3. Configure the PLC hardware and assign IP address.
4. Open the Main Program Block (OB1) and select Ladder Diagram (LAD).
5. Insert input contacts (NO, NC) and output coils to create logic gates.
6. Assign input and output addresses (e.g., %I0.0, %I0.1, %Q0.0).
7. Create tag names for each address (e.g., %I0.0 Tag- "Input-A", %I0.1 Tag-"Input-B", %Q0.0 Tag- "Output-C").
8. Compile the program to check for any errors.
9. Connect the PLC to the computer using Ethernet or USB cable.
10. Download the program to the PLC memory.

11. Switch the PLC to RUN mode.
12. Go online to monitor the ladder program.
13. Connect the push buttons available on the trainer kit to the respective input lines of the PLC using connecting wires (I0.0 and I0.1) and Output Lines to indicator (RED).
14. Apply different input combinations as per the truth table by pressing the push buttons.
15. Observe the output indicator (lamp or LED) for each input condition.
16. Record the input and output status in an observation table matching the truth table.

XI. Resources used during performance

Table 5.3

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.

XIII. Observation Table

Table 5.4

Input -A	Input-B	AND- Output- C	OR- Output- C	XOR- Output- C	NAND-Output-C	NOR-Output-C
0/OFF	0/OFF					
0/OFF	1/ON					
1/ON	0/OFF					
1/ON	1/ON					

XIV. Results

.....

XV. Interpretation of results

.....

XVI. Conclusions and Recommendations

.....

XVII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

1. Draw the symbol and truth table for NOT gate.
2. Prepare a ladder logic for $Y = (A+B) CD$.
3. Draw and verify ladder logic program for three inputs NAND Gate.

[Space for Answers] (If required attach separate page)

.....

XVIII. Suggested references for further reading

Table 5.4

Sr. No.	Link / Portal / VLab	Description
1	https://youtu.be/qaI48NCUvkA?si=az3zmpYRnEff4cQF	Ladder logic description

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Identification and selection of tools/devices	10%
2	Selection of proper devices and cables in Cisco Packet Tracer	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Successful simulation of star topology	10%
2	Proper connectivity verification using ping command	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.6: Develop ladder program for 4:1 Multiplexer

I. Practical Significance

A ladder program for a 4:1 multiplexer is practically significant because it allows a PLC to select one of several inputs to control an output efficiently, without manual rewiring or complex logic minimization. This makes industrial automation systems more flexible and easier to maintain, enhancing the speed and reliability of process control and signal routing tasks. The practical significance of developing a ladder program for a 4:1 multiplexer is that it lets a PLC select one of four inputs to route to a single output efficiently, making process control and signal selection easier and more flexible in automation systems without complex wiring or logic simplification. This improves reliability and simplifies troubleshooting in industrial setups.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

CO3 - Develop ladder logic program for various logic gates and Boolean equations.

IV. Laboratory Learning Outcome

LLO 6.1 Design 4:1 multiplexer using ladder diagram.

V. Relevant Affective domain related Outcomes

- Demonstrate working as a leader or a team member.
- Follow ethical practices.
- Encourages discipline through precise wiring, programming, as well as thorough documentation of automation systems."
- Develops a sense of responsibility.

VI. Relevant Theoretical Background

- There are m-data inputs, one output and n select lines, with $2^m = n$.
- To select n inputs, we need m select lines such that $2^m = n$. Depending on the output. The selection of one of the n inputs is done by the select pins.
- It does not need K-map and simplification so one step is eliminated to create ladder logic diagram.
- Realize the multiplexer using logic gates.
- Truth Table can be written as given below.

Table 6.1: Truth table of 4:1 Multiplexer

Data Input	Select input lines		Output
	S1	S0	
D0	0	0	D0
D1	0	1	D1
D2	1	0	D2
D3	1	1	D3

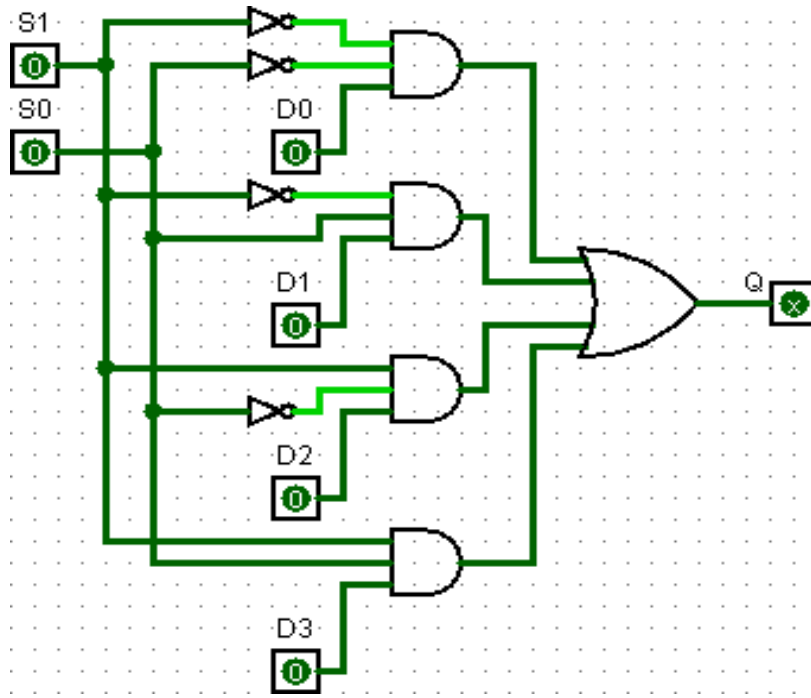


Fig. 6.1: 4:1 Multiplexer design using logic gates

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

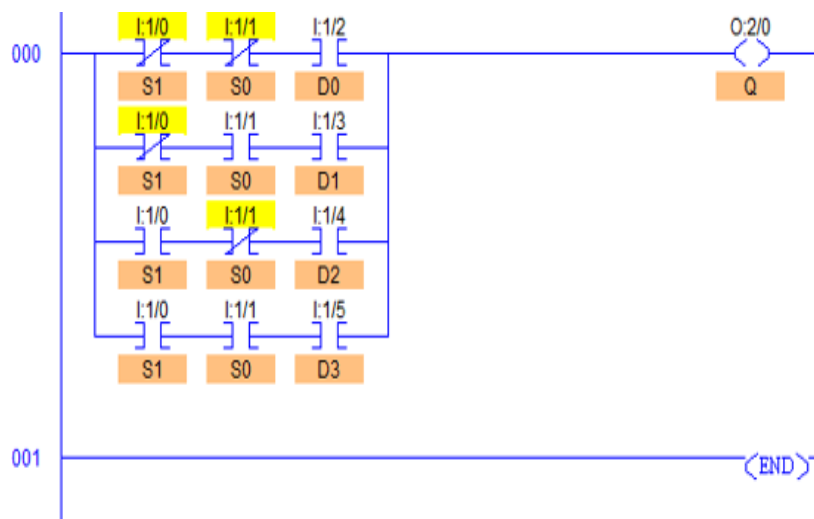


Fig. 6.2: Ladder logic for 4:1 Multiplexer

B. Actual Diagram (If required attach separate page)**VIII. Required Resources/apparatus/equipment with specifications**

Table 6.2

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: SIEMENS S7-1214C DC/DC/DC (6ES7 214-1AG31- OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer/Laptop	PC preloaded with required PLC software (TIA Software for Siemens PLC) and I/O communication facility.	1
3	Input output devices	Switches, Push button, LED etc.	1

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.
4. Use correct grounding and wiring practices.
5. Do not connect or disconnect devices when PLC is powered ON.
6. Verify addressing and signal polarity before operation.

X. Suggested Procedure

1. Identify the I/O devices (digital or analog).
2. Connect input devices to the PLC input terminals (common and signal).
3. Connect output devices to the PLC output terminals.
4. Configure I/O addresses in the PLC software (e.g., I0.0, Q0.0).
5. Develop and download the ladder logic or control program.
6. Test the operation to verify correct response between input actions and output responses.

XI. Resources used during performance

Table 6.3

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: Digital input: Digital Outputs: Analog Inputs: Analog Outputs: External Power Supply: Memory:	
2	Computer/Laptop	Computer/Laptop Configuration: Programming software used:	
3	Input output devices used	1) 2) 3) 4) 5)	

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

XIII. Observation Table

Table 6.4

Data Input	Address used for data inputs	Status of data input switch (ON/OFF)	Status of selector switch S1, S2 (ON/OFF)		Status of output (ON/OFF)
			Address of S1:	Address of S0:	Address of Q:
D0					
D0					
D1					
D1					
D2					
D2					
D3					
D3					

XIV. Results

.....

XV. Interpretation of results

.....

XVI. Conclusions and Recommendations

.....

XVII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

- 1) Develop ladder diagram for EX-OR gate.
- 2) Develop ladder diagram for automatic ON/OFF control of appliances connected in room like bulb, Fan, AC etc. With neat field diagram, wiring diagram, I/O list, address list and execution description.

[Space for Answers] (If required attach separate page)

.....

XVIII. Suggested references for further reading

Table 6.5

Sr. No.	Link / Portal / VLab	Description
1	Frank D. Petruzella Programmable <i>Logic Controllers</i> , 5th Edition McGraw-Hill Education, 2016. ISBN: 978-0073373843	Refence Book
2	https://youtu.be/qTrm4GvfrpA?si=85uUpNIMMOrm4NyR	Mux Ladder design

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Identification and selection of tools/devices	10%
2	Selection of proper devices and cables in Cisco Packet Tracer	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Successful simulation of tree topology	10%
2	Proper connectivity verification using ping command	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.7: Test the functionality of latching using basic relay type instructions in ladder diagram.

I. Practical Significance

Latching using basic relay-type instructions in a ladder diagram is that it demonstrates how to create a self-maintaining circuit in a PLC program. This allows an output, such as a motor or actuator, to remain energized even after the initiating input (like a pushbutton) is released. It helps understand how to implement start/stop control mechanisms where the output remains "latched" on until a stop command is given, improving automation reliability and operational efficiency. Testing latching in ladder logic also helps students and technicians grasp key PLC programming concepts such as memory of output states, OR logic pathways, and circuit safety with stop signals. This practical knowledge is essential for designing real-world industrial control systems that need sustained outputs without continuous operator intervention, simplifying maintenance and enhancing process control.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

CO3 - Develop ladder logic program for various logic gates and Boolean equations.

IV. Laboratory Learning Outcome

LLO 7.1 Test relay type instructions (NO, NC, output coil etc) using ladder diagram.

V. Relevant Affective domain related Outcomes

1. Demonstrate working as a leader or a team member.
2. Follow ethical practices.
3. "Encourages discipline with accuracy in wiring, programming plus thorough documentation of automation systems.
4. Develops a sense of responsibility plus safety consciousness while handling PLC hardware alongside field devices.
5. Promotes confidence alongside a professional attitude while dealing with real-time industrial automation tasks.

VI. Relevant Theoretical Background

- In many PLCs, Latching and Unlatching instructions are not available to latch and unlatch outputs directly.
- To achieve this, Seal in contact must be used to obtain similar level of Latching.

- This technique of latching is called Latching by Seal in contact.
- This seal in contact must be used in parallel with the main input Start Push Button and address of this parallel contact must be same as Output of which we want to latch.
- By performing this simple technique, we can obtain Latching of output that of similar to Latch/Set/Keep and Unlatch/Reset/Bit instructions of Allen Bradley/Siemens/Omron PLCs respectively.
- List of Input and outputs:
 - a) Start Push Button (Input) with address I:1/0 or I 0.0
 - b) Stop Push Button (Input) with address I:1/1 or I 0.1
 - c) Output with address Q:2/0 or Q 0.0

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

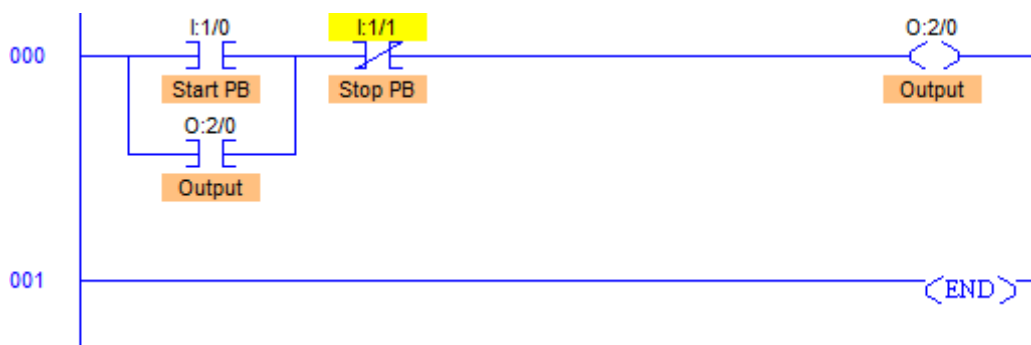


Fig. 7.1: ladder logic for latching and unlatching

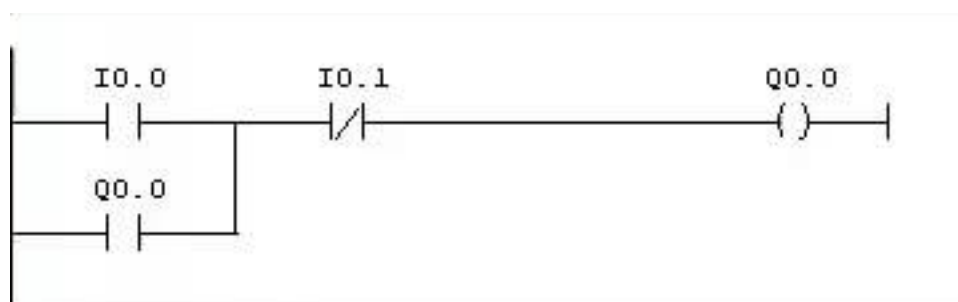


Fig. 7.2: ladder logic for latching and unlatching

➤ Program Description

1. Fig.7.1 shows latching of output for Allen Bradley PLCs and fig.7.2 shows similar operation for Siemens PLCs. Similarly, in Omron, same contacts may be used to obtain this operation with the only difference of Input-Output addresses.
2. There are two types of Scanning Order: Horizontal and Vertical. Allen Bradley, Siemens,

Omron and such PLCs come with Horizontal Scanning order and PLCs such as AEG Modicon come with Vertical Scanning order.

3. As we now know from the theory of PLC Programming using Ladder Diagram that in most of the PLC manufacturers provide Horizontal Scanning order, input and output image tables are updated accordingly.
4. So here when Start PB is pressed, due to the sequence of Ladder Logic in this program, it immediately latches the output with its own bit stored in Output Image Table due to Horizontal Scanning order.
5. Stop PB, which is XIO/Normally Closed contact, simply breaks the current path causing the Output to go false from its latched condition.
6. Similarly, it works in Siemens and Omron PLCs as well.

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 7.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: SIEMENS S7-1214C DC/DC/DC (6ES7 214-1AG31- OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1

2	Computer/Laptop	PC preloaded with required PLC software (TIA Software for Siemens PLC) and I/O communication facility.	1
3	Input output devices	Toggle Switch	1
		Push button (Push to ON)	1
		Push button (Push to OFF)	1
		Sensor (Object detector)	1
		Relay (Electromechanical SPST, SPDT etc.)	1
Neon Bulb	1		

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.
4. Use correct grounding and wiring practices.
5. Do not connect or disconnect devices when PLC is powered ON.
6. Verify addressing and signal polarity before operation.

X. Suggested Procedure

1. Identify the I/O devices (digital or analog).
2. Connect input devices to the PLC input terminals (common and signal).
3. Connect output devices to the PLC output terminals.
4. Configure I/O addresses in the PLC software (e.g., I0.0, Q0.0).
5. Develop and download the ladder logic or control program.
6. Test the operation to verify correct response between input actions and output responses.

XI. Resources used during performance

Table 7.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.

XIII. Observation Table

Table 7.3

Steps	Sequence of Operation	Effect on output
1	Start Push button is initially pressed and keep pressed	
2	Start push button is released	
3	Again, start push button is pressed.	
4	Stop push button is pressed and keep pressed	
5	Stop push button is released	
6	Again, stop push button is pressed.	

XIV. Results

.....
.....

XV. Interpretation of results

.....
.....

XVIII. Suggested references for further reading

Table 7.4

Sr. No.	Link / Portal / VLab	Description
1	Frank D. Petruzella Programmable <i>Logic Controllers</i> , 5th Edition McGraw-Hill Education, 2016. ISBN: 978-0073373843	Reference Book
2	https://youtu.be/VfVTweiyGxw?si=PA3xs4Dh0B6xqEbd	PLC Latching and Unlatching Circuit - Function and Ladder Logic

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Proper connection of computers and network devices	10%
2	Correct IP addressing and configuration on all systems	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Successful resource (file/folder/printer) sharing between computers	10%
2	Verification of connectivity using ping command	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.8: Develop a ladder program for sequential ON-OFF control of lamps/motors.

I. Practical Significance

A ladder program for sequential ON-OFF control of lamps or motors is practically significant because it automates the process of starting and stopping devices in a predetermined order, improving efficiency and safety. This type of control is widely used in industrial automation to ensure that motors or lamps operate in a specific sequence without manual intervention. It enables real-time monitoring and easy troubleshooting due to its clear and visual rung-based design, making it simple to modify and adapt for varying operational needs. Overall, such programs reduce human error, optimize process control, and enhance system reliability in applications like conveyor systems, lighting controls, and automated machinery.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

CO 3. Develop ladder logic program for various logic gates and Boolean equations.

IV. Laboratory Learning Outcome

LLO 8.1 Test ladder program for sequential ONOFF control of lamps/ motors.

V. Relevant Affective domain related Outcomes

- Demonstrate working as a leader or a team member.
- Follow ethical practices.
- "Encourages discipline with accuracy in wiring, programming plus thorough documentation of automation systems.
- Develops a sense of responsibility plus safety consciousness while handling PLC hardware alongside field devices.
- Promotes confidence alongside a professional attitude while dealing with real-time industrial automation tasks.

VI. Relevant Theoretical Background

- In this case, we have to operate motors sequentially. There are total 3 motors to be controlled in a sequence.
- So that each motor will start sequentially, say Motor 1 will START then after some delay then motor 2 will start and after some delay motor 3 will start.
- So that whole operation will take 10 seconds to start all motors in a sequence.
- By providing this delay we can avoid the problem of taking large current by motors during initial start up.

- All motors will be operating in the sequence and 5 seconds time delay is to be provided between operations of each motor.
- List of Inputs & Output
- Inputs List
 - Start PB: I0.0
 - Stop PB: I0.1
- Outputs List
 - Cycle on: Q0.0
 - Motor 1: Q0.1
 - Motor 2: Q0.2
 - Motor 3: Q0.3

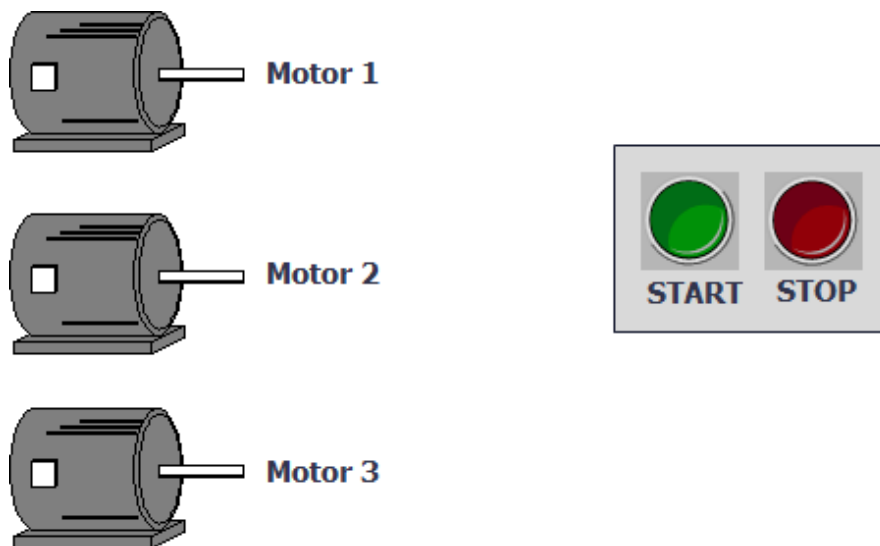


Fig. 8.1 System design for three motor sequence control

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

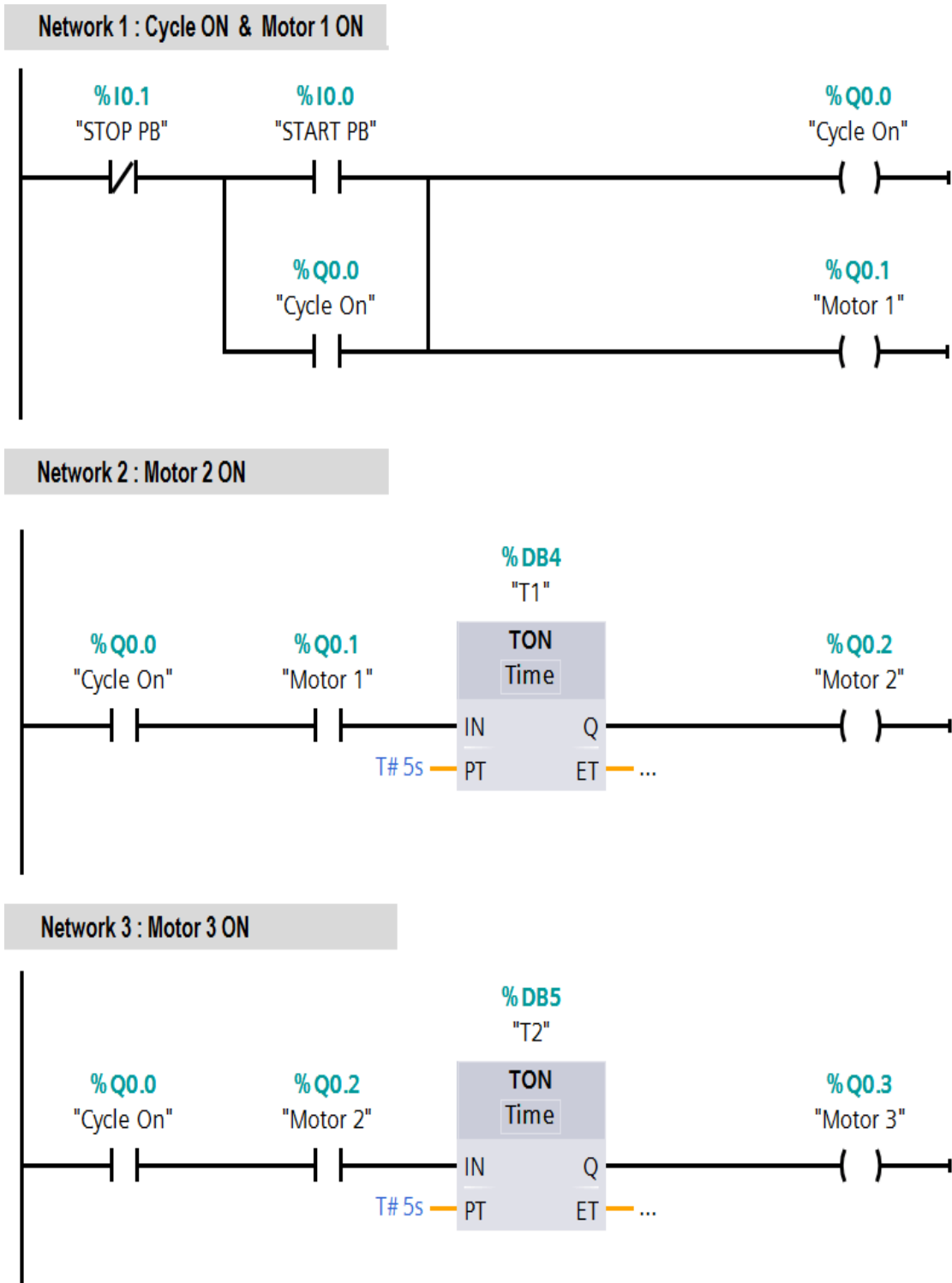


Fig. 8.2: Ladder logic for motor sequence control

➤ Program Description

Network 1:

- In Network 1, we wrote logic for cycle ON condition. Here cycle ON (Q0.0) lamp will indicate cycle status. Cycle can be started by pressing START PB (I0.0) push button and can be stopped by pressing STOP PB (I0.1) push button.
- When cycle will be ON, at same time Motor 1(Q0.1) will be started. And at the same time, timer instruction will be executed.

Network 2:

- In Network 2, the NO contact of Motor 1 starts Timer T1 and when Timer for Motor 2 (Q0.1) will reach the set value 5 seconds. Then NO contact of the T1 will START the Motor 2 (Q0.1).

Network 3:

- In Network 3, we have taken logic for motor 3. Here we have given NO contact of motor 2 for starting the timer of motor 3. When T2 will reach the set value 5s, the NO contact of the T2 will START the Motor 3(Q0.0).
- When STOP PB (I0.1) will be pressed then NC contact will be activated which makes Cycle (Q0.0) OFF. And also motor 2 and 3 will stop working.

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 8.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: SIEMENS S7-1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer/Laptop	PC preloaded with required PLC software (TIA Software for Siemens PLC) and I/O communication facility.	1
3	Input output devices	Push button (Push to ON)	1
		Push button (Push to OFF)	1
		LED	3

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.
4. Use correct grounding and wiring practices.
5. Do not connect or disconnect devices when PLC is powered ON.
6. Verify addressing and signal polarity before operation.

X. Suggested Procedure

1. Identify the I/O devices (digital or analog).
2. Connect input devices to the PLC input terminals (common and signal).
3. Connect output devices to the PLC output terminals.
4. Configure I/O addresses in the PLC software (e.g., I0.0, Q0.0).
5. Develop and download the ladder logic or control program.
6. Test the operation to verify correct response between input actions and output responses.

XI. Resources used during performance

Table 8.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

XIII. Observation Table

Table 8.3

Steps	Sequence of Operation	Effect on output
1	Start PB is Pressed	
2	After 5 seconds of motor 1 is ON	
3	After 5 seconds of motor 2 is ON	
4	Stop PB is Pressed	

XVIII. Suggested references for further reading

Table 8.4

Sr. No.	Link / Portal / VLab	Description
1	https://youtu.be/wc4XO64_wmM?si=MrIUZpRDfIVl6p40	Sequencing in Ladder Logic: Step by Step - PLC Programming
2	https://youtu.be/5lh5-RCEZYU?si=sp9kt7EmrxE07jp4	Allen Bradley PLC Sequence Programming Tutorial.

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Correct assignment of IP addresses and routing setup before VPN configuration	10%
2	Verification of VPN tunnel establishment using simulation tools or commands	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Successful creation of secure VPN tunnel between remote networks	10%
2	Correct simulation result showing encrypted packet flow between routers	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.9: Develop a ladder program to process analog signal

I. Practical Significance

In industrial processes, many parameters like temperature, pressure, and level are analog in nature and vary continuously. An RTD sensor senses temperature and converts it into an equivalent electrical signal of 4–20 mA. The PLC's analog input module receives this signal and converts it into a digital value using an analog-to-digital converter. Using scaling instructions such as NORM_X and SCALE_X, this digital value is converted into actual temperature units in degrees Celsius.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

CO3 - Develop ladder logic program for various logic gates and Boolean equations.

IV. Laboratory Learning Outcome

LLO 9.1 Test ladder program to monitor the temperature of a given liquid using RTD/Thermocouple and PLC (use Analog scaling instruction).

V. Relevant Affective domain related Outcomes

- Develop interest and confidence in handling PLC-based automation systems.
- Exhibit logical thinking and problem-solving attitude while developing ladder programs.

VI. Relevant Theoretical Background

The RTD (Resistance Temperature Detector) produces a current signal (4–20 mA) proportional to temperature. This current is converted into a proportional voltage signal (0–5 V or 0–10 V), which is applied to the Analog-to-Digital Converter (ADC) of the PLC. The ADC then converts this voltage into a digital value within a numerical range — 0 to 13824 for a 0–5 V signal and 0 to 27648 for a 0–10 V signal.

Table 9.1

Temperature (°C)	RTD Output (mA)	Converted Voltage of RTD (0–5 V Range)	ADC Digital Value (0–13824 Range)
0°C	4 mA	0 V	0
25°C	8 mA	1.25 V	3456
50°C	12 mA	2.5 V	6912
75°C	16 mA	3.75 V	10368
100°C	20 mA	5 V	13824

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

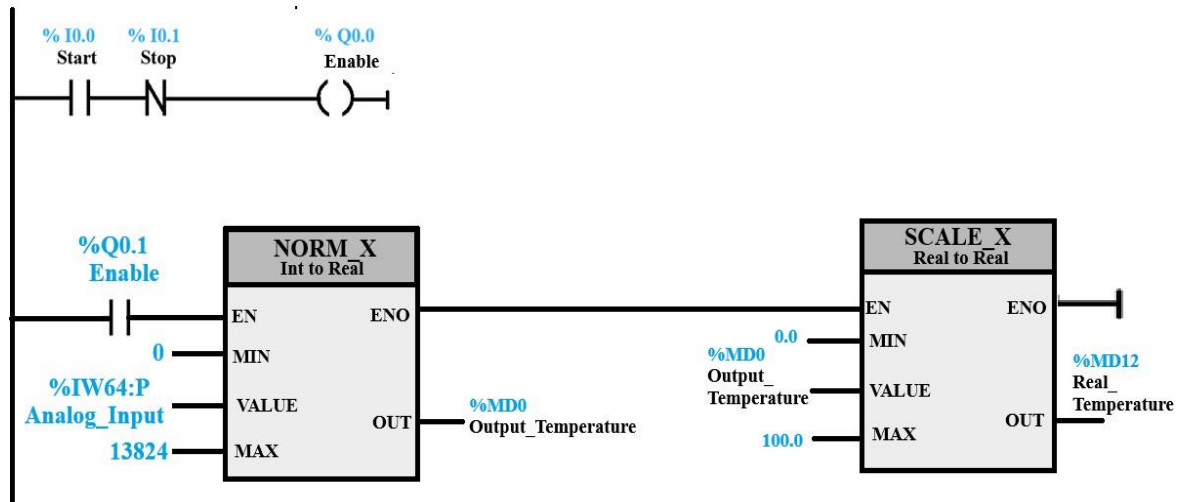


Fig. 9.1: Ladder diagram for analog signal processing

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 9.2

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller Trainer	CPU: 1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02	1

		External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	
2	Computer /Laptop	Computer or laptop with pre-installed PLC software	1
3	RTD PT-100	Input Voltage 24v, Current 4 mA to 20 mA	1

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors) directly to the PLC without relay/contactor.
3. Connect input devices (switches, sensors) and output devices (lamps, motor) only to their designated terminals.

X. Suggested Procedure

1. Open TIA Portal and create a new project named RTD_Temperature_Measurement.
2. Add your PLC (e.g., S7-1200 CPU 1212C) under Devices & Networks.
3. Configure the analog input channel for RTD (PT100) or 4–20 mA current input.
4. Set the input range to 0–5 V or 0–10 V depending on the signal conditioner.
5. Note the analog address (e.g., IW64) from connecting the RTD to PLC.
6. Create a new OB1 program block for the main logic.
7. Insert the NORM_X instruction to normalize the analog value.
8. Set NORM_X parameters: MIN = 0, MAX = 13824 (for 5 V) or 27648 (for 10 V).
9. Insert the SCALE_X instruction to convert normalized value into temperature.
10. Set SCALE_X parameters: MIN = 0 °C , MAX = 100 °C
11. Monitor observe real-time temperature in °C.

XI. Resources used during performance

Table 9.3

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.

XIII. Observation Table

Table 9.4

Sr. No.	Analog Voltage from RTD	Output value (NORM_X)	Output Value (Scale_X)
1			
2			
3			

XIV. Results

.....

XV. Interpretation of results

.....

XVI. Conclusions and Recommendations

.....

XVII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

1. Explain the scaling instruction used in ladder program of PLC
2. Write any four specifications of RTD PT-100.
3. List the different types of analog sensors use in PLC to read different analog signal.

[Space for Answers] (If required attach separate page)

.....

XVIII. Suggested references for further reading

Table 9.5

Sr. No.	Link / Portal / VLab	Description
1	https://youtu.be/ZS3W7uBdQok?si=OiH-VJOJgksrTjht	PLC Analog Inputs and Signals

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Correct connection and device configuration	10%
2	Setting up bridge and repeater as per network design	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Network successfully extended using bridge and repeater	10%
2	Checking connectivity across network segments	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.10: Develop ladder program to control the direction (Clockwise and Anticlockwise) of stepper motor.

I. Practical Significance

Developing a ladder program to control the direction (clockwise and anticlockwise) of a stepper motor lies in its critical role in precise motion control in automated industrial systems. Stepper motors, controlled via ladder logic in PLCs, enable accurate positioning and speed regulation by energizing motor phases in a sequence that determines direction of rotation. This control is essential in applications like CNC machines, robotic arms, conveyor systems, and automated packaging where precise bidirectional movement is required. Using ladder logic to manage motor direction simplifies programming, allows easy integration with other control system inputs (such as sensors and switches), and enhances system flexibility by enabling quick changes to the motion sequence without hardware rewiring. Overall, this improves automation efficiency, reduces mechanical wear by controlled starts/stops and reversals, and increases operational safety in industrial environments.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcomes

- CO 3. Develop ladder logic program for various logic gates and Boolean equations.
- CO 4. Develop ladder logic program for given application.

IV. Laboratory Learning Outcome

- LLO 10.1 Control the direction of stepper motor using ladder diagram.

V. Relevant Affective domain related Outcomes

- Students show awareness and attentiveness to the importance of precise motor control in automation processes.
- Students actively engage in hands-on learning, demonstrating willingness to participate in PLC programming and motor control exercises.
- Students internalize values related to meticulous programming and automation best practices, exhibiting consistent responsible behavior in designing and troubleshooting control systems.

VI. Relevant Theoretical Background

A stepper motor rotates the shaft in fixed, discrete steps rather than continuously turning like traditional motors. It consists of a stator with multiple electromagnets and a rotor that is either a permanent magnet or made of soft iron with teeth.

➤ **Step by step rotation:**

- When electrical pulses are sequentially sent to the stator windings each energized phase generates a magnetic field that attracts the rotor teeth.

- The rotor aligns with the energized stator phase, then shifts step-by-step as the pulses advance.
- **Controlling direction:**
- The direction (clockwise or anticlockwise) is controlled by the order in which the coils are energized.
- For clockwise rotation the activating pulses follow one sequence of stator coils.
- For anti- clockwise rotation this pulse sequence is reversed.
- Each pulse moves the rotor by a precise angle (the "step angle"). The speed of rotation depends on the pulse frequency the faster the pulses, the faster the rotation.
- Stepper motors can be driven by various excitation modes such as wave drive, full-step, half-step, or micro-stepping, which affect smoothness, torque, and precision.
- Here is a typical truth table for operating a stepper motor in clockwise (CW) and anticlockwise (ACW) directions. The table shows the coil energizing sequence for the phases (A, B, C, D) for a common 4-phase stepper motor.

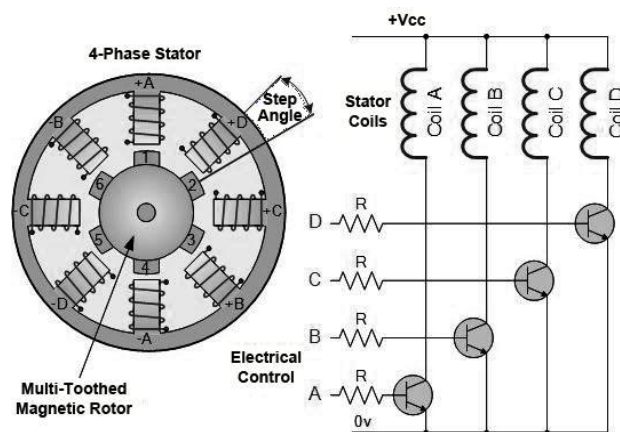


Fig.10.1 Stepper motor structures

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram

Table 10.1 Clockwise sequence of stepper motor

Step	Coil A	Coil B	Coil C	Coil D	Direction sequence
1	1	0	0	0	Start
2	1	1	0	0	CW: step 2 forward
3	0	1	0	0	CW: step 3 forward
4	0	1	1	0	CW: step 4 forward
5	0	0	1	0	CW: step 5 forward
6	0	0	1	1	CW: step 6 forward
7	0	0	0	1	CW: step 7 forward
8	1	0	0	1	CW: step 8 forward

Table 10.2 Anti-clockwise sequence of stepper motor

Step	Coil A	Coil B	Coil C	Coil D	Direction sequence
1	1	0	0	0	Start
2	1	0	0	1	ACW: step 2 reverse
3	0	0	0	1	ACW: step 3 reverse
4	0	0	1	1	ACW: step 4 reverse
5	0	0	1	0	ACW: step 5 reverse
6	0	1	1	0	ACW: step 6 reverse
7	0	1	0	0	ACW: step 7 reverse
8	1	1	0	0	ACW: step 8 reverse

The binary values 1 and 0 indicate energized and de-energized coils, respectively. This basic sequence can be programmed into a PLC ladder logic to drive the stepper motor for the desired direction control.

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 10.3

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: SIEMENS S7-1214C DC/DC/DC (6ES7 214-1AG31- OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer/Laptop	PC preloaded with required PLC software (TIA Software for Siemens PLC) and I/O communication facility.	1
3	Input output devices	Push button (Push to make)	1
		Push button (Push to break)	1

		Relay (Electromechanical)	1
		Stepper motor (Step angle- 1.8 degree, 12VDC, 4 phase, current rating 400mA)	1

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.
4. Use correct grounding and wiring practices.
5. Do not connect or disconnect devices when PLC is powered ON.
6. Verify addressing and signal polarity before operation.

X. Suggested Procedure

1. Identify the I/O devices (digital or analog).
2. Connect input devices to the PLC input terminals (common and signal).
3. Connect output devices to the PLC output terminals.
4. Configure I/O addresses in the PLC software (e.g., I0.0, Q0.0).
5. Develop and download the ladder logic or control program.
6. Test the operation to verify correct response between input actions and output responses.

XI. Resources used during performance

Table 10.4

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.

XIII. Observation Table (If required attach separate page)

Table 10.5

Sr. No.	Step angle	Direction	Motor coil status				Remark
			A	B	C	D	
1							
2							
3							
4							
5							
6							

XIV. Results

.....

XV. Interpretation of results

.....

XVI. Conclusions and Recommendations

.....

XVII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

- 1) Describe Sequencing operation with example.
- 2) Design ladder diagram for automatic door opening and closing system.

[Space for Answers] (If required attach separate page)

.....

XVIII. Suggested references for further reading

Table 10.6

Sr. No.	Link / Portal / VLab	Description
1	Frank D. Petruzella Programmable <i>Logic Controllers</i> , 5th Edition McGraw-Hill Education, 2016. ISBN: 978-0073373843	Reference Book
2	https://youtu.be/w_XAQXtVqKY?si=9P0mAsEHE9UIXfYk	Stepper Motor Forward and Reverse Control Using PLC & HMI

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Execution of Commands	10%
2	Correct identification of PC, network cables, and connectivity	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Troubleshooting and Analysis	10%
2	Verification of Results	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.11: Develop ladder program for traffic light control system using virtual lab simulator

I. Practical Significance

Developing a ladder program for a traffic light control system using a virtual lab simulator offers significant practical benefits. It provides students with hands-on experience in designing and implementing real-world traffic light sequences in a safe and controlled virtual environment without the need for physical hardware. This approach enhances understanding of time-based control and logical sequencing using PLC timers and counters, essential concepts in industrial automation. Virtual simulation allows easy testing, debugging, and modification of the program, promoting active learning and experimentation without the risk of damaging equipment. Moreover, it is cost-effective, making traffic control system training accessible to more learners and institutions. By mimicking real urban traffic scenarios, students gain relevant skills that prepare them for automation roles in transportation and smart city systems, bridging theoretical knowledge with practical application effectively

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

- CO3 - Develop ladder logic program for various logic gates and Boolean equations.
- CO4 - Develop ladder logic program for given application.

IV. Laboratory Learning Outcome

LLO 11.1 Test ladder program for automatic traffic control using virtual lab

V. Relevant Affective domain related Outcomes

1. Demonstrate working as a leader or a team member.
2. Encourages discipline and accuracy in wiring, programming, and documentation of automation systems.
3. Develops a sense of responsibility and safety consciousness while handling PLC hardware and field devices.
4. Promotes confidence and professional attitude in dealing with real-time industrial automation tasks.

VI. Relevant Theoretical Background

- A Programmable Logic Controller (PLC) is an industrial digital computer designed to control and automate electromechanical processes such as machinery operation, assembly lines, and robotic systems. It operates based on input and output (I/O) interfacing, where input devices like sensors, switches, and push buttons send signals to the PLC, which processes them according to the

programmed logic, and output devices such as motors, lamps, and relays execute the desired actions.

- The PLC continuously scans inputs, executes the control program (usually written in ladder logic), and updates outputs accordingly. Interfacing I/O devices enables the PLC to interact with the external environment, making automation possible.
- In a virtual lab environment, these I/O operations are simulated using software tools that replicate the behavior of real sensors and actuators. This allows learners to understand signal flow, logic processing, and control system operation safely and efficiently while reinforcing theoretical concepts of digital logic, control systems, and industrial automation.

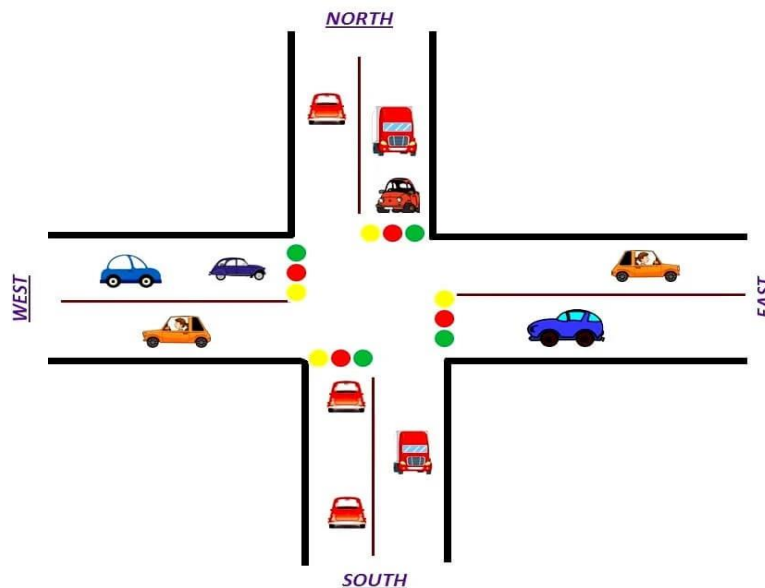
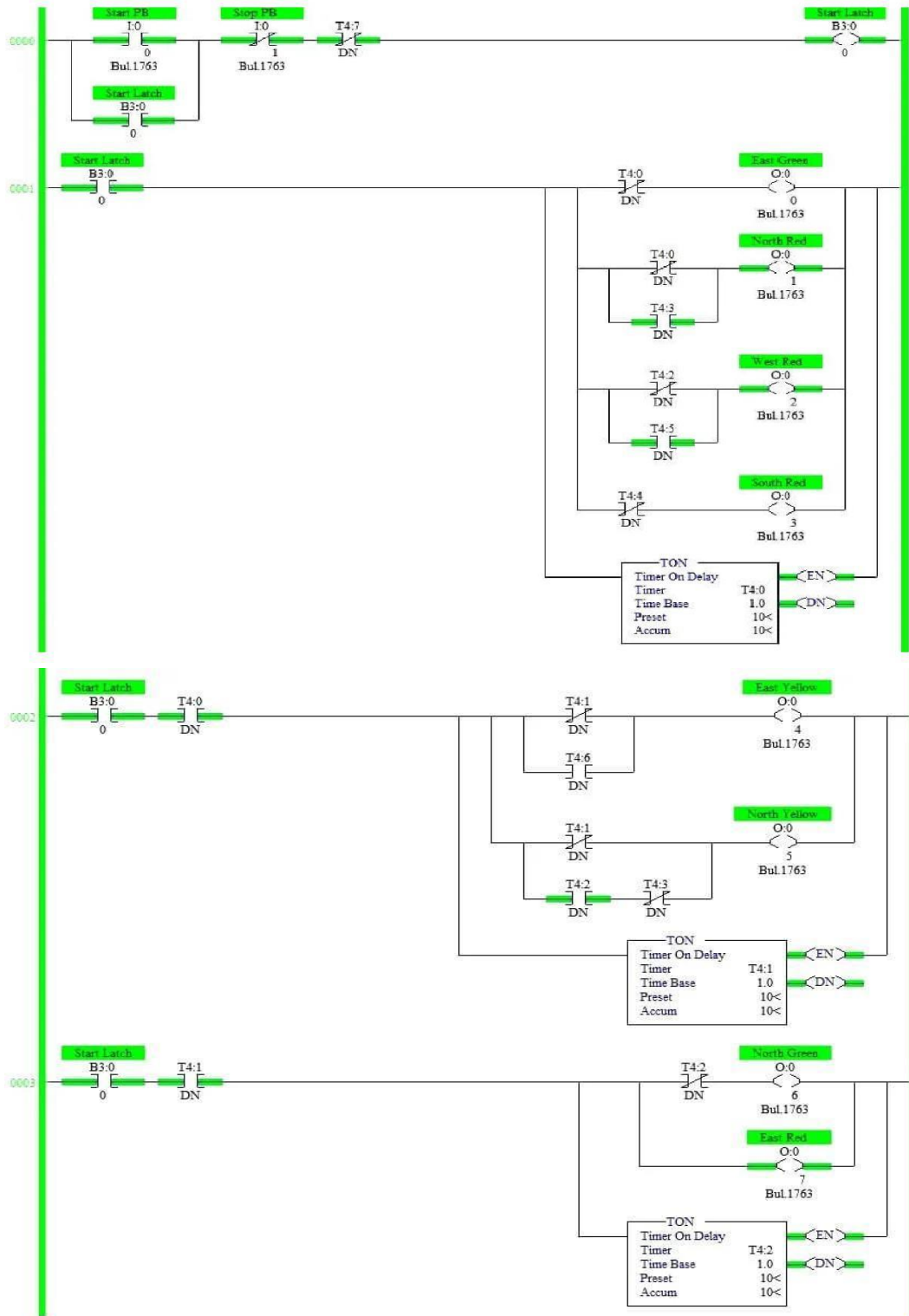


Fig. 11.1 Traffic light system

VII. Circuit diagram / block diagram / flowchart/Ladder diagram
A. Suggestive Block Diagram



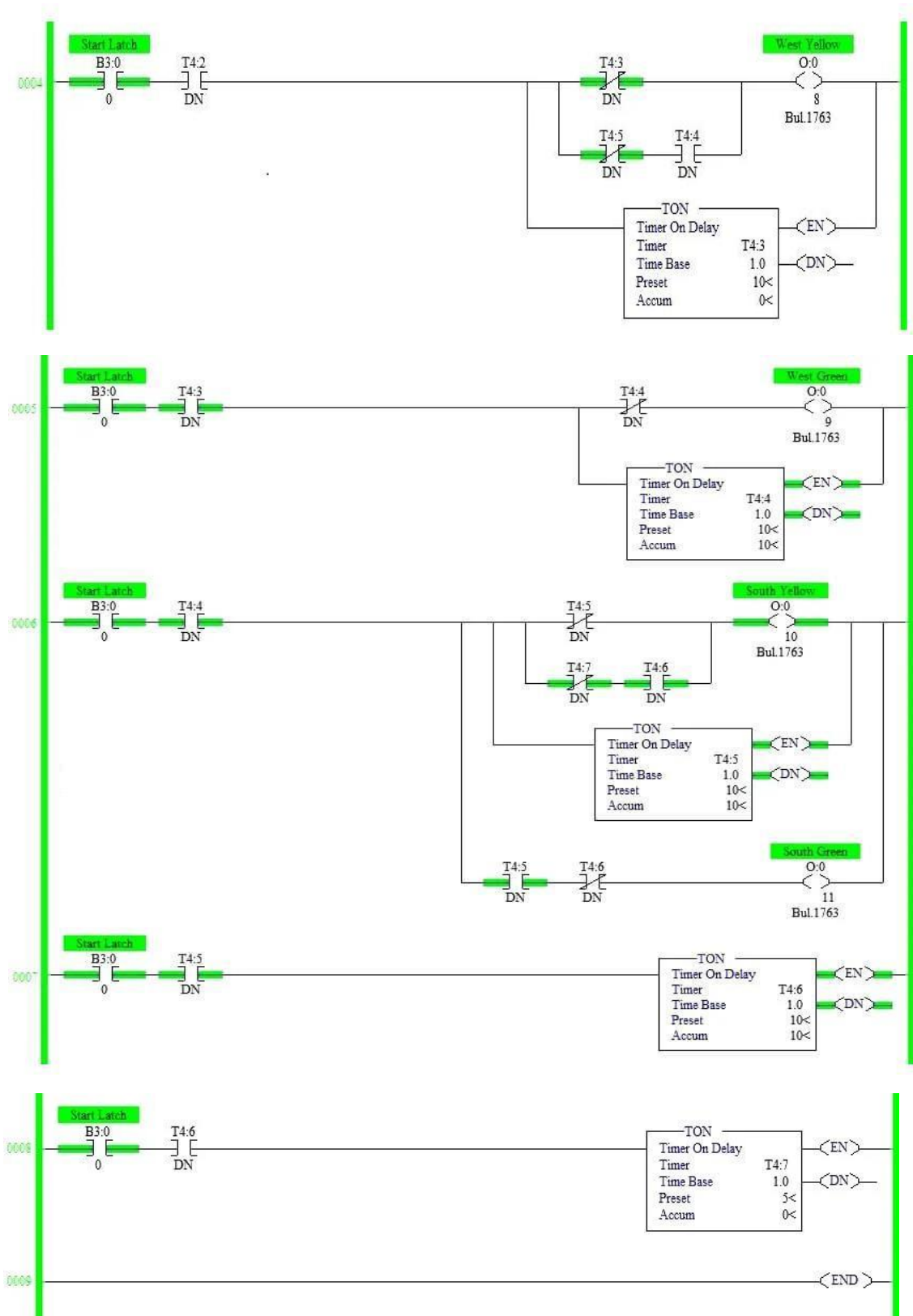


Fig. 11.2 Ladder diagram for Traffic light system

B. Actual Block Diagram (If required attach separate page)**VIII. Required Resources/apparatus/equipment with specifications**

Table 11.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Computer/Laptop	Minimum Intel i3 or equivalent processor, 4 GB RAM (8 GB recommended), Windows 10 or above / Linux OS. Internet connection to access virtual lab simulator.	1

IX. Precautions to be followed

1. Ensure the virtual PLC simulator and I/O modules are correctly configured before starting.
2. Follow the logical connections between inputs and outputs as per the circuit diagram.
3. Verify ladder logic or control program before running the simulation.
4. Monitor input/output status continuously to detect errors early.
5. Save your work regularly to prevent loss due to crashes.
6. Use step-by-step simulation modes to test the program gradually.

X. Suggested Procedure

1. Open virtual lab software.
2. Select PLC Lab.
3. Open list of experiments tab.
4. Click on hardware and software of PLC.
5. Read related theory concepts carefully and appear for pretest.
6. Follow given procedure to perform simulation.
7. Take printout final simulation and stick in given space.

XI. Resources used during performance

Table 11.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.

XVIII. Suggested references for further reading

Table 11.3

Sr. No.	Link / Portal / VLab	Description
1	https://youtu.be/LsyGmTwJTl8?si=UyMXqG8abZaHxxSx	PLC Traffic Light Example Program - Red, Yellow, Green Lights
2	https://youtu.be/taW1xJvESgM?si=bCs3hrVOOTSmFe0H	Automatic traffic light controller - Virtual PLC lab experiment.

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Execution of Commands	10%
2	Correct use of syntax to display, add, or delete routes and interpret the routing table	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Route traced successfully with hop-wise statistics and minimal packet loss	10%
2	Verification of Results	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.12: Develop ladder program to sort metallic and non-metallic objects

I. Practical Significance

A PLC (Programmable Logic Controller) is used to automate the sorting process. A metal sensor (proximity sensor) detects whether the object is metallic or non-metallic. When a metallic object is detected, the PLC activates a pneumatic cylinder or diverter to push it into the metallic bin. If the object is non-metallic, it passes straight to another bin. The PLC continuously reads sensor inputs and controls outputs like conveyor motors and actuators according to the logic programmed in the ladder diagram.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcomes

CO3 - Develop ladder logic program for various logic gates and Boolean equations.

CO4 - Develop ladder logic program for given application.

IV. Laboratory Learning Outcome

LLO 12.1 Test ladder program to identify metallic and non-metallic objects

V. Relevant Affective domain related Outcomes

- Develop interest and confidence in handling PLC-based automation systems.
- Exhibit logical thinking and problem-solving attitude while developing ladder programs

VI. Relevant Theoretical Background

Inductive Proximity Sensor is used to detect metallic objects moving on the Conveyor Motor. When the sensor detects a metallic object, it sends a signal to the PLC. The PLC then activates a Motor-operated Diverter to push the metallic object into a separate bin. Non-metallic objects continue to move straight on the conveyor.

An Inductive Proximity Sensor is designed to detect only metallic materials because it works on the principle of eddy current generation in metals.

- Ferrous metals (like iron and steel) are detected easily and at a longer sensing distance.
- Non-ferrous metals (like aluminum, copper, and brass) can also be detected but at a shorter sensing distance.

Non-metallic materials such as plastic, wood, paper, or glass cannot be detected by inductive sensors because they do not produce eddy currents.

VII. Circuit diagram / block diagram / flowchart /Ladder diagram

A. Suggestive Block Diagram

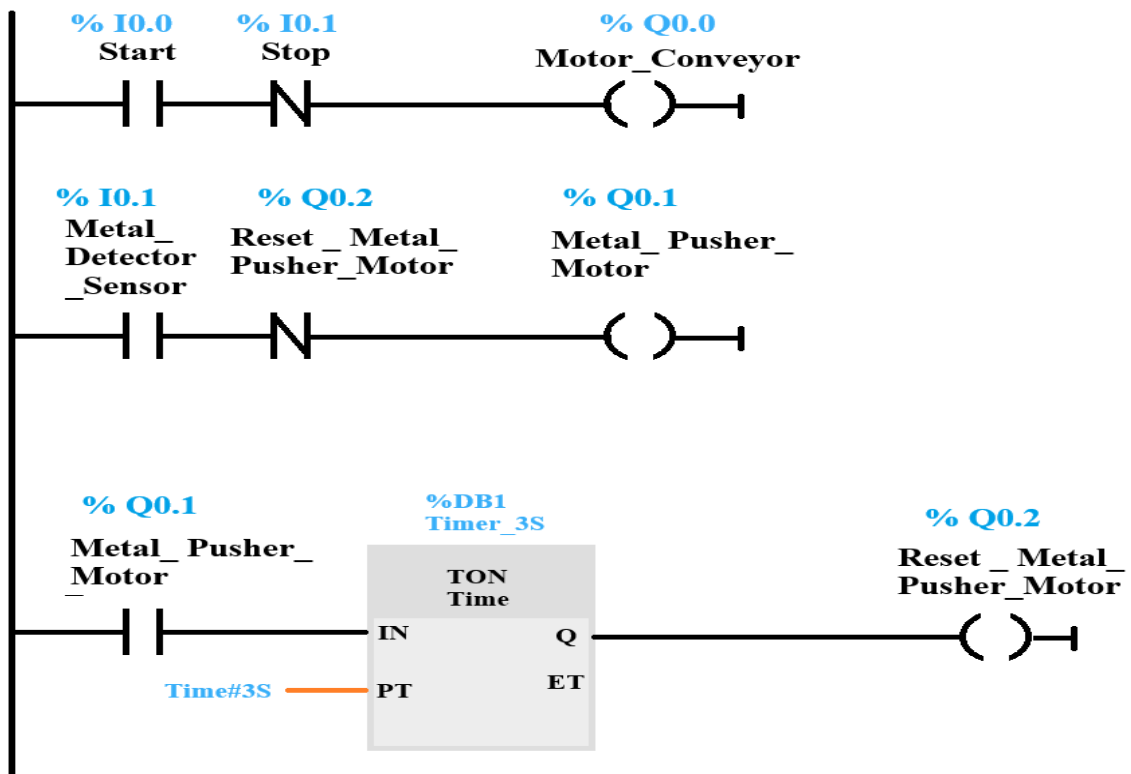


Fig.12.1 PLC Ladder Diagram

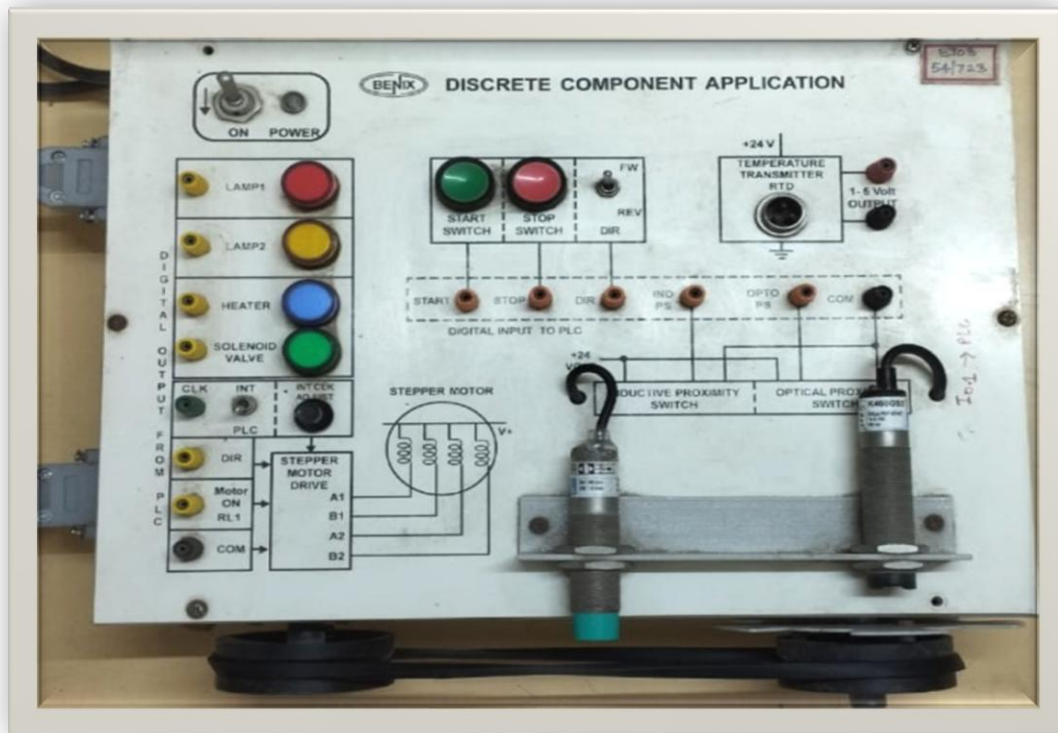


Fig.12.2 System for object sorting

B. Actual Block Diagram/Ladder Diagram (If required attach separate page)**VIII. Required Resources/apparatus/equipment with specifications**

Table 12.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller Trainer	CPU: 1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer /Laptop	Computer or laptop with pre-installed PLC software	1
3	Inductive Proximity Sensor	Sensing Distance: 5–15 mm (typical for metal) Supply Voltage: 10–30 V DC Output: PNP	1
4	DC Motor Pusher Motor Control	DC Motor (Geared) , Voltage: 12–24 V DC , Power: 30–50 W ,Speed: 50–100 RPM.	1
5	Conveyor Drive System Interface to PLC	Voltage: 12–24 V DC	1

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors) directly to the PLC without relay/contacter.
3. Connect input devices (switches, sensors) and output devices (lamps, motor) only to their designated terminals.

X. Suggested Procedure

1. Open TIA Portal software.
2. Create a new project.
3. Assign input and output addresses.
4. Draw the ladder diagram as per logic.
5. Compile the program and check for errors.
6. Download the program into the PLC.
7. Put the PLC in RUN mode.
8. Press the START button to start the conveyor motor.
9. Bring a metal object near the sensor to start the pusher motor.
10. After 3 seconds, the pusher motor will stop automatically.
11. Press the STOP button to stop the conveyor motor.
12. Observe and record the result

XI. Resources used during performance

Table 12.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.

XIII. Observation Table

Table 12.3

Sr. No.	Input/ Output	Select Condition
1	Start Button = ON /OFF	Conveyor Motor = On/OFF
2	Stop Button = ON /OFF	Conveyor Motor = On/OFF
3	Inductive Proximity Sensor = On- for Metal, Off- for Non-Metal	Metal_Pusher_Motor = ON/Off
4	Metal_Pusher_Motor_Reset in Sec

XIV. Results

.....

XV. Interpretation of results

.....

XVI. Conclusions and Recommendations

.....

XVII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

1. Explain the function of TON timer used in metal sorting Ladder program
2. Practical specifications of an inductive proximity sensor.
3. Different types of proximity sensors based on material detection.

[Space for Answers] (If required attach separate page)

.....

XVIII. Suggested references for further reading

Table 12.4

Sr. No.	Link / Portal / VLab	Description
1	https://youtu.be/u2bZSoe-2yI?si=w7283rK-A9Lorqv6	Sorting System Metal & Non-Metal Detection
2	https://youtu.be/-SVn6lxjBEo?si=AZ7I-DjMMuwDQam8	PLC Based Product Sorting Machine System

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Proper selection and use of tools (UTP cable, RJ-45 connector, crimping tool, cable tester)	10%
2	Correct wire arrangement as per T568B colour code standard	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Accuracy of wiring sequence	10%
2	Correct wiring sequence verified using cable tester	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.13: Develop Sequential Function Chart (SFC) to sort metallic and non-metallic objects.

I. Practical Significance

Developing a Sequential Function Chart (SFC) to sort metallic and non-metallic objects involves creating a step-by-step control sequence for an automated system by using a Programmable Logic Controller (PLC). SFC represents a process as a series of steps, transitions, and actions, making it ideal for applications requiring sequential control.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcomes

- CO3 - Develop ladder logic program for various logic gates and Boolean equations.
- CO4 - Develop ladder logic program for given application.

IV. Laboratory Learning Outcome

- LLO 5.1 Test functionality of logic gates using ladder diagram.

V. Relevant Affective domain related Outcomes

1. Demonstrate working as a leader or a team member.
2. Follow ethical practices.
3. Encourages discipline and accuracy in SFC programming
4. Develops a sense of responsibility and safety consciousness while handling PLC hardware and field devices.
5. Promotes confidence and professional attitude in dealing with real-time industrial automation tasks.

VI. Relevant Theoretical Background

Sequential Function Chart (SFC) is one of the five standard programming languages defined in the IEC61131-3 standard for Programmable Logic Controllers (PLCs). It is used to represent and control sequential processes in an organized, visual, and easy-to-understand way.

➤ Flow of Sequential Function Chart (SFC)

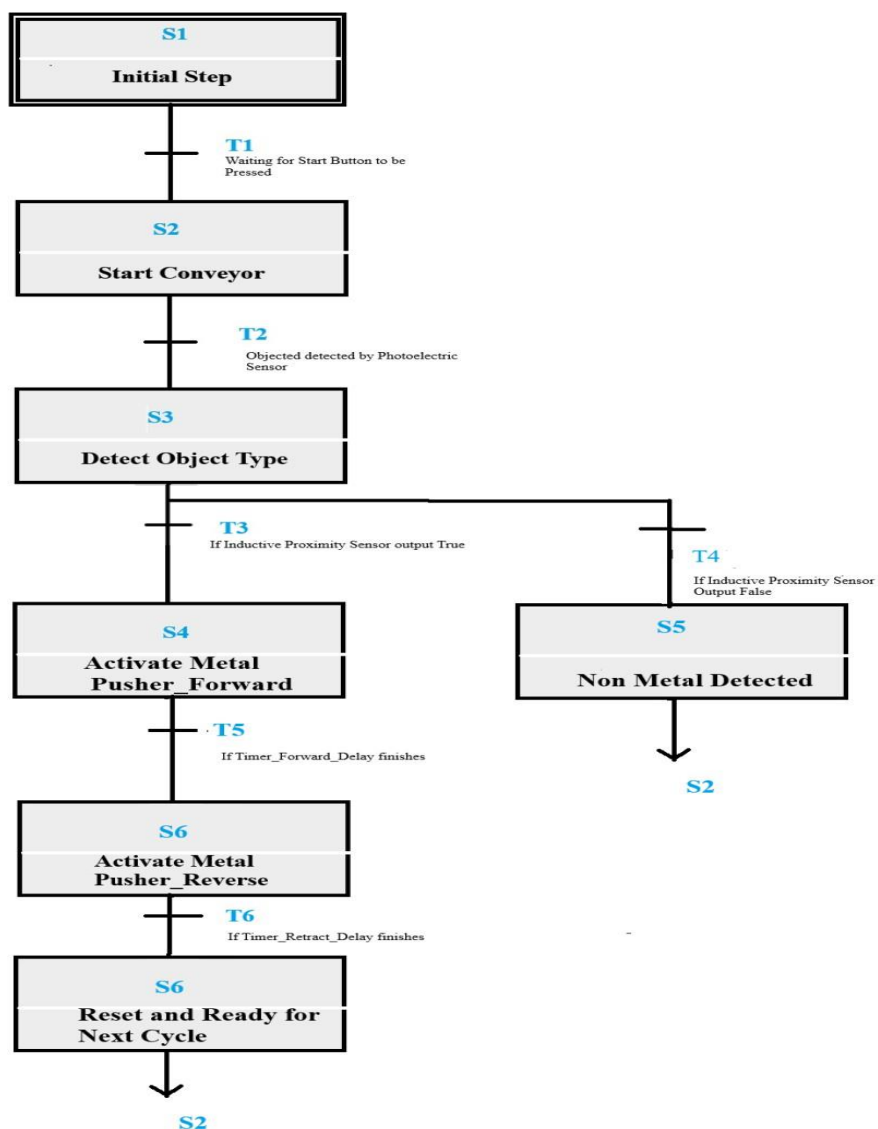
1. Start with the initial step.
2. When the transition condition is true, the control moves to the next step.
3. The actions linked with the active step are executed.
4. The process continues sequentially or in parallel depending on the logic.

➤ **Basic Components of SFC**

- **Initial Step:** The first step that activates when the program starts
- **Step:** Represents a specific state or stage in the process
- **Transition:** A condition that allows the program to move from one step to the next
- **Action:** The operation performed when a step is active
- **Branching:** Used for parallel or alternative paths

VII. Circuit diagram / block diagram / flowchart /Ladder diagram

A. Suggestive Block Diagram



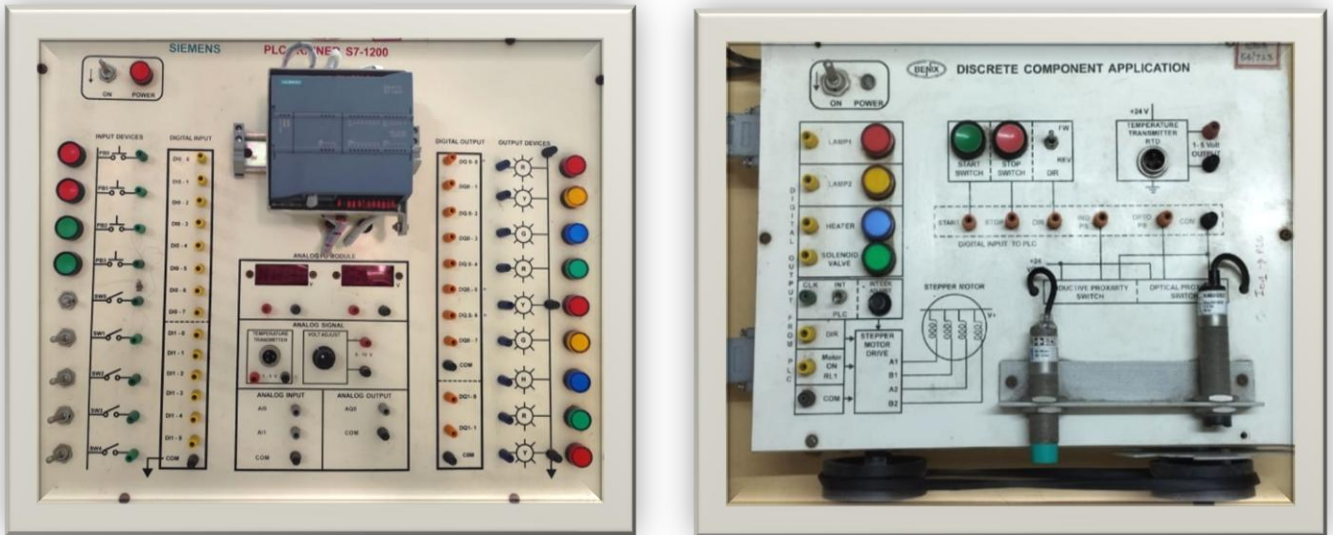


Fig. 13.1 SFC chart and system design

B. Actual Block Diagram (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 13.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU: 1214C DC/DC/DC (6ES7 214-1AG31-0XBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer /Laptop	Computer or laptop with pre-installed PLC software	1
3	Push to ON Switch (ON/OFF)	Operating Voltage: 24 V, Current Rating: 15-50 mA	1
4	Photoelectric Sensor	Sensing Distance: 50–150 mm	1

		Supply Voltage: 12–24 V DC Output: PNP	
5	Inductive Proximity Sensor	Sensing Distance: 5–15 mm (typical for metal) Supply Voltage: 10–30 V DC Output: PNP	1
6	DC Motor Pusher Motor Control	DC Motor (Geared) Voltage: 12–24 V DC Power: 30–50 W Speed: 50–100 RPM Direction controlled via H-Bridge or relay from PLC output	1
7	Conveyor Drive System Interface to PLC	Voltage: 12–24 V DC	1

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.

X. Suggested Procedure

1. Open TIA Portal and create a new project (MetalSorter_TimeSFC).
2. Add your PLC hardware (CPU 1212C) under Devices & Networks.
3. Configure I/O addresses for sensors and actuators: I0.0 = Start Button, I0.2 = Object Detected, I0.3 = Metal Sensor, Q0.0 = Conveyor Motor, Q0.1 = Pusher _Forward, Q0.2 = Pusher Reverse.
4. Create PLC tags for all inputs, outputs, and timers (Timer_ Forward_ Delay, Timer_Retract_Delay) with meaningful names.
5. Add a new SFC program block (Sort SFC) under Program Blocks.
6. Create Step S1 (Idle / Initialization) and set all outputs = OFF. Transition to S2 when Start Button = TRUE.
7. Create Step S2 (Start Conveyor), set Conveyor Motor = TRUE. Transition to S3 when Object Detected = TRUE.
8. Create Step S3 (Stop & Detect Object Type), set Conveyor Motor = FALSE. Transition to S4 if Metal Sensor = TRUE, else to S5 if Metal Sensor = FALSE.
9. Create Step S4 (Metal Object – Push Forward), set Pusher Forward = TRUE, start Timer_Forward_Delay. Transition to S6 when timer finishes.
10. Create Step S5 (Non-Metal Forward), Jump to S2 (Start Conveyor).
11. Create Step S6 (Pusher Retract), set Pusher Forward = FALSE, Pusher Reverse = TRUE, start

- Timer_Retract_Delay. Transition to S7 when timer finishes.
12. Create Step S7 (Reset & Ready for Next Object), set Pusher Reverse = FALSE, Conveyor Motor = TRUE. Transition to S2 when Object Detected = TRUE.
13. Compile and Download the program in TIA Portal to check sequence correctness.

XI. Resources used during performance

Table 13.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.

XIII. Observation Table

Table 13.3

Step	Step Description	Input Conditions (ON/OFF)	Output Actions (ON/OFF)	Transition Condition/Next Step
S1	Idle / Initialization	StartButton =	All outputs	StartButton = Next Step =
S2	Start Conveyor	StartButton =	ConveyorMotor =	ObjectDetected = Next Step =
S3	Stop & Detect Object Type	ObjectDetected =	ConveyorMotor =	Metal Sensor = Next Step = Metal Sensor = Next Step =

S4	Metal Object – Push Forward	Metal Sensor =	Pusher_Forward = Timer_Forward_Dela y =	Timer_Forward_Delay = Next Step =
S5	Non-Metal Object	Metal Sensor =	ConveyorMotor =	ObjectDetected = Next Step =
S6	Pusher Retract	Timer_Forward_Delay = done/Not Done	Pusher Forward = Pusher Reverse = Timer_Retract_Delay =	Timer_Retract_Delay = Next Step =
S7	Reset & Ready for Next Object	Timer_Retract_Delay = done/Not Done	Pusher Reverse = Conveyor Motor =	ObjectDetected = Next Step =

XIV. Results

.....

XV. Interpretation of results

.....

XVI. Conclusions and Recommendations

.....

XVII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

1. Draw the SFC (Sequential Function Chart) for traffic Light Control system.
2. State any four advantages of using Sequential Function Chart (SFC) in PLC programming.
3. Compare between Ladder Logic and Sequential Function Chart (SFC).

[Space for Answers] (If required attach separate page)

.....

XVIII. Suggested references for further reading

Table 13.4

Sr. No.	Link / Portal / VLab	Description
1	http://kcl.digimat.in/nptel/courses/video/108105088/lec29.pdf	SFC Details
2	solisplc.com/tutorials/an-introduction-to-the-graph-language-in-tia-portal-sequential-function-chart	

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Proper selection and use of tools (UTP cable, RJ-45 connector, crimping tool, cable tester)	10%
2	Correct wire arrangement at each end according to T568A and T568B standards	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Accuracy of wiring sequence	10%
2	Correct wiring sequence verified using cable tester	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.14: Develop ladder program for automatic car parking system

I. Practical Significance

The automatic car parking system using PLC helps to solve the common problem of finding empty parking spaces. In normal parking, drivers waste time searching for vacant spots and there is no real-time information. This system uses sensors to detect if a car is present or not in each slot. The PLC processes this data, turns on LEDs to show which slots are free, and updates a digital display with the number of empty spots. It makes parking faster, automatic, and easy to manage, reducing time, effort, and confusion.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

- CO3 - Develop ladder logic program for various logic gates and Boolean equations.
- CO4 - Develop ladder logic program for given application.

IV. Laboratory Learning Outcome

- LLO 14.1 Test ladder program for automatic car parking system.

V. Relevant Affective domain related Outcomes

1. Demonstrate working as a leader or a team member.
2. Follow ethical practices.
3. Develop interest and confidence in handling PLC-based automation systems.
4. Exhibit logical thinking and problem-solving attitude while developing ladder programs

VI. Relevant Theoretical Background

In automatic car parking system counter is used to count the number of empty spots. Proximity Sensors or IR Sensors are used to detect the presence of car. Value of counter is displayed on the display which is mounted outside the parking plot.

This counter value is converted into decimal.

Table 14.1 List of Inputs and Outputs

Address	Type of Instruction	Remark
I:1/0 to I:1/4	Input	IR Sensor to detect the presence of cars
O:2/0 to O:2/4	Output	LEDs to indicate presence of car spots
C5:0	Count Up	To increment when Car exits
C5:1	Count Down	To decrement when Car enters
O:6	Output	Display address

VII. Circuit diagram / block diagram / flowchart /Ladder diagram

A. Suggestive Diagram

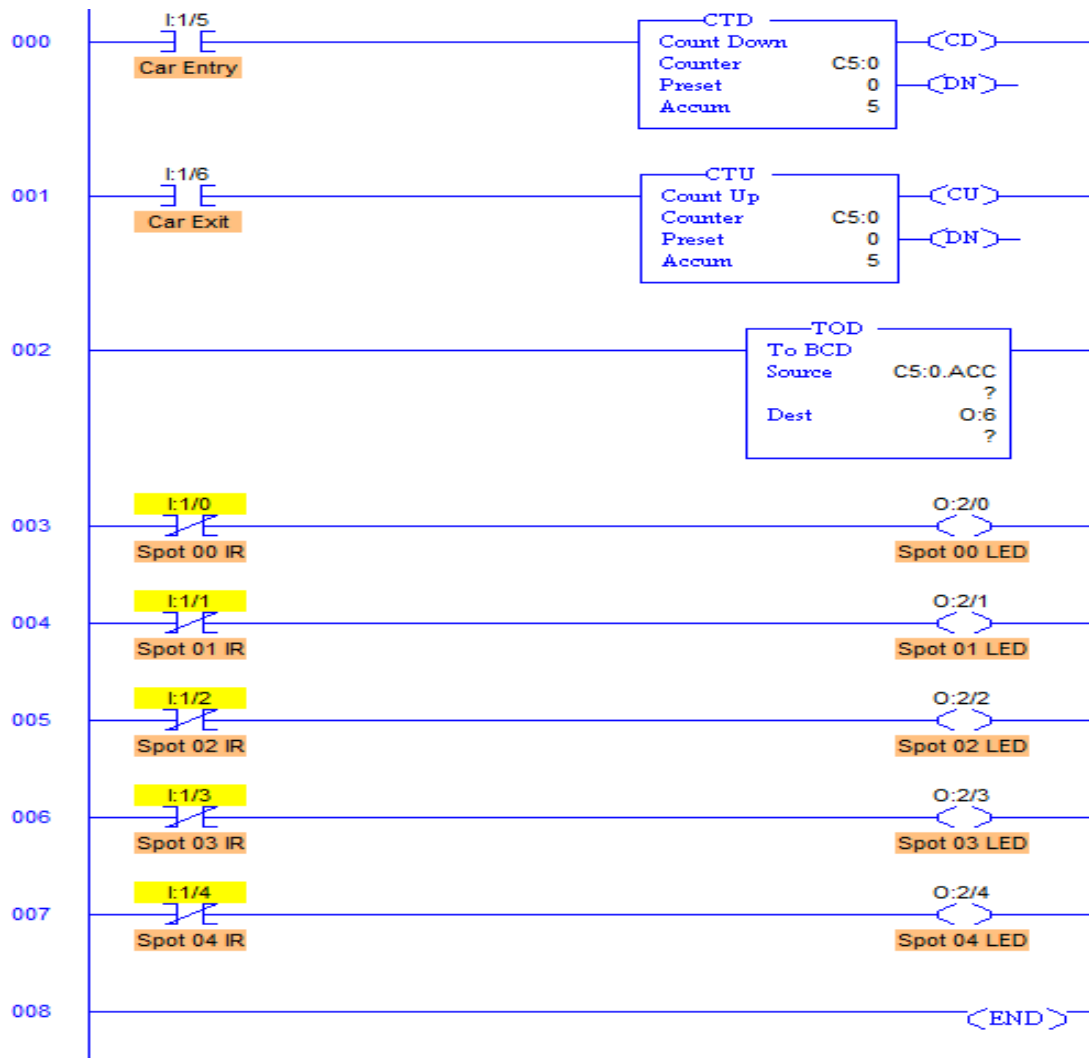


Fig. 14.1 Ladder program for car parking system

VIII. B. Actual Diagram (If required attach separate page)**IX. Required Resources/apparatus/equipment with specifications**

Table 14.2

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller Trainer	CPU: 1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer /Laptop	Computer or laptop with pre-installed PLC software	1
3	IR Sensor /Inductive Proximity Sensor	Sensing Distance: 5–15 mm (typical for metal) Supply Voltage: 10–30 V DC Output: PNP	1

X. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors) directly to the PLC without relay/contactor.
3. Connect input devices (switches, sensors) and output devices (lamps, motor) only to their designated terminals.

XI. Suggested Procedure

1. Open TIA Portal and create a new project named Auto CarParking_CTU_CTD.
2. Add PLC hardware (CPU 1212C DC/DC/DC) under Devices & Networks.
3. Open Main OB1 and select Ladder Diagram (LAD) as the programming language.
4. Assign I:1/0 to I:1/4 = IR Sensors to detect the presence of cars (Inputs).
5. Assign O:2/0 to O:2/4 = LEDs to indicate parking spot availability (Outputs).
6. Assign I:1/5 = Entry sensor for car entering.
7. Assign I:1/6 = Exit sensor for car leaving.
8. Use C5:0 = Counter Up (CTU) to increment count when a car exits.
9. Use C5:0 = Counter Down (CTD) to decrement count when a car enters.
10. Preset counter value (PV) = 5, as total parking spots = 5.
11. Accumulator (CV) value represents current available slots.
12. Connect accumulator output to O:6 (Display output) through BCD converter.
13. Use Normally Closed contacts for IR sensors so LEDs remain ON when spots are empty.
14. Compile the program, download to PLC, and test entry and exit operation for verification.

XII. Resources used during performance

Table 14.3

Sr. No.	Name of Resource	Specifications	Quantity

XIII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.

6.

7.

XIV. Observation Table

Table 14.4

Sr. No.	Entry Sensor (I:1/5)	Exit Sensor (I:1/6)	Parking Slot Sensors (I:1/0-I:1/4)	Counter Value (C5:0.AC C)	Display (O:6)	Lamp Status					Remark (Car Entry/Exit)
						O:2/0	O:2/1	O:2/2	O:2/3	O:2/4	
1	0	0	00000	5	5	ON	ON	ON	ON	ON	All slots empty
2	1	0	00001	4	4	ON	ON	ON	ON	OFF	One Car entered
3	1	0	00011	3	3						Two cars entered
4	0	1	00010	4	4						One Car Exit from
5	1	0	00110	3	3						
6	0	0	00110	3	3						

XV. Results

.....

XVI. Interpretation of results

.....

XVII. Conclusions and Recommendations

.....

XVIII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

1. Mention the instruction used to latch the entry and exit operations.
2. State the condition for activating the “Parking Full” indicator.

XIX. Suggested references for further reading

Table 14.5

Sr. No.	Link / Portal / VLab	Description
1	https://youtu.be/yHIOTO6ae4g?si=xzbZEy4alFf5mo04	Simple car parking PLC ladder diagram in the Siemens TIA Portal

XX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Proper selection and use of PDU tool	10%
2	Correct step-by-step observation of PDUs at each OSI layer	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Correct creation of PDU with proper encapsulation	10%
2	Proper identification of addressing (MAC, IP, ports)	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.15: Interface and test PLC with profibus and profinet network protocol.

I. Practical Significance

Interfacing and testing a PLC with PROFIBUS and PROFINET is practically significant because it enables fast, reliable communication and control of industrial devices, ensuring efficient automation. PROFIBUS offers deterministic, mature fieldbus communication ideal for real-time control, while PROFINET provides high-speed, flexible Ethernet-based networking suitable for modern scalable systems. Testing ensures seamless integration, reduces downtime, enhances diagnostics, and supports safe, flexible, and efficient industrial operations. This leads to improved productivity, easier maintenance, and future-proof automation.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

- CO-5 Use the relevant communication protocol for specific automation system.

IV. Laboratory Learning Outcome

LLO 15.1 Test and compare profibus and profinet network protocol.

V. Relevant Affective domain related Outcomes

1. Demonstrate working as a leader or a team member.
2. Follow ethical practices.
3. Develop a positive mindset toward adopting advanced industrial communication technologies.
4. Value collaboration and teamwork during system integration and testing processes.
5. Cultivate a sense of responsibility for ensuring reliable and safe network operations.
6. Demonstrate motivation to stay updated and adapt to evolving automation protocols.
7. Foster attentiveness and commitment to quality in configuring and troubleshooting networks.

VI. Relevant Theoretical Background

- PROFIBUS defines the technical features of a serial field bus system, by which distributed digital automation devices, from field to cell level, can be networked together.
- It is a multi-master system and so allows the combined operation on one bus of several automation, engineering, and visualization systems with remote peripherals.

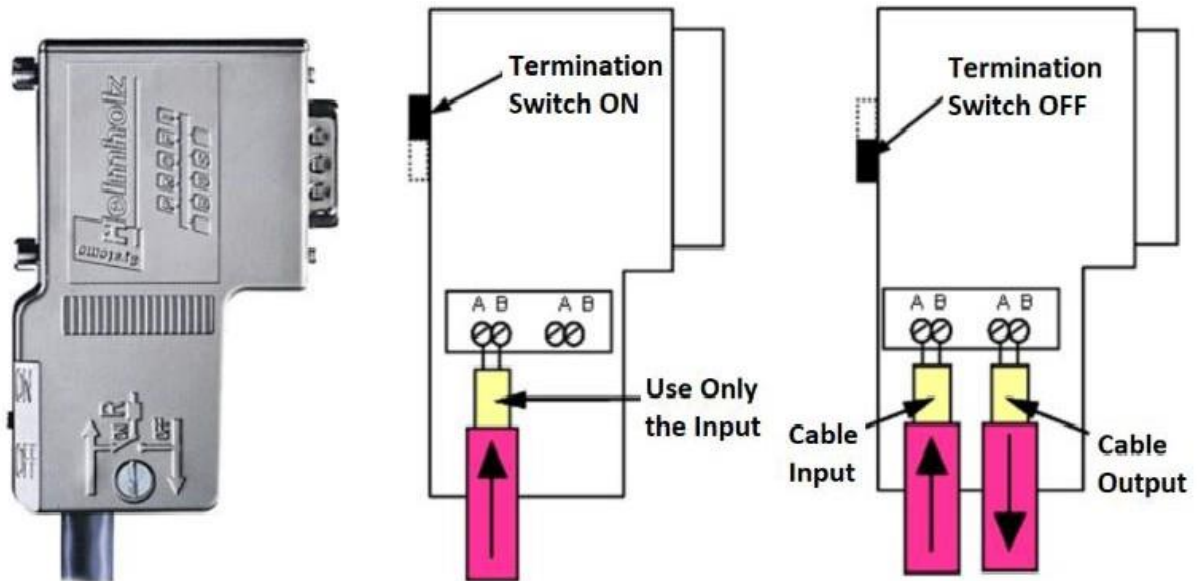


Fig. 15.1 Profibus connector

- Profinet is an industrial Ethernet-based system.
- Using Profinet we can connect facilities like PLC, HMI, Distributed I/O, a different type of transmitters, sensor, actuator, VFD, etc. all on one network.
- Profinet provides faster response time so the collection of the data becomes even greater.
- Industrial Profinet comes with shielding provides better performance in an electrically noisy environment.
- To recognize Profinet devices it must be defined with IP address and device name.
- Each device in a network must be assigned with IP address to communicate.
- Profinet devices are recognized by valid IP addresses. IP address or internet protocol is used to define addresses to recognize devices in the network.

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Flowchart

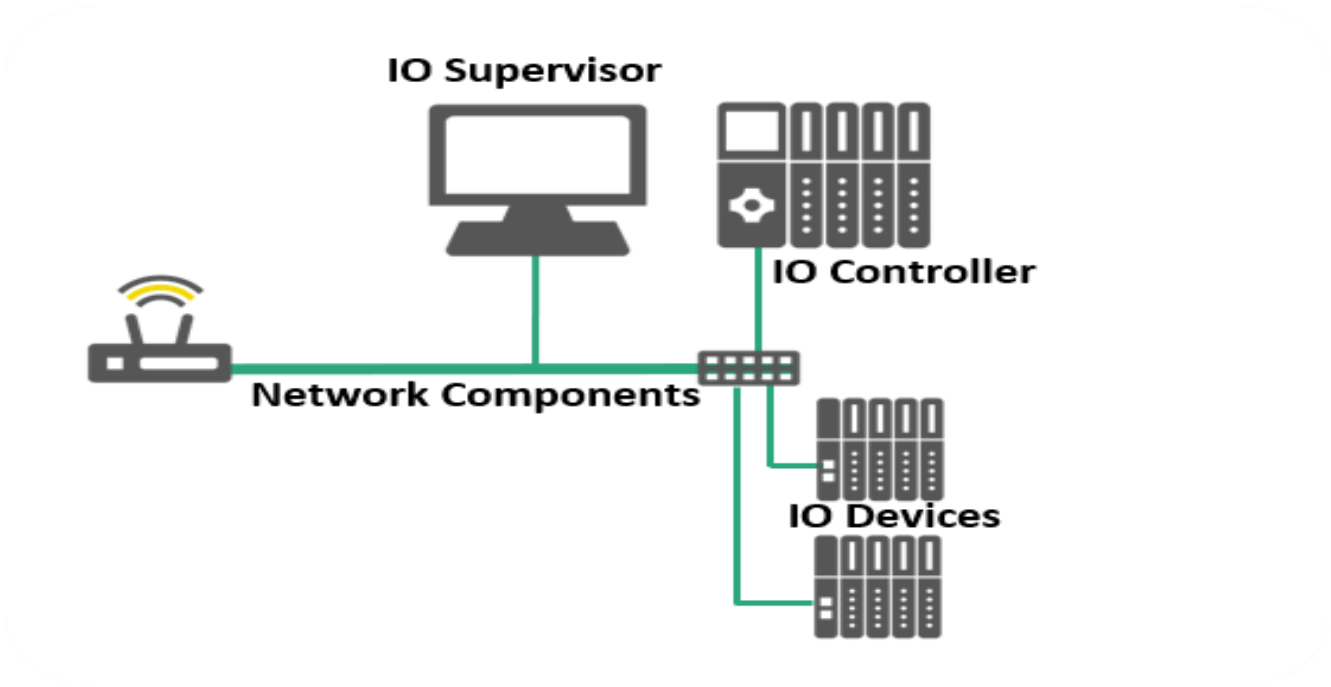


Fig. 15.2 Profinet connectors

B. Actual Flowchart (If required attach separate page)

VIII. Required Resources/apparatus/equipment with specifications

Table 15.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU : 1214C DC/DC/DC (6ES7 214-1AG31-0XBO) Digital input: 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs: 12 Nos with 24V operated Lamp. Analog Inputs: 02 Analog Outputs: 02 External Power Supply: 24 V DC. Memory: 16 K data memory +351K Code Memory +96K upload Memory.	1

2	Computer /Laptop	Computer or laptop with pre-installed PLC software	1
3	Push to ON Switch (ON/OFF)	Operating Voltage : 24 V , Current Rating : 15-50 mA	1
4	Profibus connectors and cables	RS485 connector and cable with adaptor	1
5	Profinet components	Network switch , network (LAN) cables, network connectors	1
6	Start push button Stop push button	Push to ON switch and Push to Off switch	1
7	Output device	Lamp, Buzzer etc	1

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors, heaters, pumps) directly to the PLC without relay/contactors.
3. Connect input devices (switches, sensors) and output devices (lamps, hooters) only to their designated terminals.

X. Suggested Procedure

➤ Steps to configure a PROFIBUS network

- 1) First of all, we will make our Hardware configuration and connect the two PLCs through (DP port)
- 2) Then we are going to set the DP address and parameters of the PLC by clicking on the PROFIBUS port for (S7-412)
- 3) Then we have to set the parameters for the other PLC (S7-312)
- 4) You should be aware that the communication between the two PLCs via PROFIBUS protocol stands on the Input / Output Memory of the devices, for this part you can customize your data addressing for the communication.
- 5) If you want to change transferring speed you have to click on the PROFIBUS connection between the two PLCs then you can change from here.
- 6) Finally, you can download your program on the PLCs.

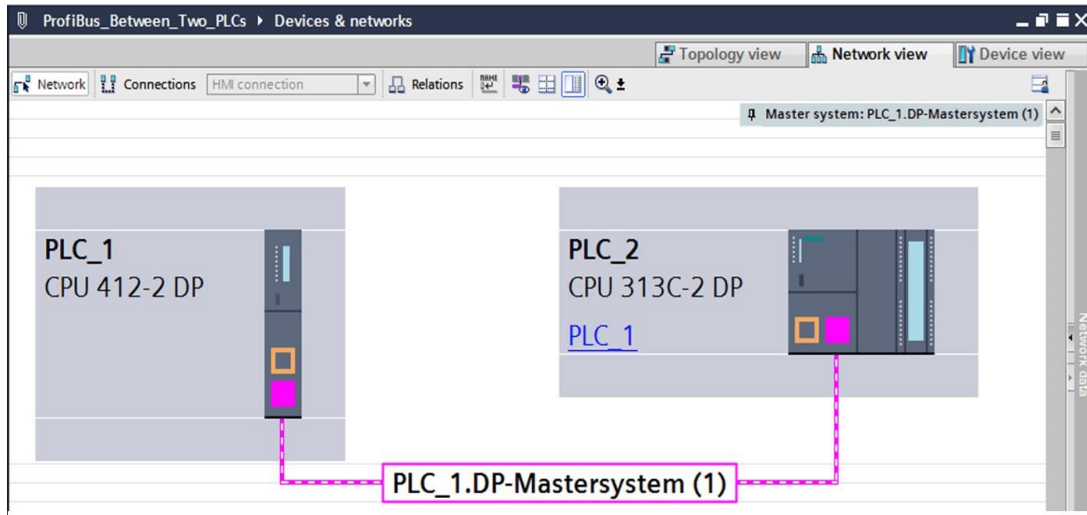


Fig. 15.3 Step 1 of Profibus Configuration

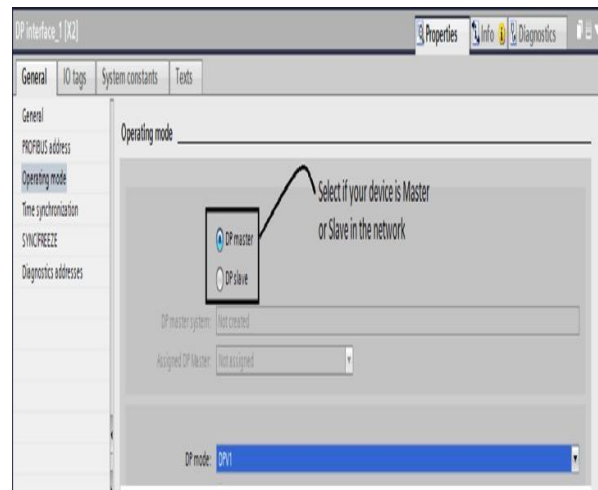
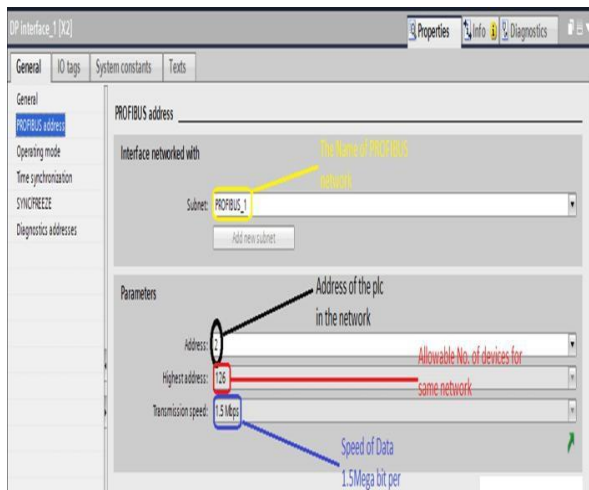


Fig. 15.4 Step 2 of Profibus Configuration

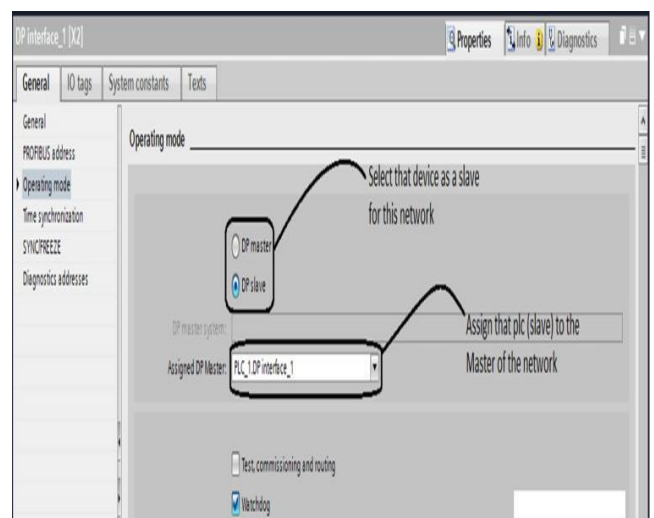
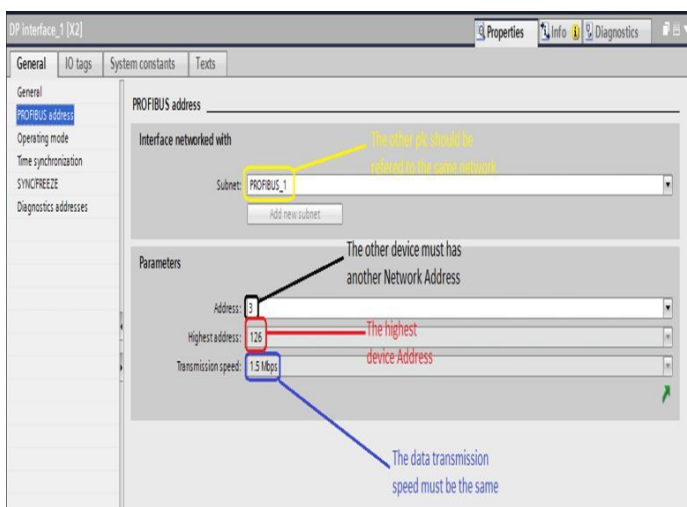


Fig. 15.5 Step 3 of Profibus Configuration

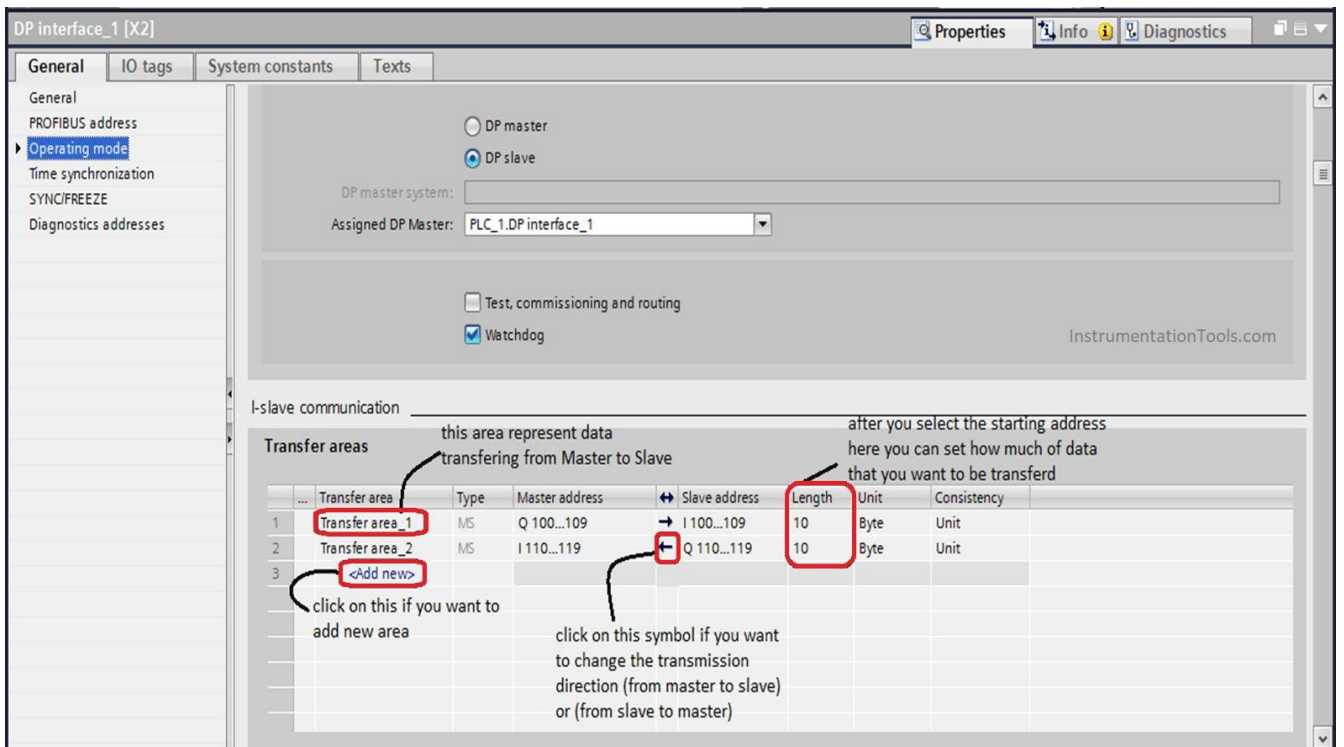


Fig. 15.6 Step 4 of Profibus Configuration

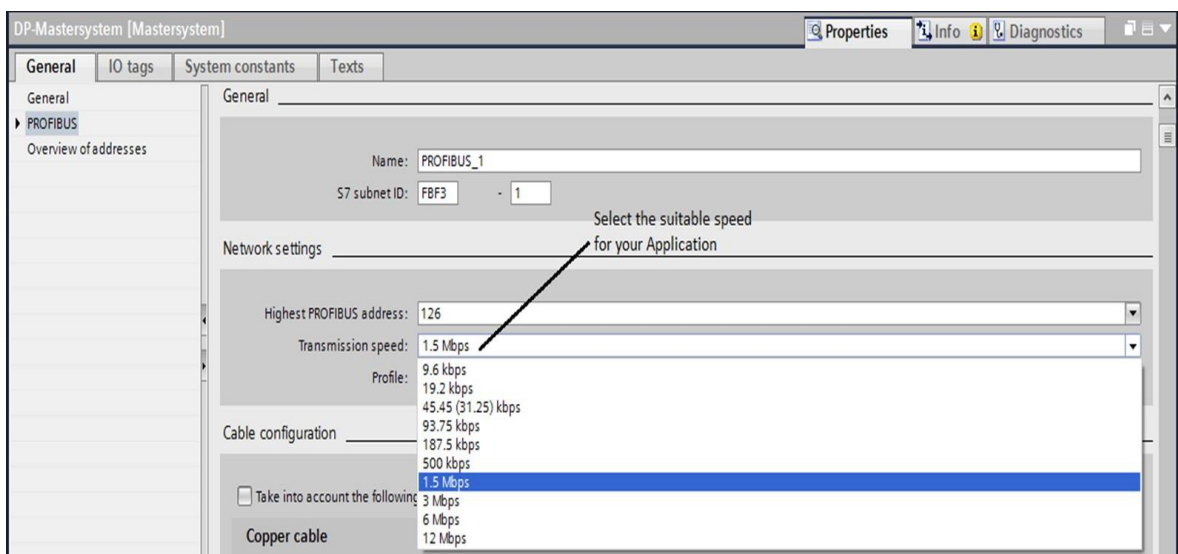


Fig. 15.7 Step 5 of Profibus Configuration

➤ Steps to configure a PROFINET network

- 1) Open TIA PORTAL. Click on “project view”.

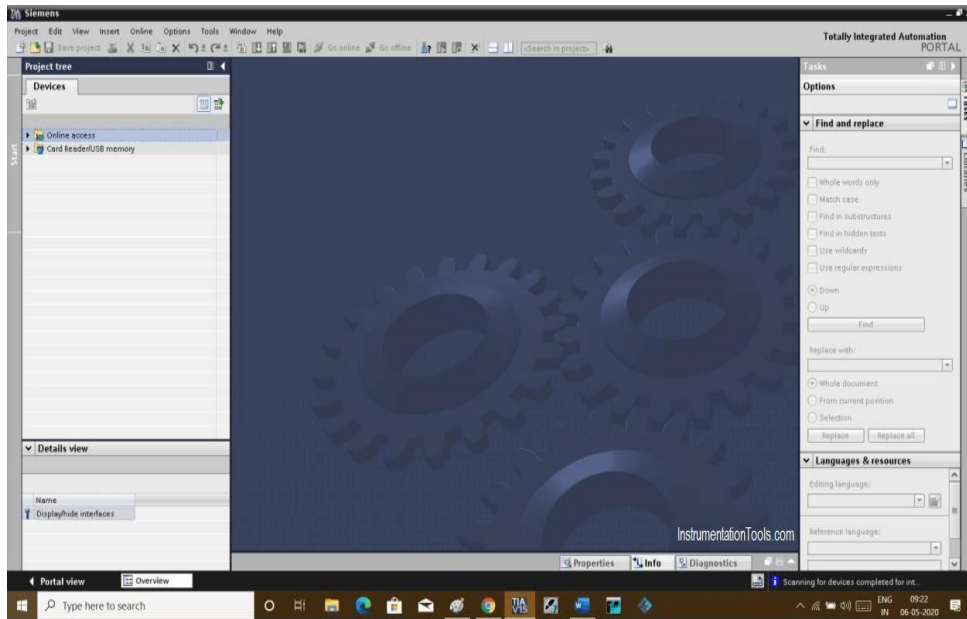


Fig. 15.8 Step 1 of Profinet Configuration

2) The following window will pop up. Expand “online access”.

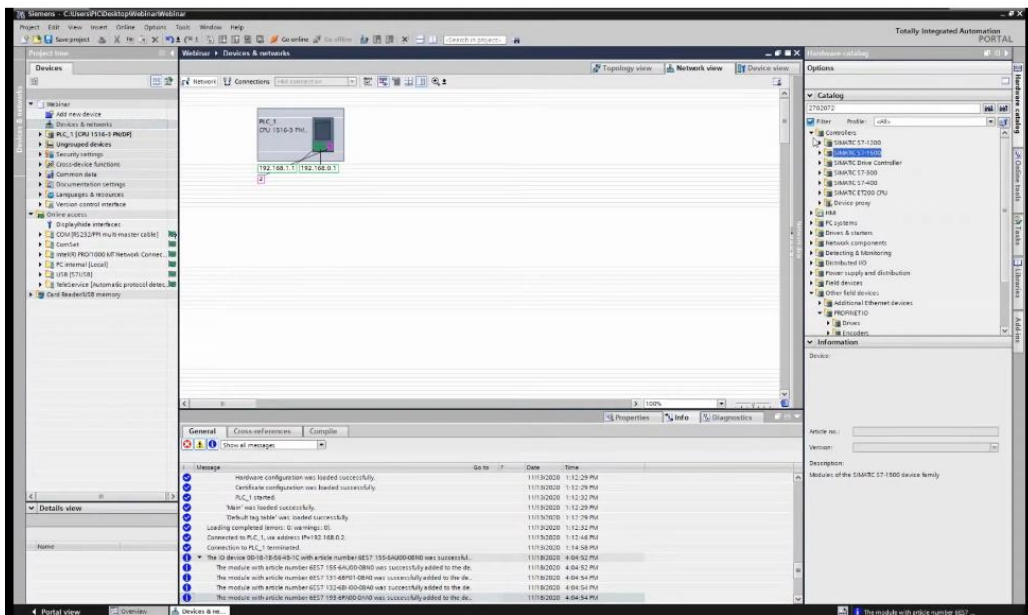


Fig. 15.9 Step 2 of Profinet Configuration

3) In online access, you can find an option written “intel”, expand it. Double click on “update accessible devices”. After a few seconds “accessible devices” will appear.

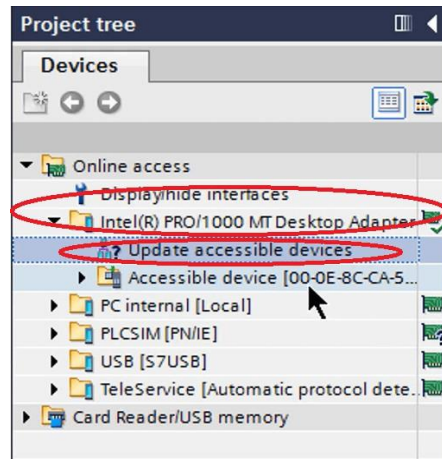


Fig. 15.10 Step 3 of Profinet Configuration

- 4) Clicking on accessible devices will open up the following window. Here Expand “function”.
 Click on IP address to assign an IP address. Click on “Assign IP address” to finish the procedure.

XI. Resources used during performance

Table 15.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.

XIII. Observation Table

Table 15.3

Sr. No.	Observations	Remark
1	Type of connecting port used for Profibus	
2	Number of connecting terminals in Profibus cable	
3	Type of connecting port used for	

XVIII. Suggested references for further reading

Table 15.4

Sr. No.	Link / Portal / VLab	Description
1	http://kcl.digimat.in/nptel/courses/video/108105088/lec29.pdf	Communication protocol used in PLC
2	solisplc.com/tutorials/an-introduction-to-the-graph-language-in-tia-portal-sequential-function-chart.	
3	Instrumentation.com	

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Correct C program logic for Hamming Code	10%
2	Successful compilation and execution in Turbo C	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Correct generation of encoded bits	10%
2	Error detection verification	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	

Practical No.16: Develop SCADA graphic screen and integrate with PLC to perform the sequential ON-OFF control of Lamps/motors

I. Practical Significance

Integrating a SCADA graphic screen with a PLC for sequential ON-OFF control of lamps or motors provides a powerful solution for industrial automation by enabling real-time monitoring, control, and visualization of processes from a central interface, which enhances operational efficiency, reduces downtime, supports predictive maintenance, and improves safety by minimizing manual interventions and optimizing equipment performance through reliable, automated sequencing.

II. Industry/Employer Expected Outcome

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences: "Maintain Automation systems."

III. Course Level Learning Outcome

- CO-5 Use the relevant communication protocol for specific automation system.

IV. Laboratory Learning Outcome

LLO 16.1 Develop SCADA graphic screen integrate it with PLC to perform the sequential ON-OFF control of Lamps/motors

V. Relevant Affective domain related Outcomes

- Develop a positive attitude toward the adoption and use of automation technology.
- Cultivate responsibility and discipline in monitoring and controlling industrial processes.
- Enhance teamwork and communication skills through collaborative problem-solving.
- Build confidence in operating and troubleshooting advanced control systems

VI. Relevant Theoretical Background

- SCADA (Supervisory Control and Data Acquisition) consists of both software and hardware elements working together to oversee and manage industrial operations.
- These systems are used to supervise and control extensive industrial activities such as power generation, water treatment, and manufacturing.
- SCADA provides significant oversight, collects data, and performs analysis, enabling operators to monitor device and process conditions, detect anomalies, and make informed decisions.
- Over time, SCADA systems have evolved to include enhanced features like remote access, advanced data analytics, and integration with enterprise systems.

➤ SCADA Components

- Sensors and Actuators: Sensors are devices that collect real-time data from the physical environment. They measure parameters such as temperature, pressure, level, and more. Actuators, on the other hand, are devices responsible for initiating actions based on control

commands. Sensors provide essential input data to SCADA for monitoring, while actuators execute control actions to influence processes.

- **SCADA Field Controllers: Remote Terminal Units (RTUs) and Programmable Logic Controllers (PLCs)** are field devices that collect data from sensors and control actuators in the industrial process. They communicate with the SCADA system to transmit data and receive control commands.
- **SCADA Master Station (or SCADA Server):** The SCADA Master Station is the central component of the SCADA system, responsible for data acquisition, processing, and control. It communicates with RTUs or PLCs to collect data, processes the data to generate meaningful information, and sends control commands to the field devices.
- **Human-Machine Interface (HMI):** The HMI is the graphical interface that allows operators to interact with the SCADA system. It displays real-time data, historical trends, and alarms, enabling operators to monitor the status of the industrial process and make informed decisions. HMIs can be standalone devices or software applications running on computer systems or mobile devices.
- **Communication Network:** The communication network connects the SCADA Master Station with the field devices (RTUs or PLCs) and the HMI. It can be based on various communication technologies, such as wired or wireless networks, and use different
- communication protocols, such as Modbus, Profibus, or Ethernet/IP. Communication protocols such as Modbus, DNP3, and OPC facilitate seamless data exchange.
- **Historian (or Data Storage):** The historian is a database that stores historical data collected by the SCADA system. It allows operators and engineers to analyze trends, perform diagnostics, and generate reports for decision-making and process optimization.
- **Alarm and Event Management System:** The alarm and event management system is responsible for detecting and managing alarms and events in the SCADA system. It monitors the incoming data for anomalies, generates alarms when predefined conditions are met, and logs events for further analysis and troubleshooting.

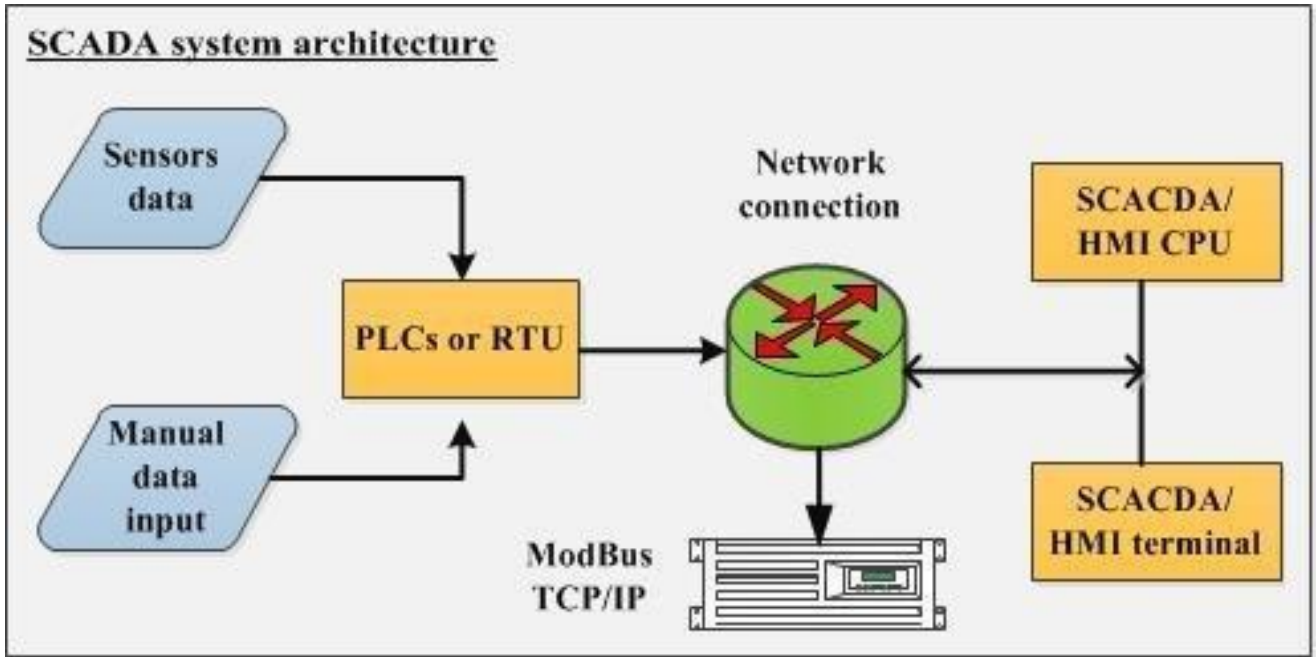
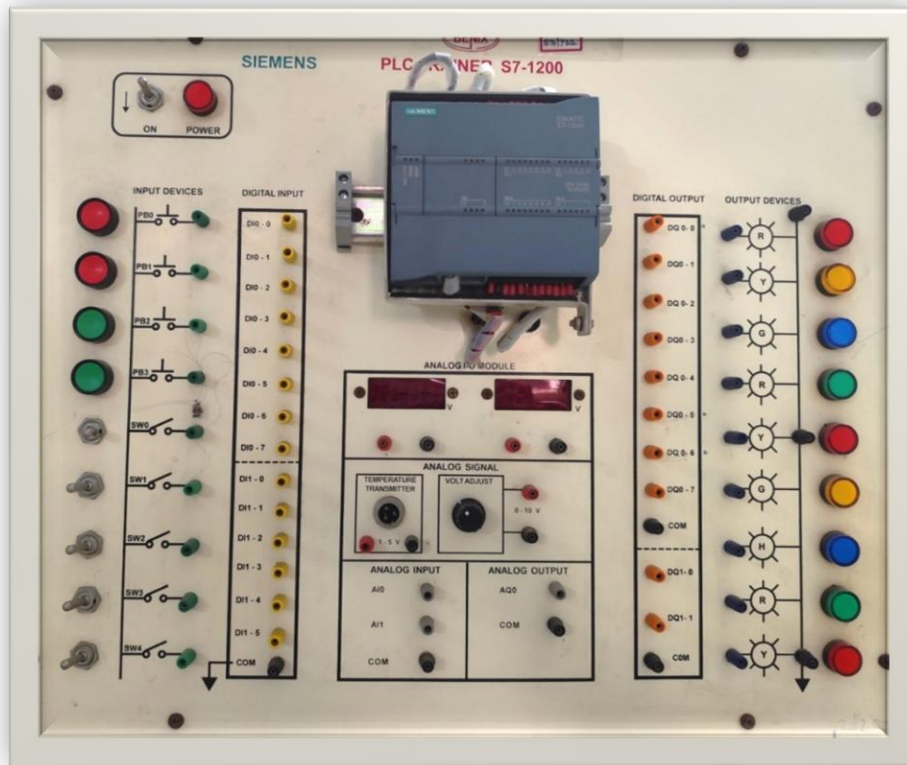


Fig. 16.1 SCADA Connection

VII. Circuit diagram / block diagram / flowchart

A. Suggestive Block Diagram



B. Actual Block Diagram (If required attach separate page)**VIII. Required Resources/apparatus/equipment with specifications**

Table 16.1

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Programmable logic controller	CPU : 1214C DC/DC/DC (6ES7 214-1AG31-OXBO) Digital input : 12 nos. with toggle switches for applying 24V dc inputs. Digital Outputs : 12 Nos with 24V operated Lamp. Analog Inputs : 02 Analog Outputs : 02 External Power Supply : 24 V DC. Memory : 16 K data memory +351K Code Memory +96K upload Memory.	1
2	Computer /Laptop	Computer or laptop with pre-installed PLC software	1
3	Push to ON Switch (ON/OFF)	Operating Voltage : 24 V , Current Rating : 15-50 mA	1
4	HMI Screen	Human Machine Interface Screen with size 7 inch	1
5	Profinet components	Network switch , network (LAN) cables, network connectors	1
6	Start push button Stop push button	Push to ON switch and Push to Off switch	1
7	Output device	Three Lamp or Motor.	3 each

IX. Precautions to be followed

1. Do not short-circuit the input or output terminals.
2. Do not connect high-power loads (motors) directly to the PLC without relay/contacter.
3. Connect input devices (switches, sensors) and output devices (lamps, motor) only to their designated terminals.

X. Suggested Procedure

1. Define the Control Logic: Plan the sequential ON-OFF control sequence for lamps/motors and write the ladder logic program for the PLC accordingly.
2. PLC Programming: Use PLC programming software to implement the control logic. Assign input/output addresses to control the lamps or motors.

3. **Configure Communication:** Establish communication between the PLC and SCADA system using appropriate industrial protocols (e.g., Modbus, Profibus, or OPC).
4. **SCADA Graphic Development:** Open SCADA software's graphic design tool and create screens. Add graphical elements representing lamps/motors and controls (e.g., push buttons, indicators).
5. **Tag Configuration:** Add and link SCADA tags to the PLC's input/output addresses to monitor and control the real-time status of lamps/motors.
6. **Add Control Elements:** Implement interactive buttons and switches on the graphic screen to toggle lamps/motors sequentially as per PLC logic.
7. **Testing & Simulation:** Test the system in simulation mode to verify correct sequential control operation of lamps/motors and adjust the SCADA graphics and logic if needed.
8. **Deploy & Monitor:** Deploy the integrated system on real hardware, monitor real-time operation through the SCADA screen, and troubleshoot as required.
9. **Add Alarms & Data Logging (Optional):** Enhance SCADA screen with alarms for abnormal conditions and log operational data for future analysis.

XI. Resources used during performance

Table 16.2

Sr. No.	Name of Resource	Specifications	Quantity

XII. Actual Procedure (If required attach separate page)

- 1.
- 2.
- 3.
- 4.
- 5.

XIII. Observation Table

Table 16.3

Sr. No.	Observation	Remark
1	Industrial protocol used for communication	
2	SCADA graphic software used	
3	Control elements used specify with their address	

XIV. Results

.....
.....

XV. Interpretation of results

.....
.....

XVI. Conclusions and Recommendations

.....
.....

XVII. Practical Related Questions:

Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.

- 1) Describe interfacing steps of SCADA with PLC.
- 2) List practical significance of Modbus RTU and Modbus TCP/IP.

[Space for Answers] (If required attach separate page)

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

XVIII. Suggested references for further reading

Table 16.4

Sr. No.	Link / Portal / VLab	Description
1	Instrumentation.com	Virtual Lab experiment link

XIX. Assessment Scheme

Performance Indicators		Weightage
Process Related : 15 Marks		60%
1	Successful installation of Packet Tracer	10%
2	Identification of Packet Tracer Simulator components	20%
3	Following procedure and maintaining lab discipline	20%
4	Working in teams	10%
Product Related: 10 Marks		40%
1	Create a simple network topology	10%
2	Demonstrate device configuration and connections	05%
3	Conclusion	05%
4	Answer to sample questions	15%
5	Submitting the journal in time	05%
Total (25 Marks)		100 %

Marks Obtained			Dated Sign of Teacher
Process Related (15)	Product Related (10)	Total (25)	