SCHEME :K

Name :___________________________
Roll No.:________ Year : 20 ___ 20 __
Exam Seat No. :____________________

LABORATORY MANUAL FOR
INDUSTRIAL AUTOMATION (316329)

ELECTRICAL ENGINEERING GROUP

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

Maharashtra State
Board of Technical Education, Mumbai

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 challenging technological & 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 programmes

CORE VALUES:

MSBTE believes in the following:

- 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 Practical Manual
for

INDUSTRIAL AUTOMATION (316329)

Semester– (VI)

(Diploma in Electrical Engineering)

Maharashtra State Board of Technical Education, Mumbai

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

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

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

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MAHARASHTRA STATE

BOARD OF TECHNICAL EDUCATION

This is to certify that Mr. / Ms. ………………………………………….. Roll No. ……… of Sixth Semester of Diploma in Electrical Engineering of Institute ………………………………………………………………… ……..………. (Code ………………..) has completed the term work satisfactorily in course **Industrial Automation (316329)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……………….   Enrollment No……………………

Date: …....................   Exam Seat No. …………………......

Course Teacher   **Head of the Department**   **Principal**

Seal of the Institute

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 National Education Policy 2020 (NEP2020) and outcome-based education as the focus and accordingly, 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 to realize that every minute of the laboratory time need 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 'I' scheme laboratory manual development team designed the practical to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practical 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 pre-determined 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 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.

Now a day, automation is integral part of industries. It is useful to reduce cost and increase productivity as well as quality of the product. PLC and SCADA serves as mains elements of automation due to their flexibility and user-friendly operation.

The Practical manual development team wishes to thank MSBTE who took initiative in the development of curriculum and implementation and acknowledge the contribution of individual course experts who have been involved in laboratory manual as well as curriculum development (K scheme) directly or indirectly.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

Lab Manual Development Team

Program Outcomes (POs) to be achieved through Practical of this Course

Following POs are expected to be achieved through the practicals of the (Basic Electrical Engineering) course.

PO1. Basic and Discipline specific knowledge: Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the electrical engineering problems.

PO2. Problem analysis: Identify and analyze well-defined electrical engineering problems using codified standard methods.

PO3. Design/ development of solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs in Electrical engineering.

PO4. Engineering Tools, Experimentation and Testing: Apply modern electrical engineering tools and appropriate technique to conduct standard tests and measurements.

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

PO6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities in diverse and multidisciplinary fields.

PO7. Life-long learning: Ability to analyze individual needs and engage in updating in the context of technological changes in electrical engineering.

List of Industry Relevant Skills-

The following industry relevant skills of the competency in ‘Industrial Automation’ used in industrial zone are expected to be developed in you by undertaking the practical of this laboratory manual.

1. Control Panel Wiring and Assembly, reading control wiring diagrams, cable routing, termination, ferruling, and labeling
2. PLC Programming Skills to understand PLC hardware and modules, and develop ladder logic programs.
3. Handling of industrial Sensors (proximity, photoelectric, limit, and temperature sensors) and Actuators (solenoids, motors, relays, contactors).
4. Interfacing PLC with SCADA/HMI
5. Industrial Safety Skills as Electrical safety and safe working practices, following safety standards, use of emergency stop, latching etc.
6. Understand working of DCS.

Practical- Course Outcome matrix

Course Outcomes (COs)

1. Develop control and power circuits for the given application.
2. Apply the fundamentals of PLC for effective operation.
3. Apply the basics of PLC programming for a given application.
4. Test ladder logic programs for given industrial applications.
5. Familiarize the SCADA and DCS architecture for process control and data acquisition from the field.

Sr. No.	Laboratory Practical Titles	CO 1	CO 2	CO 3	CO 4	CO 5
1	* Identification of symbols used in industrial control diagrams.	√	-	-	-	-
2	Simulation of a simple seal-in circuit using PLC simulator	-	-	-	√	-
3	Testing of the ladder logic program for basic logic gates operations	-	√	-	-	-
4	PLC program to create a delay using a given timer function	-	-	√	-	-
5	Ladder logic program for STAR- DELTA staring of a 3ph. Induction motor	-	-	√	-	-
6	* Reversal of Direction of rotation of 3ph. Induction motor with the help of PLC.	-	-	-	√	-
7	Control of the direction of rotation of a given stepper motor.	-	-	-	√	-
8	* Control of Temperature with the help of PLC	-	-	-	√	-
9	* Simulating traffic light control with the help of PLC	-	-	-	√	-
10	Ladder logic for blinking of a lamp	-	-	√	-	-
11	*Implementation of Logic gates using PLC using Virtual Lab	-	-	√	-	-
12	*Ladder logic for automatic bottle filling plant using virtual lab	-	-	-	√	-
13	* Automatic water tank level control system using PLC	-	-	-	√	-
14	Identification of various components in library/ Wizard and properties of SCADA software	-	-	-	-	√
15	* Identification of hardware and software platform for DCS using virtual lab	-	-	-	-	√

Guidelines to Teachers

1. ***Teacher need to ensure that a dated log book*** for the whole semester, apart from the laboratory manual is maintained by every student which she/he has to ***submit for assessment to the teacher*** in the next practical session.
2. There will be two sheets of blank pages after every practical for the student to report other matters (if any), which is not mentioned in the printed practical.
3. For difficult practical if required, teacher could provide the demonstration of the practical emphasizing of the skills, which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. One or two questions ought to be added in each practical for different batches. For this teacher can maintain various practical related question banks for each course.
7. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
8. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read the complete write-up of that practical sheet.
9. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.
10. Teacher ought to assess the performance of students continuously according to the MSBTE guidelines

Instructions for Students

1. For incidental, writing on the day of each practical session every student should maintain a ***dated logbook*** for the whole semester, apart from this laboratory manual, which she/he has to ***submit for assessment to the teacher*** in the next practical session.
2. For effective implementation and attainment of practical outcomes, in the beginning of each practical itself, students need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
3. Student ought to refer the data books, software instructions, Safety norms, Technical Manuals and specifications of devices used, etc.
4. Student should not hesitate to ask any difficulties they face during the conduct of practical.

Content Page

List of Practical and Progressive Assessment Sheet

S. No.	Laboratory Practical Titles	Page No.	Date of performance	Date of submission	FA- PR marks (25)	Dated sign. of teacher	Remarks (if any)
15	* Identification of hardware and software platform for DCS using virtual lab	101					
Total							

Note: To be transferred to Proforma of CIAAN-2023.

- **A suggestive list of LLOs is given in the above table.**
- **More such LLOs can be added to attain the COs and competency.**

A judicial mix of minimum 12 or more practical need to be performed, out of which, the practical marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.

Practical No. 1
Identification of symbols used in industrial control diagrams

I. Practical Significance

Industrial control diagrams are the universal language for designing, building, troubleshooting, and maintaining automation systems. Knowledge of these symbols allows technicians and engineers to:

- Read and interpret PLC ladder diagrams, relay logic, motor control circuits, and safety interlocks.
- Communicate designs effectively across teams and vendors.
- Reduce downtime through accurate fault diagnosis and repair.

It bridges theoretical knowledge with practical applications in electrical engineering.

II. Industry/Employer Expected Outcome (s)

To interpret and create control diagrams, ensuring safe and efficient operation of industrial systems, reducing downtime, and improving productivity.

III. Course Level Learning Outcome (CO)

CO1: Develop control and power circuits for the given application.

IV. Laboratory Learning Outcome(s)

LLO 1.1. Interpret different symbols used in a given industrial control diagram.

V. Relative Affective Domain related Outcome(s)

- To interpret and create control diagrams.

VI. Minimum Theoretical Background with diagram (if required):

Industrial control system (ICS) diagram is kind of diagram which are typically used in industries such as electrical, water, oil, gas and data. Based on data received from remote stations, automated or operator-driven supervisory commands to remote station control devices can be gained via the ICS diagram. With the coming of age of process control via diagram software, industry has an opportunity to reap significant financial advantage from applying the latest systems in this field. Cost effectiveness, flexibility, total capability and reliability have now advanced to the stage where industry need no longer hesitate on the grounds of poor performance in these areas.

Also different types of control devices are used. These devices work as sensors to identify the condition occurred in the process and they give feedback to the processor, according to which processor runs the program and necessary output is generated.

Symbols of some of the control devices are shown as follow.

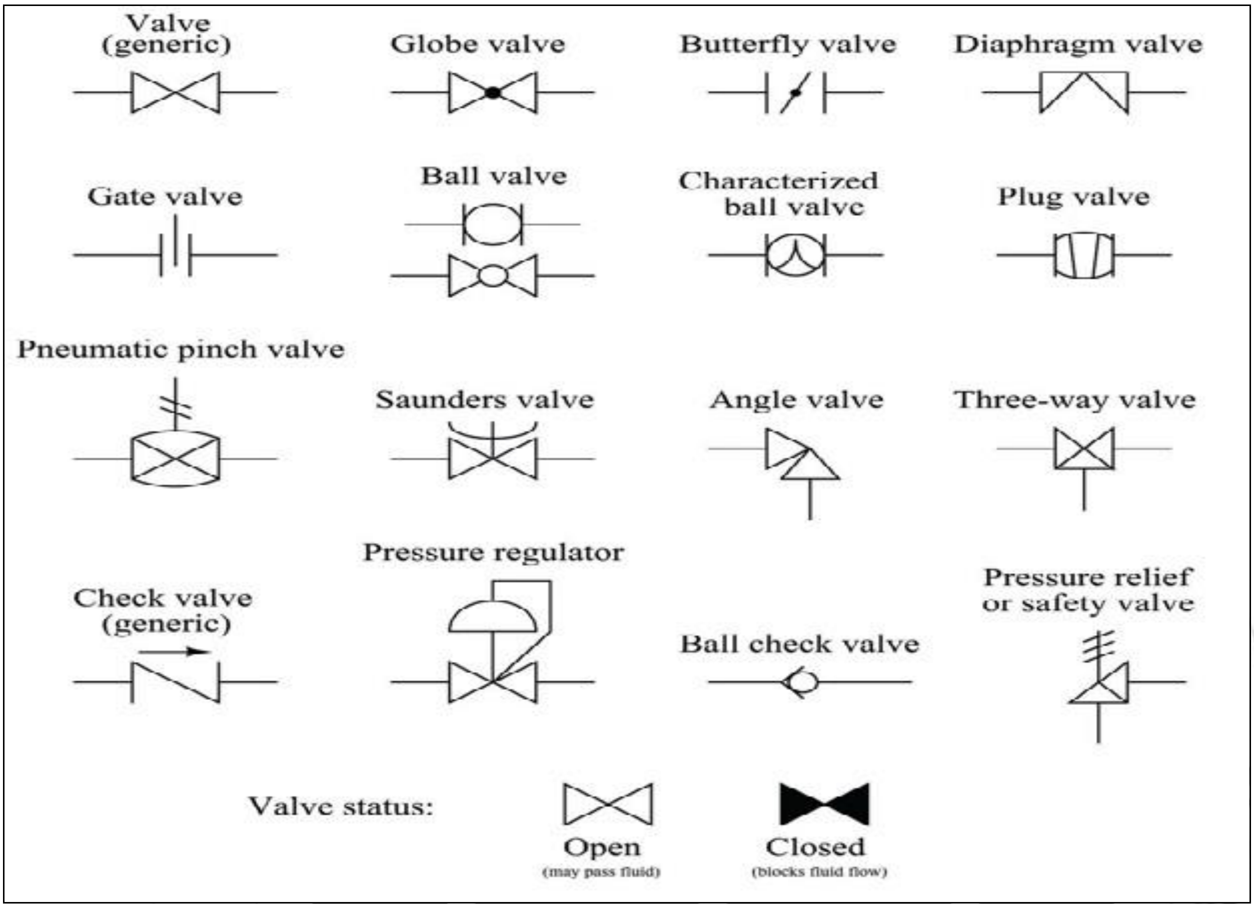

Fig. 1.1: Symbols of Process type valves used in control diagram

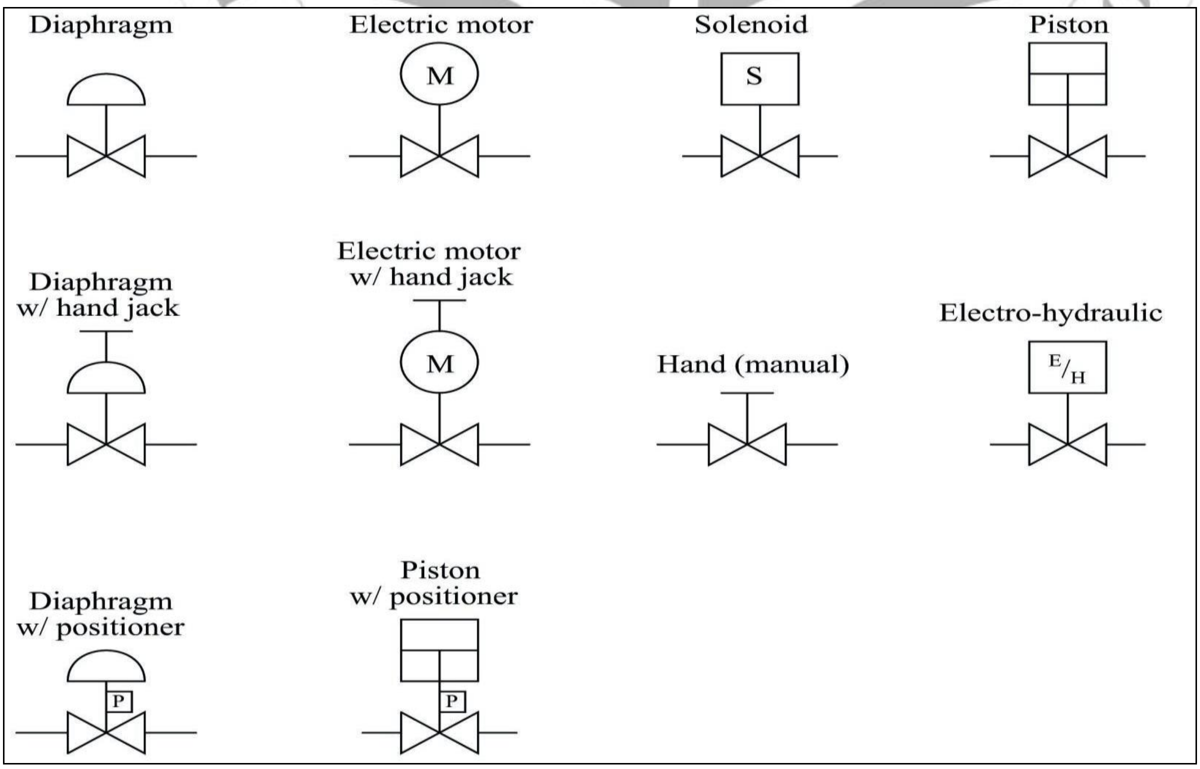

Fig. 1.2: Symbols of Valve type actuator used in control diagram

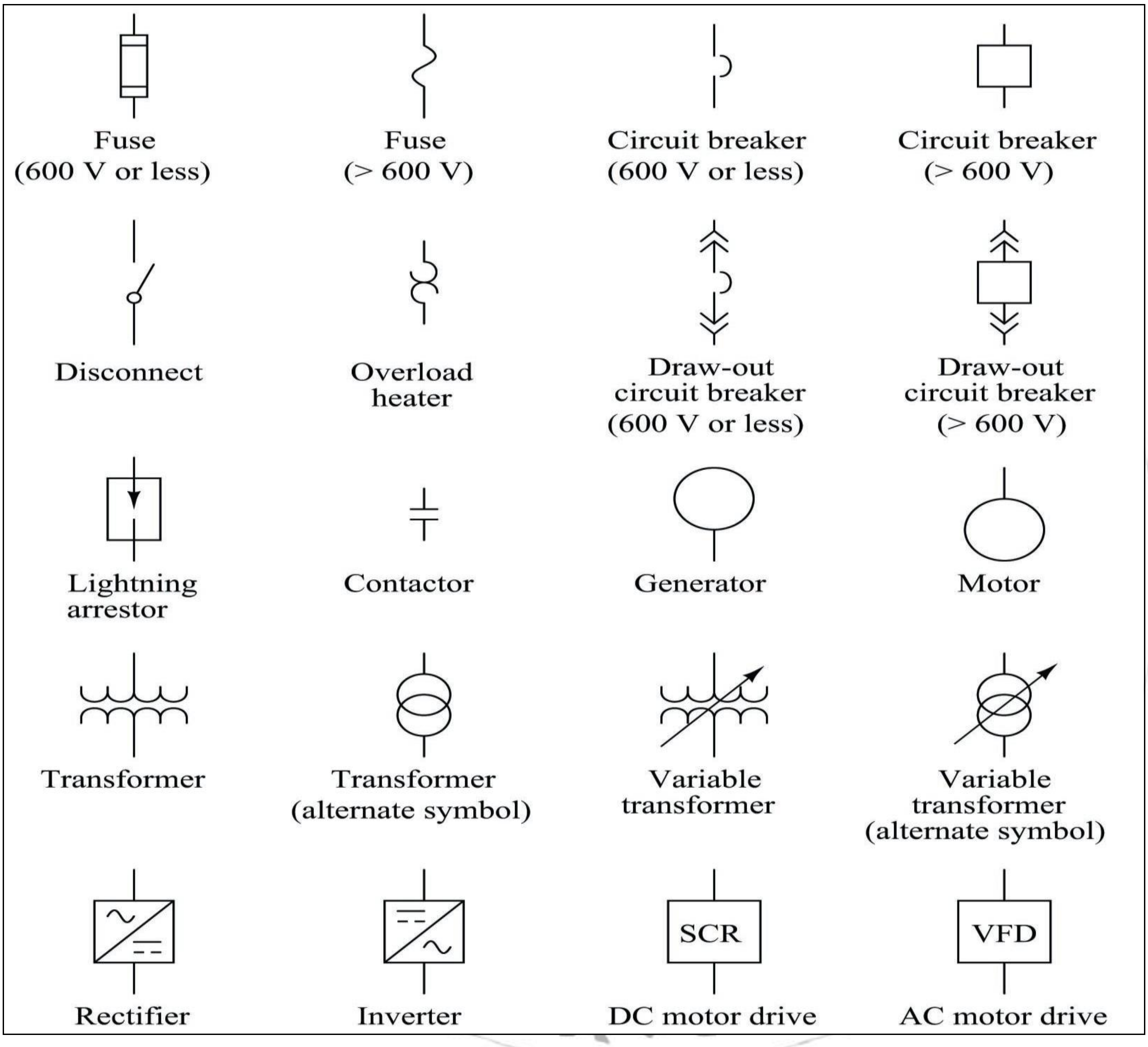

Fig 1.3: Single-line electrical diagram symbols

VII. Experimental setup

- Students will use a computer with diagramming software to create the diagrams.

VIII. Required Resources /Apparatus/Equipment with specification

Equipment	Quantity
Push buttons	4 Nos.
indicating lamps	4 Nos.
float switch,	4 Nos.
Selector Switch	4 Nos.
Limit switch	4 Nos.

proximity switch (Capacitive, Inductive, Magnetic)	4 Nos.
Pressure switch (Danfoss KP36 or equivalent)	4 Nos.
Flow Sensors	4 Nos.
Proximity Sensors	4 Nos.
LVDT Sensors	4 Nos.
Optical Sensors	4 Nos.
Temperature Sensors	4 Nos.
Pressure Sensor	4 Nos.
Piezoelectric Sensors	4 Nos.
Photoelectric Sensors	4 Nos.
Inductive Sensors	4 Nos.
Capacitive Sensors	4 Nos.
Ultrasonic Sensors	4 Nos.
DIN rail mounted AC contactor (3 power pole with 1 NO & 1 NC contact)	1 No.

IX. Precautions to be Followed

- Use proper symbols.
- Maintain clarity and readability in the diagram for effective implementation.

X. Procedure

1. Review the theoretical background on control symbols.
2. Draw a simple control circuit for a given application, e.g. a motor starter circuit.
3. Label all symbols appropriately.

XI. Observations and Calculations

- Observe if the diagram correctly represents the circuit.
- No calculations needed, but perhaps verify the number of components.

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

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

1. State the significance of symbols used for control diagram.
2. Draw any six symbols used to draw control diagrams.
3. State the importance of drawing control diagrams in industrial automation.

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. Eswar, U.S., Handbook of Electrical Motor Control Systems, McGraw Hill Education, New Delhi, 2013, ISBN : 978-0074601112
2. https://eleccircs.com/system-diagram-symbols

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1.	Handling the components	10%
2	Drawing Ladder Diagrams	20%
3	Observing Outputs	20%
4	Working in a Team	10%
	Product Related (10 Marks)	**(40%)**
1	Interpretation of Results	10%
2	Conclusions	10%
3.	Solving product related questions	10%
4.	Timely submission of journal	10%
	Total	**100 %**

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

Practical No. 2

Simulation of a simple seal-in circuit using PLC simulator.

I. Practical Significance

Seal-in or latching circuits are fundamental in industrial automation and motor control systems. They are used to maintain a device's ON condition, even after the initiating input has been released. Understanding this logic through PLC simulation helps the students to bridge the knowledge between conventional relay logic and modern PLC-based automation. This experiment demonstrates how industrial conventional start/stop control circuits are implemented using ladder logic.

II. Industry/Employer Expected Outcome (s)

- To program and simulate standard industrial logic functions such as latching, interlocking, and sequencing.
- To assign and interpret PLC I/O addressing.

III. Course Level Learning Outcome (CO)

CO4 - Test ladder logic programs for given industrial applications.

IV. Laboratory Learning Outcome(s)

LLO 2.1 Simulate a simple seal-in circuit using PLC simulator.
LLO 2.2 Addressing of Input and output devices

V. Relative Affective Domain related Outcome(s)

To create programs and simulate standard industrial logic functions with proper addressing.

VI. Minimum Theoretical Background with diagram (if required)

A seal-in (also called holding) circuit uses an auxiliary contact of the output (or an internal memory bit) wired in parallel with the start input so that once the output energizes, the auxiliary contact keeps the coil energized though the start button is released.

How it works — summary

1. Operator presses START (a normally open push button) → ladder rung becomes true → coil (OUT) energizes.
2. An auxiliary contact associated with that coil (wired in parallel with START) closes and keeps the rung true when START is released.
3. Pressing STOP (a normally closed push button) opens the rung and de-energizes the coil, breaking the seal-in.

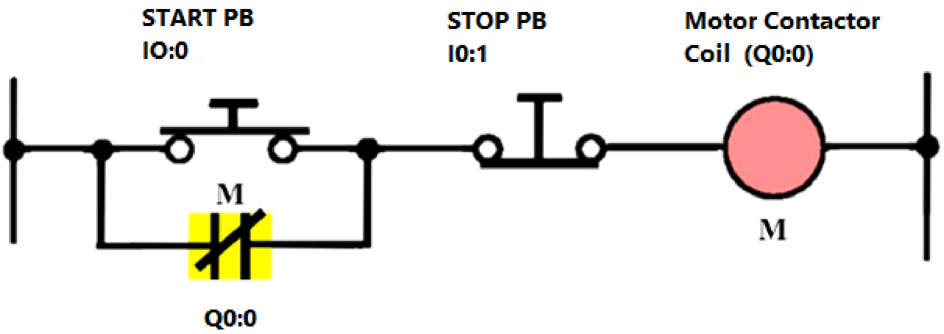

Fig. 2.1 Seal in circuit ladder diagram

Explanation:
- I:Start = normally open start pushbutton (I0.0)
- / I:Stop = normally closed stop pushbutton (I0.1) shown as a break contact
- I:AuxContact = auxiliary (seal) contact (can be internal memory or physical contact of Q0.0)
- Q:Motor = output coil controlling motor/contactors (Q0.0)

PLC Addressing Example

- Start push button: I0.0
- Stop push button: I0.1 (NC contact in ladder)
- Motor output (coil): Q0.0
- Auxiliary contact: can be represented by Q0.0 contact in ladder logic (i.e., the same output used as contact to seal-in) or by an internal bit M0.0.

VII. Experimental setup

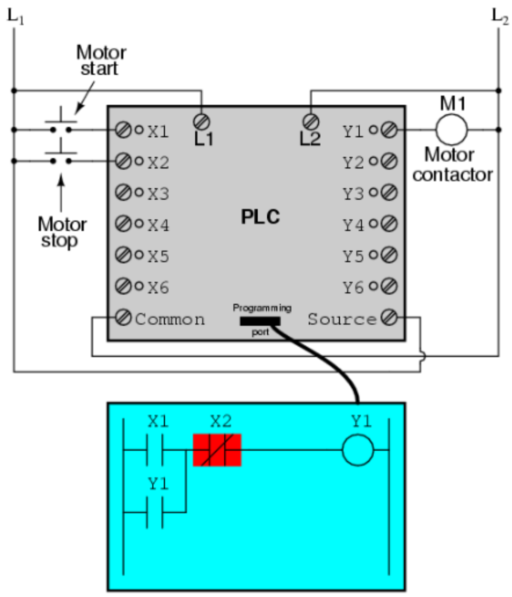

Fig. 2.2: Motor Start-Stop Control Circuit

VIII. Required Resources /Apparatus/Equipment with specification

Equipment	Specification
PC / Laptop	Windows 10/11 or Linux — minimum 4 GB RAM, recommended 8 GB, 2 GHz+ CPU
PLC Simulator Software	Any ladder-logic simulator suitable for teaching (Siemens LOGO!/S7 simulator, RSLogix Emulate, OpenPLC Editor + runtime, or other). Ensure it supports virtual I/O and run/monitor modes
Virtual I/O Panel / HMI (optional)	For nicer visualization of lamps/LEDs and pushbuttons.
Projector / Whiteboard	For instructor demonstration.
USB/Network (if using external runtime)	To transfer project to runtime if required

IX. Precautions to be Followed

1. Always run the simulator in **monitor/simulate** mode; do not attempt to connect to live hardware without instructor permission.
2. Confirm all virtual I/O addresses are proper before running the program. Incorrect addresses may give incorrect behavior or may cause accidents.
3. When using shared lab machines, save project files with proper filenames (roll number/name/batch etc.).
4. Do not attempt to bypass interlocks or safety stops in the program; always demonstrate STOP functionality.

X. Procedure

1. Project setup

- Start the PLC simulator and create a new project. Select a basic PLC model (with at least 4 inputs and 4 outputs).
- Create the I/O mapping: I0.0 = Start (NO), I0.1 = Stop (NC), Q0.0 = Motor Output (lamp).

2. Draw ladder rung

- Insert a rung with STOP (normally closed) in series with a parallel network of START (NO) and a contact representing Q0.0 (seal contact). Place the coil Q0.0 at the end of the rung.

3. Label items and document addresses

- Add textual labels: Start, Stop, Motor, Seal contact. Fill in an I/O table in the project notes.

4. **Simulate and test**
   - Switch the PLC to RUN or SIMULATE mode.
   - Press START: observe Q0.0 energize; after release of START, Q0.0 should remain ON because the auxiliary contact is closed.
   - Press STOP: observe Q0.0 de-energize.
   - Repeat several times and try pressing STOP while pressing START (to confirm proper NC contact behavior).
5. **Test variants**
   - Replace the auxiliary contact produced from Q0.0 with an internal memory bit M0.0 and modify logic accordingly — test again.
   - Add an interlock (e.g., another NC safety input) in series and show how it prevents sealing.
6. **Document run logs**
   - Record I/O states (time stamps if available), and take screenshots of the ladder in RUN mode for the lab report.

X. Observations and Calculations

Trial	Action	I0.0 (Start)	I0.1 (Stop)	Q0.0 (Motor)	Expected behavior	Remarks
1	Press Start					
2	Release Start					
3	Press Stop					

XI. Results

XVIII. Interpretation of Results

XIX. Conclusions and Recommendation

XX. Practical Related Questions

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

1. State the significance seal-in circuit.
2. List three test cases (input sequences) you will use to verify correct seal-in operation
3. Explain why the auxiliary contact of the output is placed in parallel with the Start pushbutton — what would happen if it were placed in series?

[Space for Answer]

References / Suggestions for Further Reading

1. Madhuchhanda Mitra, Samarjt Sengupta, Programmable Logic Controllers and Industrial Automation: An Introduction, Penram International Publication , New Delhi,2017, ISBN : 978-8187972631
2. https://instrumentationtools.com/what-is-seal-in-circuit/
3. https://www.allaboutcircuits.com/textbook/digital/chpt-6/programmable-logic-controllers-plc/

XXI. Rubrics for Assessment Scheme

Performance Indicators		Weight age
Process Related (15 Marks)		**(60%)**
1.	Handling the components	10%
2	Drawing Ladder Diagrams	20%
3	Observing Outputs	20%
4	Working in a Team	10%
Product Related (10 Marks)		**(40%)**
1	Interpretation of Results	10%
2	Conclusions	10%
3.	Solving product related questions	10%
4.	Timely submission of journal	10%
	Total	**100 %**

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

Practical No.3
Testing of the ladder logic program for basic logic gates operations

I. Practical Significance

This experiment introduces students to practical PLC programming and real-world control wiring. Understanding ladder logic implementation of Boolean gates is foundational for more complex control sequences used in automation (e.g., motor interlocks, safety logic, sequence control). Students will learn to map physical inputs/outputs to PLC addresses, create and test ladder rungs, and validate expected truth-table behavior using both software simulation and physical I/O.

II. Industry/Employer Expected Outcome (s)

- Ability to connect PLC hardware to a PC for programming.
- Give correct address and proper connections to inputs and outputs for a small control panel.
- Demonstrate implementation and testing of basic logic functions used in industrial control.

III. Course Level Learning Outcome (CO)

CO2: Apply the fundamentals of PLC for effective operation.

IV. Laboratory Learning Outcome(s)

LLO 3.1 Connect PLC to PC

LLO 3.2 Addressing properly different input and output devices

LLO 3.3 Test the ladder logic programs for basic logic gates operations (AND, OR, XOR, NOR)

V. Relative Affective Domain related Outcome(s):

- Demonstrate careful and safe laboratory practice when handling power and control wiring.
- Collaborate effectively in small teams to design, implement and test logic functions.
- Show attention when documenting wiring, addressing and test results.

VI. Minimum Theoretical Background with diagram (if required):

Boolean Logic & Ladder Logic Mapping

In ladder logic, we will study and verify following logic gates

1. **AND:** Output ON when Input A AND Input B are ON. series contacts simulate AND gate.

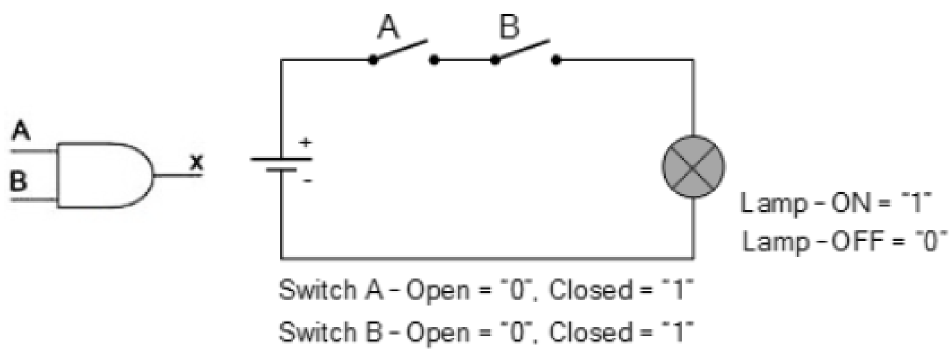

Fig. 3.1: Circuit diagram for AND Gate

Ladder diagram:

1. **OR:** Output ON when Input A OR Input B is ON. Parallel branches simulate OR.

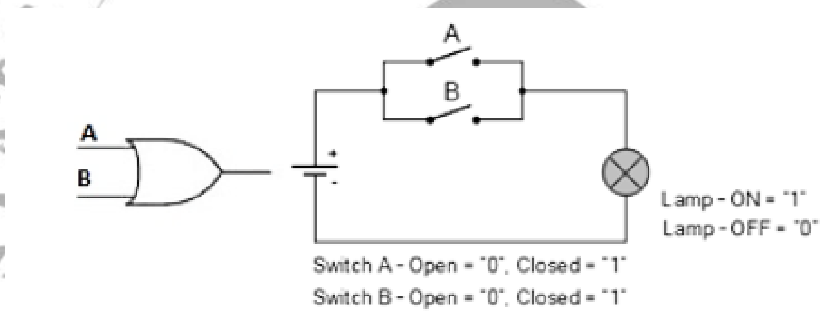

Fig. 3.2: Circuit diagram for OR Gate

Ladder Diagram:

2. **NOR:** Output ON when neither Input A nor Input B is ON (equivalent to NOT(OR)). NOR can be implemented by using a branch with normally-closed contacts or by adding a NOT to the OR result.

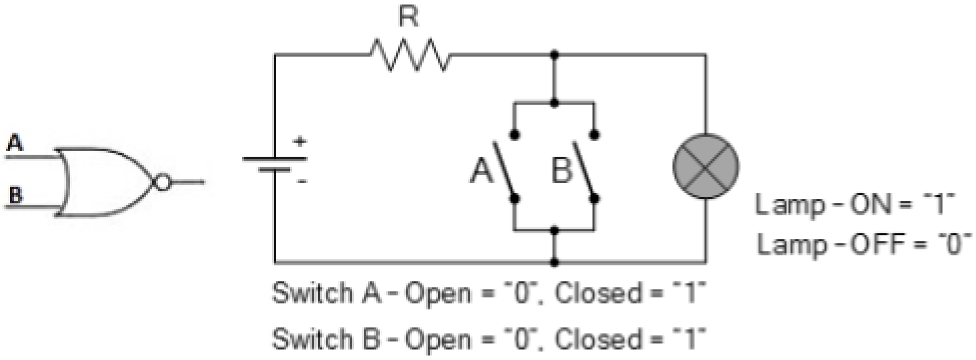

Fig. 3.3: Circuit diagram for NOR Gate

Ladder Diagram:

3. **XOR (Exclusive OR):** Output ON when exactly one of Input A or Input B is ON. XOR can be implemented by combining rungs: (A AND NOT B) OR (NOT A AND B).

   Boolean Diagram: Student should prepare diagram for XOR gate referring above diagrams.

Ladder Diagram:

VII. Experimental setup

1. Small control panel or bench with: two push-buttons (NO), two toggle switches or sensors, and four pilot lamps or LEDs for outputs.
2. PLC unit (compact) with at least 4 digital inputs (DI) and 4 digital outputs (DO) and an available programming port (USB/Ethernet).
3. PC/laptop with PLC programming software installed (e.g., vendor-supplied IDE or generic ladder editor) and the appropriate drivers/cable.
4. 24 V DC power supply for PLC I/O (or as per PLC spec), fused appropriately.
5. Power wiring (proper gauge), control wiring (shielded if required), terminal blocks and jumpers.
6. Multimeter for verification, and an insulated screwdriver set.

Place input devices on the left of the PLC module and outputs on the right; provide an earth/ground reference on the panel.

7. Required Resources /Apparatus/Equipment with specification

PLC (compact)	Minimum 4 DI, 4 DO; programming port (USB/Ethernet); 24 V DC I/O common; example: generic compact PLC or educational trainer module
PC/Laptop	Windows/Linux with PLC IDE installed; USB/Ethernet port
Programming cable	USB-A to PLC or Ethernet cable (as required)
Power Supply	24 V DC, 2 A (or per PLC spec), fused at supply output
Push-buttons	NO push-button, rated 24 V DC, 1 A

Toggle switches / Sensors	SPST 24 V DC rated
Indicator lamps / LEDs	24 V DC pilot lamps or LED modules with series resistors
Terminal blocks	For clean wiring and labelling
Multimeter	DC voltage/current, continuity test
Breadboard / relay module (optional)	For intermediate wiring or simulation
Wires / ferrules / lab tools	Assorted, correctly rated

8. Precautions to be Followed

- Ensure power supply is switched OFF when wiring or changing connections.
- Confirm PLC I/O voltage rating before connecting devices.
- Label all wires and terminals clearly with input/output addresses.
- When programming, ensure the PLC is in **PROGRAM** or **STOP** mode before making major changes; download only after confirming code.
- Record any deviations from the procedure and report faults immediately to the instructor.

9. Procedure

A. Hardware Setup

1. Mount PLC, power supply, terminal blocks and input/output devices on the lab bench.
2. Wire the power supply to the PLC (observe polarity). Fit the fuse in the supply positive line.
3. Wire two input push-buttons to PLC inputs (e.g., I0.0, I0.1). Use one side of push-button to +24 V and the other to the PLC input with common 0 V return according to the PLC wiring convention (sinking/sourcing). Label them "A" and "B".
4. Wire outputs Q0.0 — Q0.3 to the pilot lamps/LEDs via the PLC output terminals (or to relay coils if the PLC has dry contacts). Ensure outputs are rated correctly.
5. Connect the PC to the PLC using the programming cable. Install any required drivers.
6. Power up the PLC and PC. Confirm LED indicators on PLC show normal status.

B. Software & Addressing

1. Open the PLC programming software on the PC.
2. Create a new project and configure the PLC model and I/O map

   I0.0 = Push-button A,

   I0.1 = Push-button B;

   Q0.0 = AND lamp,

Q0.1 = OR lamp,

Q0.2 = XOR lamp,

Q0.3 = NOR lamp).

3. Explain addressing scheme to students and require them to write the address table in their lab book.

C. Ladder Logic Implementation

1. Implement the ladder rungs for each gate:
   - AND: series contacts for I0.0 and I0.1 energise Q0.0.
   - OR: parallel contacts for I0.0 and I0.1 energise Q0.1.
   - XOR: two branches: (I0.0 AND NOT I0.1) OR (NOT I0.0 AND I0.1) energise Q0.2.
   - NOR: use normally-closed contacts or implement NOT and OR to energise Q0.3 when both inputs are OFF.
2. Add comments on each rung describing the function.
3. Compile and download the program to the PLC (or simulate if simulator is used).

D. Testing & Observation

1. Put PLC in RUN mode.
2. For each input combination (00, 01, 10, 11) apply inputs using push-buttons or switches and record lamp status for each output.
3. Fill the truth-table (see Observations section) and compare actual outputs with expected outputs.
4. Introduce one deliberate wiring or logic fault (optional) and ask students to troubleshoot and correct it.

E. Clean up:

1. Power OFF the PLC and isolate the power supply.
2. Return bench to initial condition and store tools safely.

Observations and Calculations

- Observe if the diagram correctly represents the circuit.
- No calculations needed, but perhaps verify the number of components.

A) OR GATE:

Test No.	Input A (I0:0)	Input B (I0:1)	**OR (Q0.0) Expected**	**OR Measured**	Remark

B) AND GATE:

Test No.	Input A (I0:0)	Input B (I0:1)	**AND (Q0.0) Expected**	**AND Measured**	Remark

C) NOR GATE:

Test No.	Input A (I0:0)	Input B (I0:1)	**XOR (Q0.0) Expected**	**XOR Measured**	Remark

D) XOR GATE:

Test No.	Input A (I0:0)	Input B (I0:1)	**NOR (Q0.0) Expected**	**NOR Measured**	Remark

VIII. Results

IX. Interpretation of Results

X. Conclusions and Recommendation

XI. Practical Related Questions

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

1. Explain why series contacts implement AND and parallel branches implement OR in ladder logic.
2. Show how XOR can be implemented using AND/OR/NOT operations in ladder logic.
3. If a PLC uses sinking inputs (NPN) vs sourcing inputs (PNP), how would wiring change? What must be checked before wiring?
4. Discuss advantages of testing logic in simulation first vs direct hardware testing.

[Space for Answer]

XII. References / Suggestions for Further Reading

- Madhuchhanda Mitra, Samarjt Sengupta, Programmable Logic Controllers and Industrial Automation: An Introduction, Penram International Publication, New Delhi,2017, ISBN: 978-8187972631
- https://www.youtube.com/watch?v=_RYrgFtJY8E

Rubrics for Assessment Scheme

Performance Indicators		Weight age
Process Related (15 Marks)		**(60%)**
1.	Handling the components	10%
2	Drawing Ladder Diagrams	20%
3	Observing Outputs	20%
4	Working in a Team	10%
Product Related (10 Marks)		**(40%)**
1	Interpretation of Results	10%
2	Conclusions	10%
3.	Solving product related questions	10%
4.	Timely submission of journal	10%
	Total	**100 %**

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

Practical No.4
PLC Program to Create a Delay Using a Given Timer Function

I. Practical Significance

In industrial automation systems, it is often necessary to introduce a specific delay between the activation of input and output devices to ensure proper sequencing, safety, and synchronization of processes. Using a Programmable Logic Controller (PLC) with timer instructions allows precise and repeatable delay control without mechanical relays or time-delay circuits. This experiment enables students to understand the use of TON (ON Delay Timer) instruction in ladder logic programming for achieving time-based control.

II. Industry/Employer Expected Outcome (s)

- Ability to interpret and develop basic PLC ladder logic programs for process control applications with proper addressing.
- Understanding of how to use timer functions to implement time-based operations in automation systems.

III. Course Level Learning Outcome (CO)

CO3: Apply the basics of PLC programming for a given application.

IV. Laboratory Learning Outcome(s)

LLO 4.1: Draw logic diagram to create 10-second delay after a push button press using timer instruction block.

LLO 4.2:Address properly the input, output devices and timer instruction/ block.

LLO 4.3:Test the ladder logic for proper functioning of the delay operation.

VII. Relative Affective Domain related Outcome(s)

- Demonstrate discipline and accuracy while wiring and programming PLC systems.
- Show responsibility in safely handling electrical equipment.
- Exhibit teamwork and communication skills during experimentation.
- Reflect curiosity and initiative in exploring timer functions beyond the basic ON delay.
- Minimum Theoretical Background with diagram (if required):

VIII. A **Programmable Logic Controller (PLC)** is an industrial digital computer designed for automation of electromechanical processes. It uses **ladder logic programming**, which visually resembles relay logic diagrams.

In practical applications, sometimes we need that when one process is completed, other process should start with some time delay. Previously hardware timer was being used, but PLC has inbuilt virtual timers. Hence by simply modifying program, we can provide and modify time delay. Hence hardware complications get eliminated. There are different types of timers, here we will study with ON DELAY times only.

Timer Function (TON – ON Delay):

The **TON** (Timer ON Delay) instruction is used to delay the activation of an output for a specified time period after the input condition becomes TRUE.

Ladder Diagram:

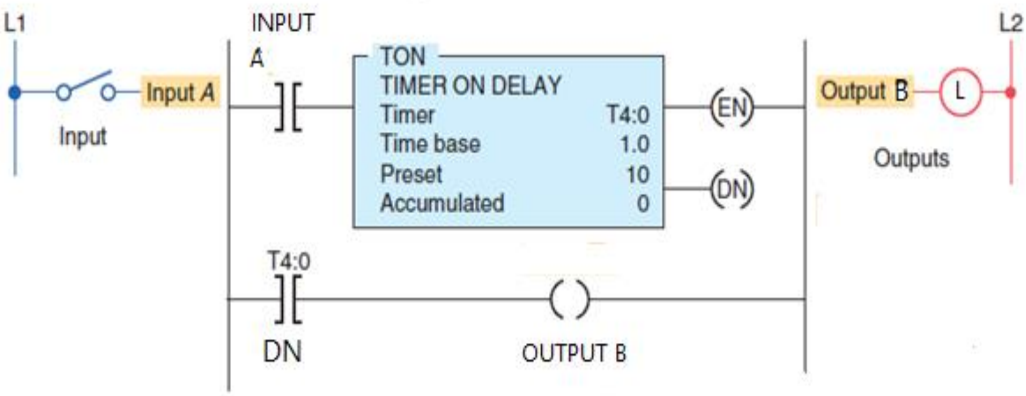

Fig. 4.1: Ladder diagram for Timer ON Delay

Where:

-][– Input push button (Start)
- T4 – Timer identifier
- PT – Preset Time (e.g., 10 seconds)
- Q – Timer done bit (TRUE after 10s)
- (L) – Output (lamp)
- (EN) - Enable Bit
- (DN) - Done Bit

When the **Start push button** is pressed, the timer starts counting. After **10 seconds**, the output (L) turns ON.

IX. Experimental setup

- One PLC trainer kit with I/O modules
- Push button (Start) connected to input

- Indicator lamp (or output device) connected to output
- Power supply for PLC and I/O
- Laptop/PC with PLC programming software (e.g., Siemens TIA Portal, Allen Bradley RSLogix, or Delta WPLSoft)

X. Required Resources /Apparatus/Equipment with specification

Equipment	Specification
PLC Trainer Kit	Siemens S7-1200 / Allen Bradley MicroLogix / Delta DVP series
Programming Cable	USB/RS232 communication cable
PC/Laptop	Minimum 4 GB RAM, PLC software installed
Push Button	NO type, 24V DC
Indicator Lamp	24V DC / 230V AC depending on output
Power Supply	24V DC regulated
Connecting Wires	Standard insulated wires
Multimeter	For voltage and continuity testing

XI. Precautions to be followed:

- Ensure correct wiring of input and output devices before powering the PLC.
- Use only rated voltage and current for connected devices.
- Verify program logic in simulation mode before downloading to PLC.
- Never touch live terminals while testing.
- Save your program before each modification.
- Disconnect power when making hardware changes.

XII. Procedure

1. **Study the PLC trainer kit** and identify input/output terminals.
2. **Connect the hardware:**
3. Connect the push button to **Input I0.0**.

4. Connect the indicator lamp to **Output Q0.0**.
5. **Open the PLC programming software** on the PC.
6. **Create a new project** and configure the PLC type and communication settings.
7. **Write the ladder logic program for 10sec delay**.
8. **Compile** and **download the program** to the PLC.
9. **Test the operation**
10. Press the **Start push button (I0.0)**.
11. Observe that after **10 seconds**, the **lamp (Q0.0)** turns ON.
12. Release the button and note timer reset behavior.
13. **Record observations** in the observation table.
14. **Repeat the procedure 7 to 13 for different time value.**

XIII. Observations and Calculations

- Observe if the diagram correctly represents the circuit.
- No calculations needed, but perhaps verify the number of components.

S. No.	Set Time (s)	Input Condition	Output Status (ON/OFF) Immediately after PB is pressed	Observed Delay (Sec.)	Output Status (ON/OFF)
1	10	Push button pressed		10	
2		Push button pressed			
3		Push button pressed			
4					
5					

XIV. Results

XV. Interpretation of Results

XVI. Conclusions and Recommendation

XVII. Practical Related Questions

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

1. What is the function of an ON delay timer in PLC?
2. What is the difference between TON and TOF timers?
3. Why is PLC preferred over traditional relay-based timing circuits?
4. What happens if the preset time is increased or decreased?
5. What safety precautions must be observed while wiring PLC circuits?
6. How would you modify this logic for a 5-second delay OFF timer? Prepare ladder diagram.

[Space for Answer]

XVIII. References / Suggestions for Further Reading

1. Madhuchhanda Mitra , Samarjt Sengupta, Programmable Logic Controllers and Industrial Automation: An Introduction, Penram International Publication , New Delhi,2017, ISBN : 978-8187972631

2. https://www.youtube.com/watch?v=QbJyuOgFGuA

Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1.	Handling the components	10%
2	Drawing Ladder Diagrams	20%
3	Observing Outputs	20%
4	Working in a Team	10%
	Product Related (10 Marks)	**(40%)**
1	Interpretation of Results	10%
2	Conclusions	10%
3.	Solving product related questions	10%
4.	Timely submission of journal	10%
	Total	**100 %**

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

Practical No.5

Ladder logic program for STAR-DELTA starting of a 3-phase Induction Motor

I. Practical Significance

Starting large 3-phase induction motors direct-on-line produces very high inrush currents and mechanical stress. The star-delta starter reduces inrush current and starting torque by initially connecting stator windings in the star and later switching to delta. This PLC-based experiment teaches sequencing, timers, interlocks, safe switching practice and I/O addressing — essential skills for industrial motor control and plant automation.

II. Industry/Employer Expected Outcome (s)

On completion students will be able to:

- Design and implement PLC ladder logic for controlled motor start sequences with safety interlocks.
- Wire and address PLC digital inputs and outputs correctly for contactor control
- Test and troubleshoot timing/sequencing faults and demonstrate safe commissioning procedures.
- Produce correct control and power wiring diagrams used in industry.

III. Course Level Learning Outcome (CO)

CO3 - Apply the basics of PLC programming for a given application.

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IV. Laboratory Learning Outcome(s)

LO 5.1 Draw ladder logic diagram for connecting a star-delta starter to a 3-phase induction motor.

LLO 5.2 Address properly the input / output devices.

LLO 5.3 Test the ladder logic program.

V. Relative Affective Domain related Outcome(s)

- Develop responsibility for safety when working with mains circuits.
- Encourage teamwork and communication during wiring and testing of industrial control systems.
- Build confidence in finding out errors and correcting them in industrial control systems.

VI. Minimum Theoretical Background with diagram (if required)

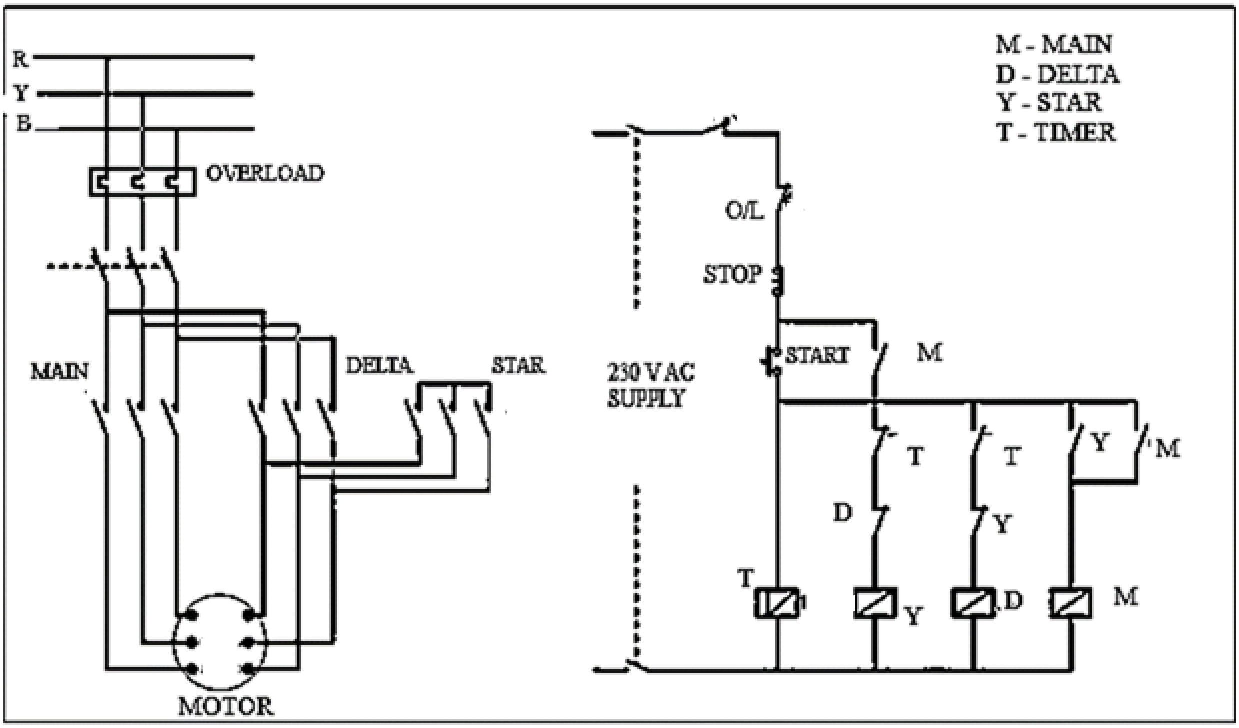

Fig. 5.1: Star-Delta Starter

Star-Delta Principle (summary):

- In star connection, each winding receives phase voltage (Vph = Vline/√3), reducing phase voltage and therefore starting current and torque (~1/3 compared with delta connection).
- After the motor attains near rated speed, windings are reconfigured to delta connection for normal operation.

Control elements (typical mapping):

- **Inputs:**
  - Start pushbutton (I0, NO),
  - Stop pushbutton (I1, NC),
  - Overload relay contact (I2, NC),
  - Emergency stop (as applicable).
- Outputs:
  - Q0 (Main contactor / KM1),
  - Q1 (Star contactor / KM2),
  - Q2 (Delta contactor / KM3),
  - Status lamps.
- Timer: T0 (On-delay) to set duration of star connection.
- Interlocks:
  - NC contacts of KM2 in KM3 coil rung and vice-versa,
  - PLC Boolean interlocks.

Simplified power wiring text (to be drawn neatly in lab):

- Supply L1, L2, L3 → KM1 (Main) → motor terminals.
- KM2 (Star) makes star links between windings;
- KM3 (Delta) makes delta links between windings. (Students must draw a full power diagram and label motor terminals, links and contactor connections for Star - Delta starter.)

VII. Experimental setup

(Student should prepare ladder diagram)

VIII. Required Resources /Apparatus/Equipment with specification

PLC trainer	24 V DC I/O, min 8 DI / 8 DO, timer function
3-phase motor	0.5–2.0 kW (lab); nameplate info available
Power contactors KM1/KM2/KM3	Rated to motor starting/operating current (e.g., 10–25A)
Overload relay	Adjustable to motor FLC
Start/Stop pushbuttons	Start (NO), Stop (NC), mushroom Stop preferred
Ammeter / Clamp meter	For peak/start and running currents
Power supply & fuses	3-phase supply with appropriate fusing
Wiring & tools	Terminal blocks, ferrules, insulated tools
Safety PPE	Gloves, goggles, emergency stop switch

IX. Precautions to be Followed

- Always switch off mains supply before changing power wiring.
- Confirm overload setting equals motor Full Load Current.
- Ensure electrical interlocks to prevent simultaneous star & delta connections.
- Keep clear of rotating parts during tests.
- Use Earth leakage protection if available.
- Do not start mains supply before proper checking of connections by the teacher.

X. Procedure

1. Preparation & Wiring

- Inspect equipment and motor terminals.
- Do the connections to the power side as -
    - KM1 (Main) in series with motor supply;
    - KM2 to close star links;
    - KM3 to connect delta links.
- Connect thermal overload relay in series with motor supply.
- Wire control inputs:
    - Start (I0), Stop (I1), OL (I2).

- Wire PLC outputs:
- Q0 → KM1 coil, Q1 → KM2 coil, Q2 → KM3 coil.

Also add indicator lamps to outputs.

- Wire auxiliary contacts (electrical interlocks) or plan to implement interlocks in ladder logic.

2. **PLC Program / Ladder Logic (design & simulate on PC)**
   - Prepare a ladder diagram

3. **Dry Run**
   - With contactor coils isolated from mains (or using pilot lamps), run PLC program and check sequence, timers, and interlocks. Correct logic if necessary.

4. **Live Test (supervised)**
   - Apply supply, press Start. Verify: Q0 (Main) ON → Q1 (Star) ON → motor accelerates with reduced inrush current → after T0 elapsed, Q1 OFF, dead time, Q2 ON (Delta), motor runs at full voltage.
   - Measure starting currents (star period) and running current (delta) with clamp meter. Record times and observations.
   - Test Stop and OL trip behaviour.

5. **Shutdown**
   - Stop motor, disconnect supply, inspect for overheating or any abnormal signs.

XI. Observations and Calculations

Observation Table:

Trial	T0 preset (sec)	Start current with DOL (Amp) (estimated) I_DOL	Start current observed (Amp) (Star connection) I_STAR	Running current (Amp) (Delta) I_DELTA	Remark
1					

Calculations

1. Percentage reduction in starting current =
   ((I_DOL − I_Star)/I_DOL) × 100.
   Example: If I_DOL = 36 A, I_Star = 12.5 A →
Then reduction = ((36 − 12.5)/36)×100 = 65.3%.

2. Time between pressing Start and T0.DN — verify within expected preset.

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions (for submission / viva)

1. What is the role of the dead time between star OFF and delta ON? What happens if it's omitted?
2. How does the timer preset T0 affect acceleration and mechanical stress? When should T0 be longer?
3. Describe two methods to ensure star and delta contactors never close simultaneously.
4. If PLC outputs cannot handle coil current, what intermediate device is used and why?

XVI. References / Suggestions for Further Reading

1. Madhuchhanda Mitra , Samarjt Sengupta, Programmable Logic Controllers and Industrial Automation: An Introduction, Penram International Publication , New Delhi,2017, ISBN : 978-8187972631
2. https://www.youtube.com/watch?v=UYzO6JXxHQI

Rubrics for Assessment Scheme

Performance Indicators		**Weightage**
Process Related (15 Marks)		**(60%)**
1.	Handling the components	10%
2	Drawing Ladder Diagrams	20%
3	Observing Outputs	20%
4	Working in a Team	10%
Product Related (10 Marks)		**(40%)**
1	Interpretation of Results	10%
2	Conclusions	10%
3.	Solving product related questions	10%
4.	Timely submission of journal	10%
	Total	**100 %**

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

Practical No. 6

Reversal of Direction of rotation of 3ph. Induction motor with the help of PLC.

I. Practical Significance

Many industrial applications (conveyors, mixers, hoists, machine tools) require reversing the direction of a 3-phase motor safely and reliably. Using a PLC to control forward and reverse contactors provides sequenced interlocks, soft timing, remote control, and integration with other automation logic. This experiment teaches safe power wiring, I/O addressing, use of motor driver or motor module, electrical interlocks to prevent simultaneous forward and reverse contactor closure, and basic fault handling.

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II. Industry/Employer Expected Outcome (s)

- Design ladder logic to control forward and reverse operation of a 3-phase induction motor.
- Correctly wire and address PLC inputs (pushbuttons, limit switches, fault inputs) and outputs (forward/reverse contactors via motor module or interface relays).
- Implement electrical and software interlocks to prevent short circuits and mechanical damage.
- Interface a motor driver/module to the PLC safely and test the system under supervised conditions.

III. Course Level Learning Outcome (CO)

CO4 — Test ladder logic programs for given industrial applications.

IV. Laboratory Learning Outcome(s)

LLO 6.1 Draw ladder logic diagram for controlling the direction of rotation for a 3-phase induction motor.
LLO 6.2 Address properly the input / output devices.
LLO 6.3 Test the ladder logic program.
LLO 6.4 Interface the 3-phase induction motor to the PLC with the help of a Motor Module.

V. Relative Affective Domain related Outcome(s)

- Improved safety awareness and discipline when working with rotating machinery and mains supplies.
- Teamwork in planning, wiring, testing and troubleshooting.
- Responsibility for documenting test results and following standard procedures

VI. Minimum Theoretical Background with diagram (if required)

Direction of Rotation

- Reversing the phase sequence applied to a 3-phase induction motor reverses its direction of rotation. Swapping any two of the three supply phases reverses the motor rotation.

Typical Power Arrangement

- Two power contactors are used: KM_F (Forward) and KM_R (Reverse). KM1 (Main contactor) may be used to feed the motor, or KM_F/KM_R may each provide full power switching with proper interlocks. Reverse wiring swaps two phase connections to the motor when KM_R is energized.

Interlocks

- Mechanical or electrical interlocks prevent both contactors KM_F and KM_R from being energized simultaneously (which would cause short circuiting of two phases). These are achieved using NC auxiliary contacts and PLC boolean logic.

Motor Module / Driver

- Many PLC trainers include a motor module or output interface (relays or solid-state relays) rated to drive contactor coils or motor starters. If PLC outputs are low-power, use interface relays between PLC outputs and contactor coils or use a motor starter module that accepts PLC commands.

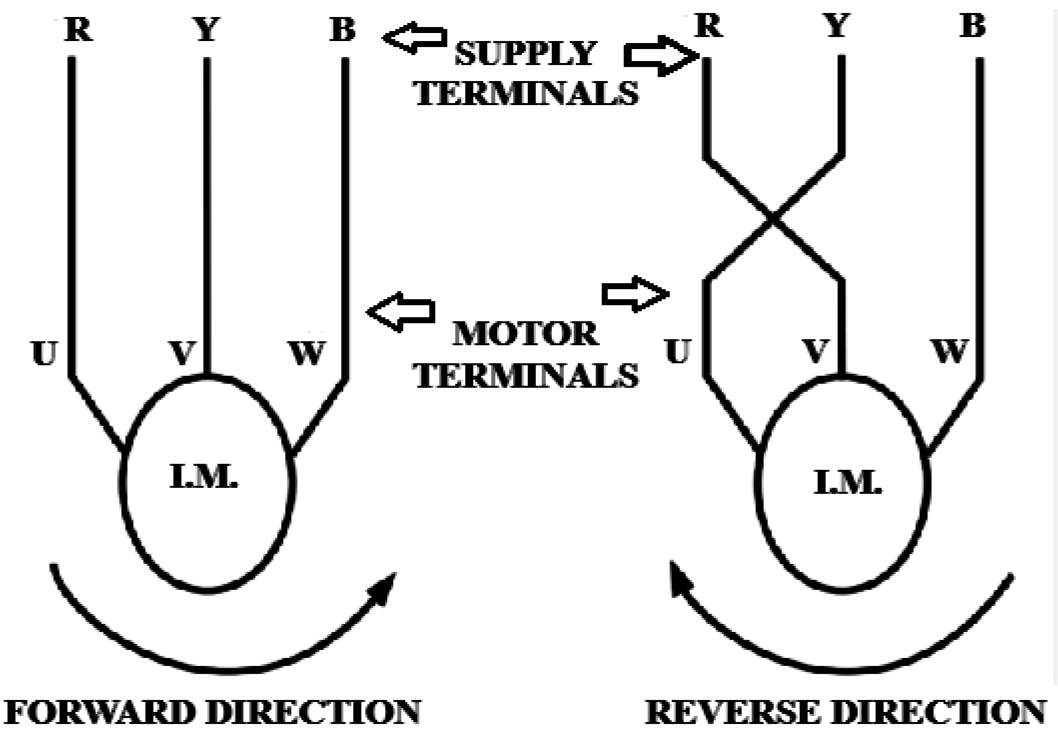

Fig. 6.1: Reversal of Direction of rotation of 3ph. Induction motor

VII. Experimental setup

(Diagrams: Students should draw the power diagram showing phase interchange for reverse, and the control diagram showing pushbuttons, auxiliary contacts and PLC I/O)

VIII. Required Resources /Apparatus/Equipment with specification

Equipment	Specification / Notes
PLC trainer & Motor Module	24 V DC I/O, min 4 DI / 4 DO. Motor module or relay outputs able to drive contactor coils or interface relays.
3-phase induction motor	0.5–2.0 kW (lab sized) with accessible terminals
Contactors KM_F, KM_R, (KM1)	Rated for motor full load and starting current (10–25 A typical)
Overload relay	Adjustable to motor FLC
Pushbuttons & selector switches	Forward NO, Reverse NO, Stop NC, Emergency Stop (mushroom)
Indicator lamps	Forward, Reverse, Fault / Running indicators
Ammeter / Clamp meter	For current measurement
Fuses & Isolator	3-phase fused isolator for safety
Wiring accessories	Terminal blocks, ferrules, insulated tools

IX. Precautions to be Followed

- Isolate power before making power wiring changes.
- Confirm overload relay is correctly set for motor FLC.
- Ensure electrical interlocks (NC contacts) are connected such that contactor KM_F and KM_R cannot energize simultaneously.
- Check PLC outputs: use interface relays or motor module if PLC outputs cannot directly drive contactor coils.
- Use emergency stop if required and ensure teachers presence during live runs.

X. Procedure

Power Wiring

- Wire contactors KM_F and KM_R so that when KM_F energizes the motor receives phases L1-L2-L3 in normal order; when KM_R energizes two of the phases are swapped (e.g., L1 and L2 swapped) to reverse rotation.
- Install overload relay in motor supply.
- Ensure mechanical or electrical interlocks: use NC auxiliary contacts of KM_F in KM_R coil circuit and NC of KM_R in KM_F coil circuit to physically prevent simultaneous closure.

Control Wiring and PLC I/O Addressing: Connect wiring as follow -

- Inputs:
  - I0 = Start-Forward (NO),
  - I1 = Start-Reverse (NO),
  - I2 = Stop (NC),
  - I3 = Overload/Fault (NC).
- Outputs:
  - Q0 = KM_F (Forward contactor through motor module or relay),
  - Q1 = KM_R (Reverse contactor),
  - Q2 = Motor Running indicator,
  - Q3 = Fault lamp / alarm as required.
- Wire pushbuttons to PLC DI and outputs to motor module or relay coils.

PLC Ladder Logic Design (Suggested)

- Prepare a ladder diagram.

(Student should prepare ladder diagram for reverse operation)

Dry Run and Simulation

- With motor disconnected from mains or with pilot lamps, test PLC logic and verify mutual exclusion (both outputs never ON simultaneously).
- Simulate fault input to verify fault handling.

Live Test (under teacher's Supervision)

- Apply 3-phase supply. Press Forward (I0): KM_F energizes, motor rotates in forward direction. Confirm and note down the direction of rotation.
- Press Stop: KM_F should de-energize.
- Press Reverse (I1) —KM_R energizes and motor rotates in opposite direction.
- Note any abnormal vibrations or noises.
- Press Stop.
- Disconnect the supply.

XI. Observations and Calculations

Observation Table:

Trial	Direction Observed	Starting current	Remark
Start PB pressed			
Reverse PB pressed			

- Confirm direction of rotation change when phases swapped.

- Record inrush currents for forward and reverse starts — they should be similar if starting method is same.

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

Practical Related Questions

1. Explain why electrical interlocks are necessary between forward and backward rotation of an induction motor.
2. Explain the necessity of reversal of direction of rotation for an induction motor.
3. State the advantage of using PLC for direction reversal of an induction motor.

(The teacher may add more questions related to this experiment).

XIII. References / Suggestions for Further Reading

Madhuchhanda Mitra , Samarjt Sengupta, Programmable Logic Controllers and Industrial Automation: An Introduction, Penram International Publication , New Delhi,2017, ISBN : 978-8187972631

https://www.youtube.com/watch?v=f_qDfJYjJo0

XIV. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1.	Handling the components	10%
2	Drawing Ladder Diagrams	20%
3	Observing Outputs	20%
4	Working in a Team	10%
Product Related (10 Marks)		**(40%)**
1	Interpretation of Results	10%
2	Conclusions	10%
3.	Solving product related questions	10%
4.	Timely submission of journal	10%
	Total	**100 %**

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

Practical No. 7

Control of the Direction of Rotation of a given Stepper Motor.

I. Practical Significance

Stepper motors are fundamental components in precision positioning and motion control applications, such as CNC machines, 3D printers, robotic arms, and automated assembly lines. Controlling their direction and speed via a Programmable Logic Controller (PLC) and a specialized motor control module exposes students to the core concepts of industrial motion control. This experiment bridges the gap between digital logic programming (Ladder Logic) and mechatronic systems.

II. Industry/Employer Expected Outcome(s)

The student should be able to:

a) **Select and interface** a stepper motor drive and motor with a PLC system.

b) **Develop and debug** PLC programs (Ladder Logic) for sequential and directional control of a motion device.

c) **Apply knowledge** of pulse and direction signals for motor control.

d) **Understand** the industrial implementation of position control.

III. Course Level Learning Outcome (CO)

CO4 - Test ladder logic programs for given industrial applications.

IV. Laboratory Learning Outcome(s)

LLO 7.1 Draw ladder logic diagram for controlling the direction of rotation for a stepper motor.

LLO 7.2 Address properly the input and output devices.

LLO 7.3 Test the ladder logic program.

LLO 7.4 Interface the stepper motor to the PLC with the help of a Motor module.

V. Relative Affective Domain related Outcome(s):

a) **Persistence:** Troubleshooting the interface and programming errors until the motor runs correctly.

b) **Attention to Detail:** Ensuring correct wiring of the pulse and direction signals.

c) **Teamwork:** Collaborating effectively during the hardware setup and programming phases.

VI. Minimum Theoretical Background with Diagram (if required):

A **stepper motor** rotates in discrete, predetermined steps. To control a stepper motor using a

PLC, two essential signals are required:

1. **PULSE (or CLK):** The frequency of this signal determines the **speed** of the motor (more pulses per second = faster rotation).
2. **DIRECTION (or DIR):** The state of this digital signal (HIGH/LOW, or 1/0) determines the **direction** of rotation (e.g., clockwise or counter-clockwise).

The PLC cannot directly generate the high-frequency pulses required. Therefore, a specialized unit like a **High-Speed Output (HSO) module** or a dedicated **Motion Control Module** is used. This module receives commands (like target speed and direction) from the main PLC CPU via Ladder Logic and generates the precise pulse and direction signals to the **stepper motor driver**. The driver, in turn, amplifies the signals and applies the necessary current to the motor windings.

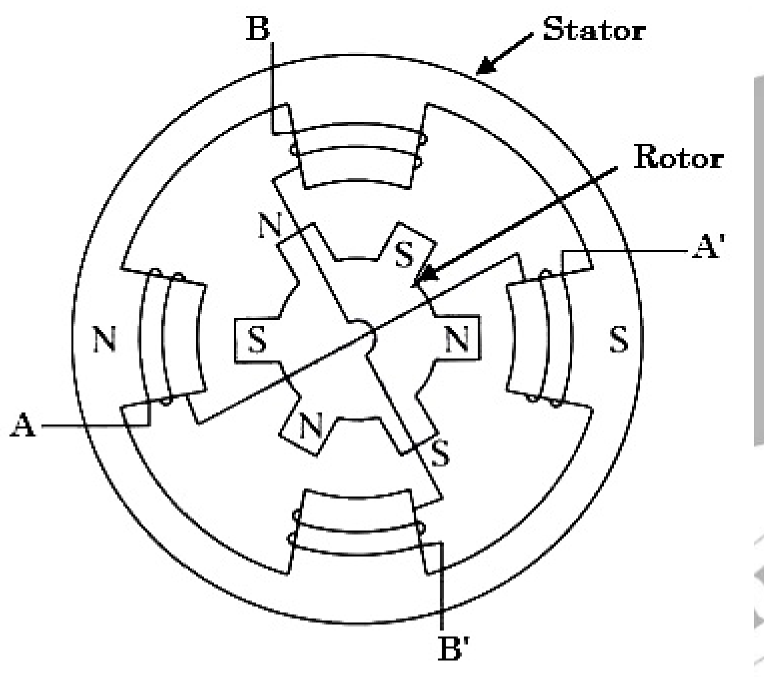

Fig. 7.1: Stepper motor construction

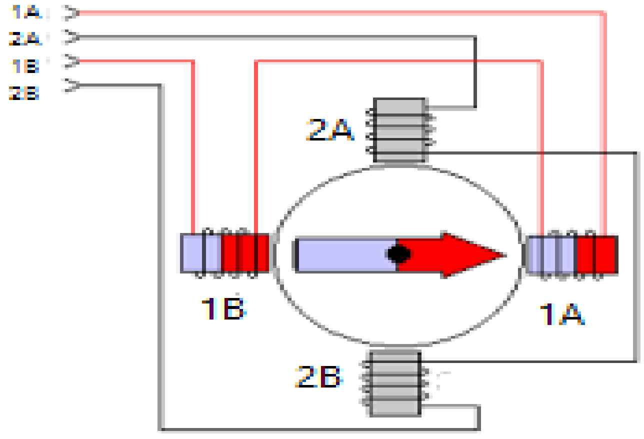

Fig. 7.2: Stepper motor operation

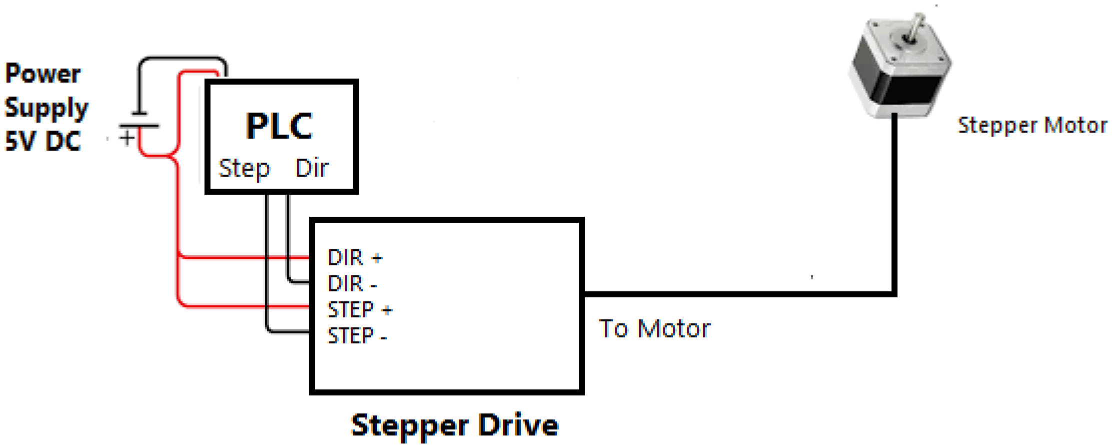

Fig. 7.3: Stepper Motor Control using PLC

VII. Experimental Setup

The setup should simulate a basic indexing system.

1. **Input Station:** Two pushbuttons (PB1 for Clockwise and PB2 for Counter-Clockwise) and one Stop pushbutton are connected to the PLC Digital Inputs.
2. **Controller:** The PLC CPU is connected to the dedicated **Motion Control Module** or the integrated **High-Speed Output (HSO)** terminals.
3. **Motor System:** The PLC's motion output (PULSE/DIR) is wired to the corresponding input terminals of the **Stepper Motor Driver**. The driver is connected to the **Stepper Motor** and its dedicated power supply.
4. **Programming Terminal:** A PC with the appropriate PLC software is connected for programming and monitoring.

VIII. Required Resources/Apparatus/Equipment with Specification

Sr. No.	Apparatus/Equipment	Specification/Range	Qty.
1	Programmable Logic Controller (PLC)	CPU with minimum 4 DI/DO, integrated HSO/Motion Module capability	1
2	Stepper Motor	Two-phase, Hybrid type (e.g., NEMA 17 or 23)	1
3	Stepper Motor Driver/Controller	Current rating compatible with the motor (e.g., 2A-4A)	1
4	DC Power Supply for Motor Driver	Voltage and current rating suitable for the motor (e.g., 24V-48V DC)	1

5	Pushbuttons/ Switches	N.O. type for Start CW, Start CCW, and Stop	3
6	Interfacing Wires and Cables	Suitable gauge wires, connectors, and PLC programming cable	As required
7	Personal Computer (PC)	With PLC programming software installed	1

IX. Precautions to be Followed:

1. Ensure the **motor driver power supply** is connected with **correct polarity** and is rated for the motor.
2. **NEVER** connect or disconnect the motor wires while the **driver is powered ON**. This can damage the driver.
3. Verify the **PULSE and DIRECTION signal voltage levels** (e.g., 5V or 24V) are compatible between the PLC output and the driver input.
4. Use proper **shielded cables** for the PULSE and DIR signals to minimize noise interference.
5. Set the current limit on the motor driver correctly according to the motor specifications.

X. Procedure

A. Hardware Interfacing

1. Connect the **Start CW** (Clockwise) and **Start CCW** (Counter-Clockwise) pushbuttons to separate **Digital Inputs** (e.g., I:0/0 and I:0/1 respectively) on the PLC.
2. Connect the PLC's **High-Speed Output** terminals (for PULSE and DIR) to the corresponding **PUL/CLK** and **DIR** input terminals on the Stepper Motor Driver.
4. Connect the Stepper Motor wires to the output terminals of the Driver.
5. Connect the separate **motor power supply** to the driver.
6. Connect the PLC to the main control power and the PC.

B. Software Configuration and Programming

1. Open the PLC programming software and create a new project.
2. **Configure the HSO/Motion Module:** Define the output terminals as a high-speed output pair (PULSE/DIR) and set the initial parameters (e.g., maximum frequency, step mode).
3. **Draw the Ladder Logic Diagram:**
4. **Download** the program to the PLC.

1. C. Testing and Observation

1. Set the PLC to **RUN mode**.
2. Press the **Start CW** pushbutton (I:0/0). The motor should start rotating **Clockwise**.
3. Press the **Stop** pushbutton. Observe that the motor stops.

4. Press the **Start CCW** pushbutton (I:0/1). The motor should rotate **Counter-Clockwise**.
5. Change the speed/frequency parameter in the program (e.g., to 1000 pulses/second) and download again. Test both directions and note the change in speed.

D. Student should draw ladder diagram

XI. Observations and Calculations

Observation Table

Test No.	Input Pressed	Direction Command (DIR Signal)	Pulse Frequency (Hz)	Calculated Speed (RPM)	Observed Rotation
1	Start Clockwise				
2	Start counter Clockwise				

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XVII. Practical Related Questions

1. Explain the difference between the **PULSE** signal and the **DIRECTION** signal in stepper motor control.
2. Why is a dedicated **High-Speed Output (HSO)** or **Motion Control Module** necessary for a stepper motor, and why can't a standard digital output be used?
3. If a stepper motor has a 1.8^0 step angle, how many pulses are needed for one full revolution?
4. What is the function of the **Stepper Motor Driver**?
5. Define Step angle.

XVIII. References / Suggestions for Further Reading

1. Madhuchhanda Mitra , Samarjt Sengupta, Programmable Logic Controllers and Industrial Automation: An Introduction, Penram International Publication , New Delhi,2017, ISBN : 978-8187972631
2. https://www.youtube.com/watch?v=UOEC8FijUFQ
3. https://www.youtube.com/watch?v=A97I3tyHDbs

XIX. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1.	Handling the components	10%
2	Drawing Ladder Diagrams	20%
3	Observing Outputs	20%
4	Working in a Team	10%
	Product Related (10 Marks)	**(40%)**
1	Interpretation of Results	10%
2	Conclusions	10%
3.	Solving product related questions	10%
4.	Timely submission of journal	10%
	Total	**100 %**

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

Practical No. 8

Title: Control of Temperature with the help of PLC

I. Practical Significance

Temperature control is a critical aspect in a vast number of industrial processes, including chemical reactions, food processing, HVAC systems, and material manufacturing. Implementing this control using a Programmable Logic Controller (PLC) provides students with practical exposure to modern industrial automation. This experiment demonstrates the use of PID (Proportional-Integral-Derivative) control or simple ON/OFF control via ladder logic, connecting theoretical knowledge of control systems to a real-world application.

II. Industry/Employer Expected Outcome(s)

The student should be able to:

1. **Program** a PLC to execute a control algorithm for a process variable (temperature).
2. **Select and interface** appropriate input (temperature sensor) and output (heater/fan) devices with a PLC.
3. **Implement** a control loop using standard industrial programming methods (Ladder Logic).

III. Course Level Learning Outcome (CO)

CO4 Test ladder logic programs for given industrial applications.

IV. Laboratory Learning Outcome(s)

LLO 8.1 **Draw ladder logic diagrams** for controlling the temperature of a given process.

LLO 8.2 **Address properly the input devices** (Temperature Sensor).

LLO 8.3 **Test the ladder logic program**.

LLO 8.4 **Interface the Temperature sensor to the PLC**.

V. Relative Affective Domain related Outcome(s):

a) **Punctuality:** Submitting the experiment report on time.
b) **Cooperation:** Working effectively in a team during the setup and testing phase.
c) **Safety Consciousness:** Handling electrical equipment and heating elements with care.
d) **Systematic Approach:** Following the experimental procedure step-by-step.

VI. Minimum Theoretical Background with Diagram (if required):

An RTD (Resistance Temperature Detector) and a thermocouple are two types of temperature sensors. They work on different operating principles and both have distinct characteristics. An RTD measures temperature by considering changes in the electrical resistance of a pure metal, offering high accuracy and stability, while a thermocouple uses the voltage generated by two dissimilar metals to measure temperature, providing a faster response and a wider temperature range. The choice between both sensors depends on the specific application's needs, such as accuracy versus temperature range, response time, and cost. The following figure shows connection diagram of one of the sensor i.e. thermocouple.

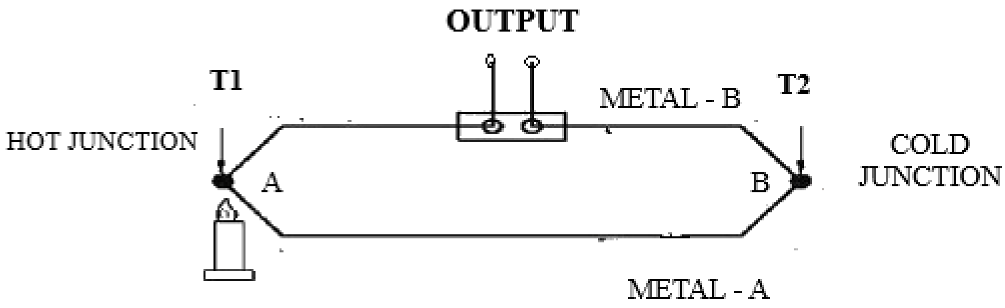

Fig. 6.2: Temperature Sensor – Thermocouple

A PLC-based temperature control system typically uses a closed-loop feedback mechanism. A temperature sensor (e.g., Thermocouple or RTD) measures the temperature of the current process, which acts as the process variable (PV). This sensor's analog signal is converted to a digital value by an Analog Input (AI) module of the PLC. The PLC compares the PV with a desired Set Point (SP).

For simple control, an ON/OFF (or bang-bang) control **is used. If** PV < SP**, the heating element (output) is turned** ON**. If** PV > SP**, the heating element is turned** OFF**. This results in temperature oscillation around the SP.**

For better control, PID control **is used, where the PLC calculates a control output based on the error** (E = SP - PV) **and its integral and derivative.**

Ladder Logic: **It's a programming language for PLCs graphically representing the electrical relay logic.**

Block Diagram of Temperature Control System:

1. **Process:** A chamber or fluid where temperature is controlled.
2. **Sensor:** Measures temperature (PV).
3. **Transducer/Signal Conditioner:** Converts sensor output to a standard signal (e.g., 4-20mA or 0-10V).
4. **PLC Analog Input Module:** Reads the signal and converts it to a digital value.
5. **PLC (Controller):** Compares PV with SP and executes the control algorithm (Ladder Logic).
6. **Output Module:** Sends a control signal (e.g., digital ON/OFF) to the actuator.
7. **Actuator:** A heater or cooling device that affects the process temperature.

VII. Experimental Setup

The setup involves a temperature control trainer kit or an actual scaled-down process model.

1. **Process Enclosure/Chamber:** A small insulated chamber with a heating element (e.g., light bulb or low-power heater) and a cooling mechanism (e.g., small fan).
2. **Sensor Installation:** The temperature sensor (e.g., RTD or Thermocouple) is mounted inside the chamber.
3. **PLC Connection:** The sensor is wired to the PLC's Analog Input (AI) module. The heater/fan is wired to the PLC's Digital Output (DO) module through a relay/contactor.
4. **Programming Terminal:** A computer running the PLC programming software is connected to the PLC.

VIII. Required Resources/Apparatus/Equipment with Specification:

Sr. No.	Apparatus/ Equipment	Specification/Range	Qty.
1	Programmable Logic Controller (PLC)	CPU with minimum 8 DI/DO, 1 Analog Input (AI) module (4-20 mA or 0-10V)	1
2	Temperature Sensor (RTD or Thermocouple)	e.g., PT100, K-Type, compatible with PLC AI module	1
3	Temperature Process Model/Trainer Kit	Small chamber with heating element (e.g., 24V DC/AC), Fan	1
4	Power Supply	24V DC and/or 230V AC (as required by components)	1
5	Interfacing Cables	PLC programming cable, wires, connectors	As required
6	Personal Computer (PC)	With PLC programming software installed	1
7	Digital Multimeter (DMM)	For continuity and voltage checks	1

IX. Precautions to be Followed

1. Ensure all **power supplies are OFF** before making or changing any wiring connections.
2. Verify the **voltage and current ratings** of the heater and output module to prevent damage.
3. Handle the **temperature sensor** carefully; avoid physical stress on the sensing tip.
5. Check the **PLC's Analog Input range configuration** matches the sensor's output signal.
6. Use **proper grounding** for the entire setup.

X. Procedure

A. Hardware Interfacing

1. Mount the **temperature sensor** inside the process chamber.

2. Wire the sensor's output (e.g., 4-20mA or 0-10V) to the designated **Analog Input terminal** of the PLC.
3. Wire the **heater/actuator** through a relay/contactor to a **Digital Output terminal** of the PLC.
4. Connect the PLC to the **power supply** and the **PC** via the programming cable.

B. Software Configuration and Programming

1. Open the PLC programming software on the PC.
2. Create a **New Project** and select the specific PLC model.
4. Configure the **Analog Input channel** by setting the correct range (e.g., 4-20mA, 0-100°C).
5. **Draw the Ladder Logic Diagram** for a simple ON/OFF control:
6. **Download** the program to the PLC.

C. Testing and Observation

1. Set the PLC to **RUN mode**.
2. Monitor the scaled temperature in the software's data table.
3. Set the **Set Point (SP)** to a desired value.
4. Observe the Heater Output status. Initially, the heater should turn ON.
5. Record the temperature and the heater status at regular intervals (e.g., every 30 seconds).
7. Continue recording until the temperature stabilizes around the Set Point.
8. Change the SP and repeat the observation.

D. Student should draw ladder diagram

XI. Observations and Calculations

Observation Table

Sr. No.	**Time (s)**	**Set Point (SP) (˚C)**	**Raw PLC AI Value (0-4095)**	**Scaled Temperature (PV◦C)**	**Heater Output Status (ON/OFF)**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

*Plot the **Scaled Temperature (PV)** versus **Time** to show the system's response.*

XII. Results

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

XV. Practical Related Questions

1. What is the function of the **Analog Input (AI) module** in the PLC?
2. Explain the concept of **scaling** in the context of PLC programming for analog signals. Why is it necessary?
3. What is **hysteresis** in an ON/OFF control system, and why is it often included?
4. If the temperature sensor provides a 4-20mA signal, and the range is 0°C to 100°C, what temperature corresponds to a current of 12mA?
5. How would the ladder logic be modified to implement a simple **high-temperature alarm** (e.g., turn on a light if PV > 60^0C)?
6. Briefly compare **ON/OFF control** with **PID control** for industrial temperature regulation.

XVI. References / Suggestions for Further Reading

1. Madhuchhanda Mitra , Samarjt Sengupta, Programmable Logic Controllers and Industrial Automation: An Introduction, Penram International Publication , New Delhi,2017, ISBN : 978-8187972631
2. https://www.youtube.com/watch?v=lrMVblRLuy0

XVII. Rubrics for Assessment Scheme

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1.	Handling the components	10%
2	Drawing Ladder Diagrams	20%
3	Observing Outputs	20%
4	Working in a Team	10%
	Product Related (10 Marks)	**(40%)**
1	Interpretation of Results	10%
2	Conclusions	10%
3.	Solving product related questions	10%
4.	Timely submission of journal	10%
	Total	**100 %**

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

Practical No.9

Simulating traffic light control with the help of PLC

I. Practical Significance

Simulating traffic light control with a PLC enhances traffic flow, reduces congestion, and improves safety by dynamically adjusting light cycles based on real-time traffic data. It also offers energy efficiency, cost-effectiveness, and easy scalability for modern urban traffic management systems.

II. Industry/Employer Expected Outcome(s)

This practical is designed to develop the ability to accurately- "simulation of traffic light helps Real time applications."

III. Course Level Learning Outcome(s) (CO)

CO4 – Test the ladder logic programs for given industrial applications.

IV. Laboratory Learning Outcome(s)

LLO 9.1 Draw ladder logic diagram for controlling the traffic lights.
LLO 9.2 Address properly the input and output devices
LLO 9.3 Test the ladder logic program

V. Relative Affective Domain related Outcome(s)

- Demonstrate working as a leader/a team member.
- Simulate the traffic light control system.
- Develop the ladder logic diagram.

VI. Relevant Theoretical Background with diagram (if required)

Traffic Light Control:

Traffic light is an arrangement of three color lights. It is used for controlling the traffic at road junctions by providing a particular sequence of these lights. Different color lights used are Red, Green and Amber (or Yellow). The red light indicates 'STOP', green light indicates 'GO' and amber light indicates 'WAIT' for red or green.

Timers are devices that count increments of time. Traffic lights are one example where timers are used. In this example timers are used to control the length of time between signal changes. The lights in a traffic signal go through a sequence: Red, green, amber, Red, green, amber etc.

When an ON/OFF switch is turned on and a START button is momentarily pressed, the red signal (R) lights for 30 seconds, then turns off and the green (G) lights for 25 seconds, then turns off and the Amber (A) turns on for 5 seconds and then turns off and back to the red. On the opposite street, the red light (R') is on during the time the light on the other street is either green or amber. Transition from red to green to amber is accomplished by cascading timer circuits. The sequence then repeats itself

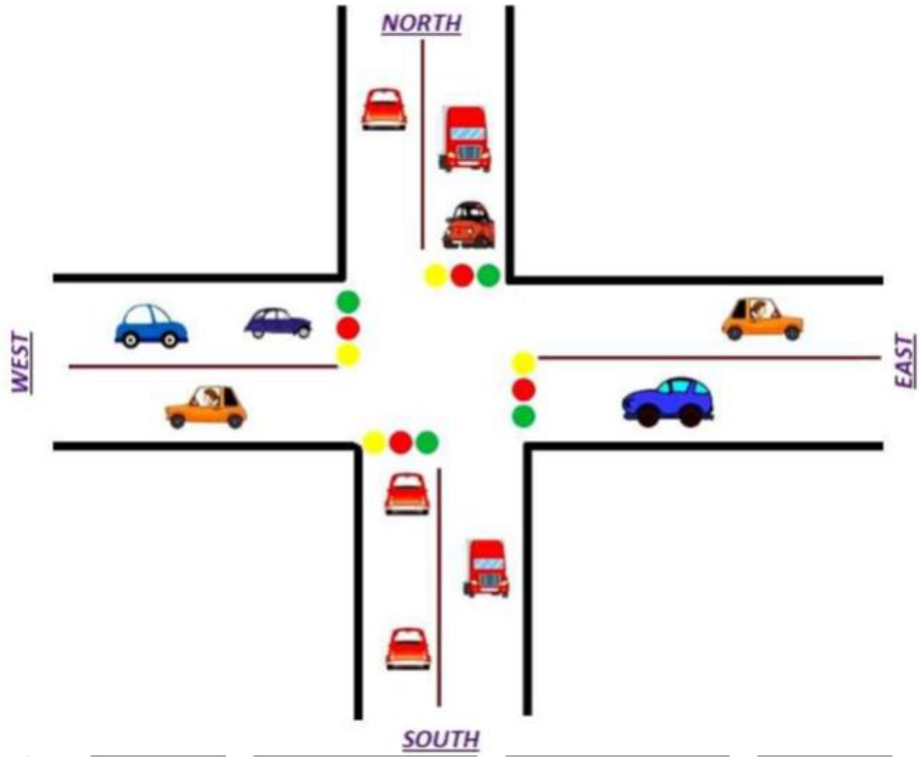

Fig 9.1 Four way traffic light control system using PLC

VII. Ladder Logic Diagram:

VIII. Required Resources /Apparatus/Equipment with specifications:

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	PLC	Allen Bradley Micro Logix 1500 LRP compatible with RX logic 500	01
2	PC with RX logic software	RX logic 500	01
3	NO and NC switches		02

IX. **Precautions to be followed:**

- Ensure all wiring is correct and secure before powering on the system.
- Do not touch live wires or terminals while the system is energized.
- Double-check timer settings and logic to avoid undesired sequences.
- Properly label all inputs and outputs in the program.

X. Procedure:

1. Load the RS Logix software to the PC.
2. Open the RS Logix software.
3. Switch On the PLC trainer.
4. Open the New project and draw the ladder logic program.
5. Compile the program.
6. Run the Program.
7. Give force and observe the output.
8. Verify that the lights change in the correct order and time durations.
9. Make adjustments in logic if required and retest.

XI. Observations:

List of Inputs and Outputs

Sr. No.	Address	Name	Input/ Output
1	I:0/0	Start	Input
2	I:0/1	Stop	Input
3	B3.0	Memory	
4	O:0/0	East Green	
5	O:0/1	North Red	
6	O:0/2	West Red	
7	O:0/3	South Yellow	
8	O:0/4	East Yellow	
9	O:0/5	North Yellow	
10	O:0/6	North Green	
11	O:0/7	East Red	
12	O:0/8	West Yellow	
13	O:0/9	West Green	
14	O:0/10	South Yellow	
15	O:0/11	South Green	

XII. Results:

XIII. Interpretation of Results:

XI. Conclusions and Recommendation

XII. Practical Related Questions

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

1. Give the enable bit of timer instruction true?
2. When is the output of a programmed timer energized?
3. How RES instruction in relation with retentive PLC timer works?
4. How accumulated count of programmed timer energized?

[Space for Answer]

XVI. References / Suggestions for Further Reading

1. https://www.scribd.com/document/550173745/Manual-EE5I-EIA-22526-131020-
2. https://www.youtube.com/watch?v=_2SWe8Zlg0Y
3. https://www.youtube.com/watch?v=1_K3cf9ntHM
4. https://srmvalliammai.ac.in/wp-content/uploads/2022/05/ei8761-industrial-automation-lab-manual.pdf

XVII: Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1	Understanding of the practical objective	20%
2	Calculation of final readings	20%
3	Identification of correct hardware elements	12%
4	Identification of correct software tools	8%
	Product Related (10 Marks)	**(40%)**
1	Accuracy of hardware and software identification	8%
2	Quality of simulation implementation	12%
3	Presentation of findings/report clarity	12%
4	Answering viva questions / conceptual understanding	8%
	Total	**100 %**

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

Practical No. 10

Ladder Logic For Blinking The Lamp.

I. Practical Significance

The practical significance of ladder logic for blinking a lamp is to indicate machine status, alarms, or process states through visual signals. It helps in learning timer functions and output control in PLC systems. This logic is widely used in industrial automation for operator awareness and system diagnostics.

II. Industry / Employer Expected Outcome

Industry expects that the blinking lamp ladder logic demonstrates a technician's ability to use timers, control outputs, and understand PLC scan cycles. Employers look for reliable, maintainable code that ensures clear visual signaling for machine status or alarms.

III. Course Level Learning Outcome (CO)

CO1 – Apply the basics of PLC programming for a given application.

IV. Laboratory Learning Outcome(s)

LLO 10.1: Draw ladder logic programme for blinking of light.

LLO 10.2: Address properly the input and output devices.

LLO 10.3: Test the ladder logic program.

V. Relative Affective Domain Related Outcome(s)

- Demonstrate working as a leader/a team member.
- Follow ethical Practices.

VI. Relevant Theoretical Background (with Diagram)

A common ladder logic for blinking a lamp involves using two timers to create a cycle of "on" and "off" periods, triggered by a start condition. The first timer turns on the lamp, and its output triggers the second timer, which then turns the lamp off and resets the first timer to repeat the cycle.

VII. Experimental Setup:

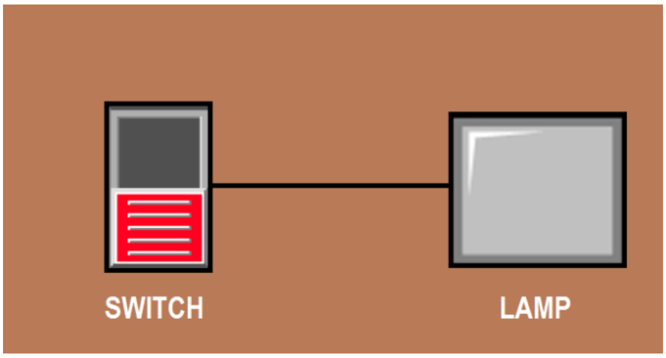

Fig.10.1: problem diagram for blinking light

This problem can be solved by using timers. In this case we will use TON (ON Delay Timer). For explanation we consider one SWITCH for enabling the ON/OFF cycle and one lamp for output. When user presses the SWITCH then lamp will energize and remains ON for 5 seconds after that it will OFF for 5 seconds. This cycle will repeat itself.

List of Inputs & Outputs

- **Inputs List**
  SWITCH : I0.0
- **Outputs List**
  Lamp : Q0.0
- **M Memory**
  M0.0 : bit memory for lamp OFF condition

LADDER LOGIC DIAGRAM:

VIII. Required Resources/Apparatus/Equipment:

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	PLC software,	PC with RS Logix Software	01
2	NO and NC switches		01

IX. Precautions to be followed (Safety instructions/Rules/Standards)

- Ensure all wiring is correct and secure before powering on the system.
- Do not touch live wires or terminals while the system is energized.
- Double-check timer settings and logic to avoid undesired sequences.
- Properly label all inputs and outputs in the program.

X. Procedure:

1. Load the RS Logix software to the PC.
2. Open the RS Logix software.
3. Switch on the PLC trainer.
4. Open the New project and draw the ladder logic program.
5. Compile the program.
6. Run the Program.
7. Give force and observe the output.

XI. Observations:

1. ON time of LED is _____seconds and OFF time of LED is _____seconds.

XII. Result:

XIII. Interpretation of Results

XIV. Conclusions and Recommendation

1. On-delay timer counts time based intervals when the rung condition is ______ (true/false).
2. Off-delay timer counts time based intervals when the rung condition is ______ (true/false)

XV. Practical Related Questions

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

1. Draw ladder diagram to make LED ON after 15 seconds when switch is pressed.
2. Give the preset bit in PLC timer indicate?
3. State the meaning of ON delay timer and OFF delay timer in PLC.
4. State the range of preset in PLC timer.
5. State function of accumulator with reference to PLC timer.
6. How the retentive PLC timer works?

[Space for Answer]

XVI. References / Suggestions for Further Reading

- https://www.youtube.com/watch?v=vlZXMAJH9Ug&t=127s
- https://instrumentationtools.com/plc-program-for-blinking-lamp-on-5-seconds-interval/

XVII. Rubrics for Assessment Scheme

	Performance Indicators	Weightage
	Process Related (15Marks)	**(60%)**
1	Identification of Component / Tool	30%
2	Recording of Simulation/Observation/ V Lab data	30%
	Product Related (10Marks)	**(40%)**
3	Interpretation of Result	10%
4	Answer to practical related questions	20%
5	Submitting the Journal in time	10%
	Total	**100 %**

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

Practical No. 11

Implementation of Logic gates using PLC using virtual lab

I. Practical Significance:

This practical helps to close the gap between digital theory and real-world automation system implementation. This exercise gives students a practical grasp of PLCs without requiring actual hardware by allowing them to create, model, and test logic gate operations using ladder logic programming in a virtual setting.

II. Industry / Employer Expected Outcome:

- Skilled in ladder logic programming to simulate digital logic circuits.
- Capable of working in virtual environments for testing and validation before physical deployment.
- Familiarity with industrial automation tools and simulation software.
- Proper addressing and configuration of I/O modules.

III. Course Level Learning Outcome (CO):

CO3 – Apply the basics of PLC programming for a given application.

IV. Laboratory Learning Outcome(s)

LLO 11.1: Draw ladder logic diagram to simulate given gate.
LLO 11.2: Address properly the input and output devices.
LLO 11.3: Test the ladder logic program.

V. Relative Affective Domain Related Outcome(s)

- Demonstrate curiosity and initiative in learning PLC programming.
- Show responsibility in configuring and testing logic circuits virtually.
- Exhibit teamwork and collaborative behavior in virtual simulation-based labs.
- Display attention to detail and accuracy in ladder diagram construction.

VI. Relevant Theoretical Background (with Diagram):

Logic Gates Basics:

Sr. No.	Gate Type	Boolean Expression	Output Logic
1	AND	Y = A · B	High if both A and B are High |
2	OR	Y = A + B	High if any one of A or B is High
3	NOT	Y = ¬A	High if A is Low
4	NOR	Y = ¬(A · B)	Opposite of AND
5	NAND	Y = ¬(A + B)	Opposite of OR

VII. Experimental Setup: Ladder Diagram:

VIII. Required Resources/Apparatus/Equipment:

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
01	Pc /Laptop	Windows 10	
02	Internet connectivity	Minimum 4 Mbps	
03	Virtual Lab Access	COEP Technological University	
04	I/O Devices (Virtual)	Push buttons, Lamps, Switches	

IX. Precautions to be followed (Safety instructions/Rules/Standards):

1. Ensure correct addressing of I/O points before running simulation.
2. Do not leave virtual switches ON unless required.
3. Save your ladder diagram periodically to avoid data loss.

4. Validate logic before execution to avoid runtime errors.
5. Follow naming conventions for clarity and debugging ease.

X. Procedure:

1. Select Gate Type: Choose the logic gate (AND, OR, NOT, etc.) to implement.
2. Open Virtual Lab Launch the virtual PLC simulator.
3. Create Ladder Diagram:

   Use input contacts for switches (I0, I1).
   Arrange contacts based on logic gate (series for AND, parallel for OR).
   Connect output coil (Q0) to represent the output.
4. Address I/O:
   Assign unique addresses (e.g., I0.0, I0.1 for inputs; Q0.0 for output).
   Simulate:
5. Run the simulation.
   Toggle input switches and observe output behavior.
6. Test Logic:
   Confirm output is as expected for all combinations of input.
7. Document Observations:
   Record input combinations and corresponding output.

XIII. Observations: For 1) AND Gate:

Sr. No.	Input A	Input B	Expected Output	Observed Output
1	0	0		
2	0	1		
3	1	0		
4	1	1		

XIV. Result:

XV. Interpretation of Results

XVI. Conclusions and Recommendation

XVII. Practical Related Questions

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

1. Name the PLC programming language that uses graphical representations of logic operations?
2. List the hardware components of a PLC system?
3. In a PLC, describe the function of an input module versus an output module?
4. How can a universal gate, like a NAND gate, be used to create other logic gates?
5. Contrast the difference between a PLC and a general-purpose computer?

[Space for Answer]

XVIII. References / Suggestions for Further Reading:

- https://plc-coep.vlabs.ac.in/exp/implementation-logic-gates/theory.html
- https://plc-coep.vlabs.ac.in/exp/implementation-logic-gates/procedure.html
- https://plc-coep.vlabs.ac.in/exp/implementation-logic-gates/simulation.html

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1	Accuracy of hardware and software identification	20%
2	Quality of simulation/virtual lab implementation	20%
3	Presentation of findings/report clarity	12%
4	Answering viva questions / conceptual understanding	08%
	Product Related (10 Marks)	**(40%)**
1	Understanding of the practical objective	8%
2	Identification of correct hardware elements	12%
3	Identification of correct software tools	12%
4	Participation & lab procedure handling	8%

<table>
<tr><th colspan="3">Marks Obtained</th><th rowspan="2">Dated signature of Teacher</th></tr>
<tr><th>Process Related (15)</th><th>Product Related (10)</th><th>Total (25)</th></tr>
<tr><td></td><td></td><td></td><td></td></tr>
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Practical No. 12

Ladder logic for automatic bottle filling plant using virtual lab

I. Practical Significance:

In today's packaging and manufacturing sectors, automation is essential. Using a **Programmable Logic Controller (PLC) to effectively control an industrial operation is exemplified by the automatic bottle filling plant.

II. Industry / Employer Expected Outcome:

- Create and put into use PLC-based industrial automation control systems.
- Ladder logic algorithms for industrial processes, such as filling, sorting, and packaging, can be simulated and tested.
- For real-time control, connect physical or virtual input/output devices to the PLC.
- Exhibit knowledge of automation systems' dependability and safety.

III.Course Level Learning Outcome (CO):

CO4 – Test the ladder logic programs for given industrial applications

IV.Laboratory Learning Outcome(s)

LLO 12.1: Draw ladder logic diagram to simulate given gate.\

LLO 12.2: Address properly the input and output devices.

LLO 12.3: Test the ladder logic program.

LLO 12.4: Interface the input and output devices to the PLC.

V. Relative Affective Domain Related Outcome(s)

- Develop a positive outlook on industrial automation and control systems.
- Recognize the value of methodical PLC programming and testing.
- And exhibit accountability, teamwork, and safety when conducting experiments.
- Exhibit interest in and drive for incorporating automation into practical engineering issues.

VI. Relevant Theoretical Background (with Diagram):

To start the process, command is given by the field operator as well as from the control room i.e. through DCS. The Conveyor belt starts running when conveyor motor (CM) is switched on. The bottles are kept manually on the conveyor belt. When bottle is reached below the filling solenoid valves (SV); detected by a limit switch (BP), CM stops. The filling process starts by opening SV, when the bottle is raised up by raising the platform by pneumatic cylinder. The time required to raise the bottle is 5 seconds. Up to 90% filling takes place through solenoid valve (coarse) and remaining 10% (100% full condition) by opening solenoid valve (fine). Bottle 90% full condition is sensed by proximity switch (coarse). Bottle 100% full condition is sensed by another proximity switch (fine). When bottle is full SV should become off and the count is displayed. When SV is closed, CM runs again till next bottle is detected by BP switch and the cycle repeats.

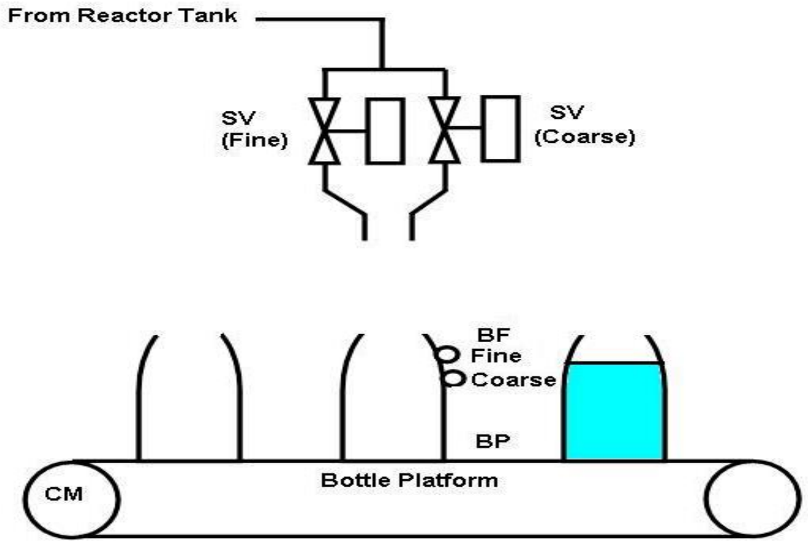

Fig. 12.1 Typical Ladder Diagram

VII. Experimental Setup: Ladder Diagram:

XI. Required Resources/Apparatus/Equipment:

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
01	Pc /Laptop	Minimum i3 Processor, 4GB RAM	
02	Internet connectivity	Minimum 4 Mbps	
03	Virtual Lab Access	COEP Technological University	
04	I/O Devices (Virtual)	Start/Stop push buttons, Sensors	
05	O/O Devices (virtual)	Motor, Solenoid Valve, Indicator Lamp	

XII. Precautions to be followed (Safety instructions/Rules/Standards):

1. Verify all I/O addresses before running the simulation.
2. Ensure proper logical sequence — avoid conflicting conditions in ladder logic.
3. Always test in simulation mode before uploading to real hardware.
4. Stop the simulation before editing ladder logic.
5. Follow safety procedures when working with physical PLC modules (if used).

XIII. Procedure:

1. Open the PLC virtual lab software.
2. Create a new project and select the desired PLC model.
3. Define input and output addresses for all devices.
4. Develop ladder logic as per the process sequence.
5. Compile and check the program for errors.
6. Simulate the process:
   * Press **Start** → Conveyor moves.
   * When a bottle is detected → Conveyor stops, valve opens.
   * When full → Valve closes, conveyor restarts.
7. Observe and record system behavior.
8. Save and document the program logic.

XIV. Observations:

Sr. No.	Input Condition	Expected Output	Actual Output	Remarks
1	Bottle absent			
2	Bottle present			
3	Bottle full			

XV. Result:

XVI. Interpretation of Results

XVII. Conclusions and Recommendation:

XVIII. Practical Related Questions

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

State the role of the proximity sensor in the automatic bottle filling system??

2. State the role of the proximity sensor in the automatic bottle filling system??
3. In the virtual lab simulation, what happens when the level sensor detects that the bottle is full?
4. How can you modify the program to count the number of bottles filled automatically?

[Space for Answer]

XXIX. References / Suggestions for Further Reading:

1) https://ial-coep.vlabs.ac.in/exp/bottle-filling-application/theory.html

2) https://ial-coep.vlabs.ac.in/exp/bottle-filling-application/procedure.html

3) https://ial-coep.vlabs.ac.in/exp/bottle-filling-application/simulation.html

	Performance Indicators	**Weightage**
	Process Related (15 Marks)	**(60%)**
1	Accuracy of hardware and software identification	20%
2	Quality of simulation/virtual lab implementation	20%
3	Presentation of findings/report clarity	12%
4	Answering viva questions / conceptual understanding	08%
	Product Related (10 Marks)	**(40%)**
1	Understanding of the practical objective	8%
2	Identification of correct hardware elements	12%
3	Identification of correct software tools	12%
4	Participation & lab procedure handling	8%

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

Practical No. 13

Automatic Water Tank Level Control System Using PLC.

I. Practical Significance

An automatic water tank level control system ensures uninterrupted water supply by maintaining the tank level automatically without human intervention. This reduces manpower, prevents overflow and dry-run conditions, saves energy, and increases pump life. This experiment helps students understand PLC-based automation used widely in commercial buildings, industries, and water management systems..

II. Industry / Employer Expected Outcome

After completing this experiment, students will be able to:

1. Develop and troubleshoot ladder logic programs used in industrial automation.
2. Interface sensors, actuators, and PLC hardware as per industrial standards.
3. Understand pump automation used in water treatment plants, residential societies, and process industries.
4. Apply PLC skills in real-world applications such as pumping stations, filtration units, and tank-level control systems.

III. Course Level Learning Outcome (CO)

CO1: Test the ladder logic programs for given industrial applications.

IV. Laboratory Learning Outcome(s)

LLO 13.1: Draw ladder logic programme for automatic water tank level control.

LLO 13.2: Address properly the input and output devices.

LLO 13.3: Test the ladder logic program.

LLO 13.4: Interface the input and output devices to the PLC.

V. Relative Affective Domain Related Outcome(S)

After performing this experiment, students will be able to:

1. Demonstrate safe and disciplined practices in industrial automation laboratories.
2. Show responsibility in handling electrical equipment and wiring.
3. Work cooperatively in groups to complete automation assignments.

VI. Relevant Theoretical Background (with Diagram):

To solve this problem, we will use S7-1200 PLC for programming.

- Here we use two sensors for level measurement, one is for High level and second is for low level.
- We use feeding valve (MV1) for filling Cycle of the tank and discharge valve (MV2) for discharging cycle of the tank. Both will be controlled according to sensor logic. So when the water level goes below low level then feeding valve will turned ON automatically and when water level reaches high and the it senses by high level sensor, then discharging process will be turned ON automatically.
- When high level is detected then buzzer will turn ON for alarm purpose. Cycle will stop if user will press stop button from the control panel.

VII. Experimental Setup:

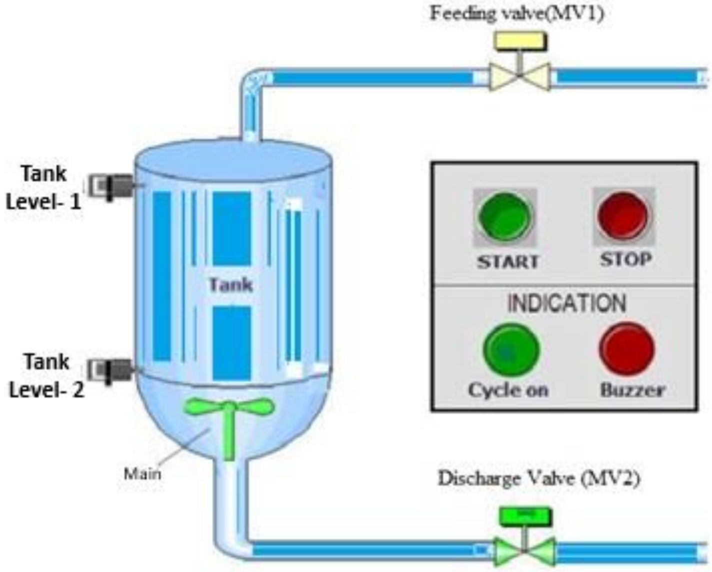

Figure 13.1 Automatic Water Tank Level

VIII. List Of Input /Output :

- **Digital Inputs**
- Start PB : I0.0
- Stop PB : I0.1
- TLB 1 : I0.3
- TLB 2 : I0.2
- **Digital Outputs**
  Cycle ON : Q0.0
  Valve MV1 (Feed) : Q0.1
- Valve MV2 (Discharge) : Q0.2
  Agitator/Mixer M : Q0.3
- Buzzer : Q0.4

IX. Ladder Logic Diagram:-

X. Required Resources/Apparatus/Equipment:

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
1	Level Control trainer kit	With built in tank ,reservoir ,pump, solenoid valve, lower and higher level sensor	01 set
2	PLC	S7-1200 PLC.	01
3	PC with software	TIA portal software	01
4	RS 232 Cable	9-pin D sub to RJ 45 or DB9 male to male	01
5	patch cords	wiring inputs and outputs to /from plc	01 set

XI. Precautions to be followed (Safety instructions/Rules/Standards)

1. Follow instructions given by faculty.
2. Use all instruments properly required during practical.
3. Prepare relevant report as per instructions given by faculty.

XII. Procedure:

1. Load the TIA portal software to the PC.
2. Open the TIA portal software.

3. Switch On the PLC trainer.
4. Open the New project and draw the ladder logic program.
5. Select the correct hardware configuration.
6. Store the program to PLC.
7. Run the Program.
8. Verify the performance of the water level control using PLC

XIII. Observations:

Sr. No.	Inputs	Outputs	Physical Elements (write the correct Observation from the given bracket)
01	I0.0 = 1	Q0.0 = 1	Cycle-------------- (ON/OFF)
02	I0.2 = 1	Q0.1 = 1	Feeding Cycle---------- (ON/OFF)
03	I0.3 = 1	Q0.2 = 1 Q0.3 & Q0.4	Discharge Cycle----------(ON/OFF) & Buzzer ----------------(ON/OFF)
04	I0.1= 1	Q0.0, Q0.1, Q0.2, Q0.3, Q0.4 = 0	Cycle ------------------(START/STOP)

XIV. Result:

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XV. Interpretation of Results

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XVI. Conclusions and Recommendation

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XVII. Practical Related Questions

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

1. State the significance of TLB1 and TLB2 in the diagram?
2. Give the function of MV1 and MV2?

3. State the advantage of using pushbutton controls (START/STOP)?
4. How does the PLC determine when to close MV1?
5. What happens if TLB1 fails and does not detect full level?

[Space for Answer]

References / Suggestions for Further Reading:

- https://srmvalliammai.ac.in/wp-content/uploads/2022/05/ei8761-industrial-automation-lab-manual.pdf

XVIII. Rubrics for Assessment Scheme

Performance Indicators		Weightage
Process Related (15 Marks)		**(60%)**
1	Understanding of the practical objective	20%
2	Calculation of final readings	20%
3	Identification of correct hardware elements	12%
4	Identification of correct software tools	8%
Product Related (10 Marks)		**(40%)**
1	Accuracy of hardware and software identification	8%
2	Quality of simulation implementation	12%
3	Presentation of findings/report clarity	12%
4	Answering viva questions / conceptual understanding	8%
	Total	**100 %**

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

Practical No. 14

Identification of Various components in library/ Wizard and properties of SCADA software.

I. Practical Significance:

By completing this experiment, students will gain:

Familiarity with SCADA software environments.

Understanding of component functions in automation systems.

Visualization of real-time data acquisition and control processes.

II. Industry / Employer Expected Outcome:

- The capacity to create and diagnose SCADA systems.
- Proficiency with SCADA software, such as Wonder ware, WinCE, Infix, and others.
- The proper components for automated tasks are identified and chosen.
- The capacity to decipher and alter SCADA interfaces in accordance with operational needs.
- Being aware of how SCADA integrates with DCS and PLCs for industrial process control.

III. Course Level Learning Outcome (CO)

CO5 – Familiarize the SCADA and DCS architecture for process control and data acquisition from the field

IV. Laboratory Learning Outcome(s)

Identify various features and properties of SCADA system

V. Relative Affective Domain Related Outcome(s)

- Develop interest in learning modern industrial automation tools.
- Show responsibility in handling software and systems during lab sessions.
- Collaborate effectively with peers during simulation and implementation tasks.
- Appreciate the role of SCADA in real-world automation systems.

VI. Relevant Theoretical Background (with Diagram):

What is SCADA?

How : By collecting Information from plant / Load centre bend reducing it to the EMS. Why : To gather Information as here (voltage, current, frequency, power, circuit breaker status) and To perform online actions.

VII. Experimental Setup:

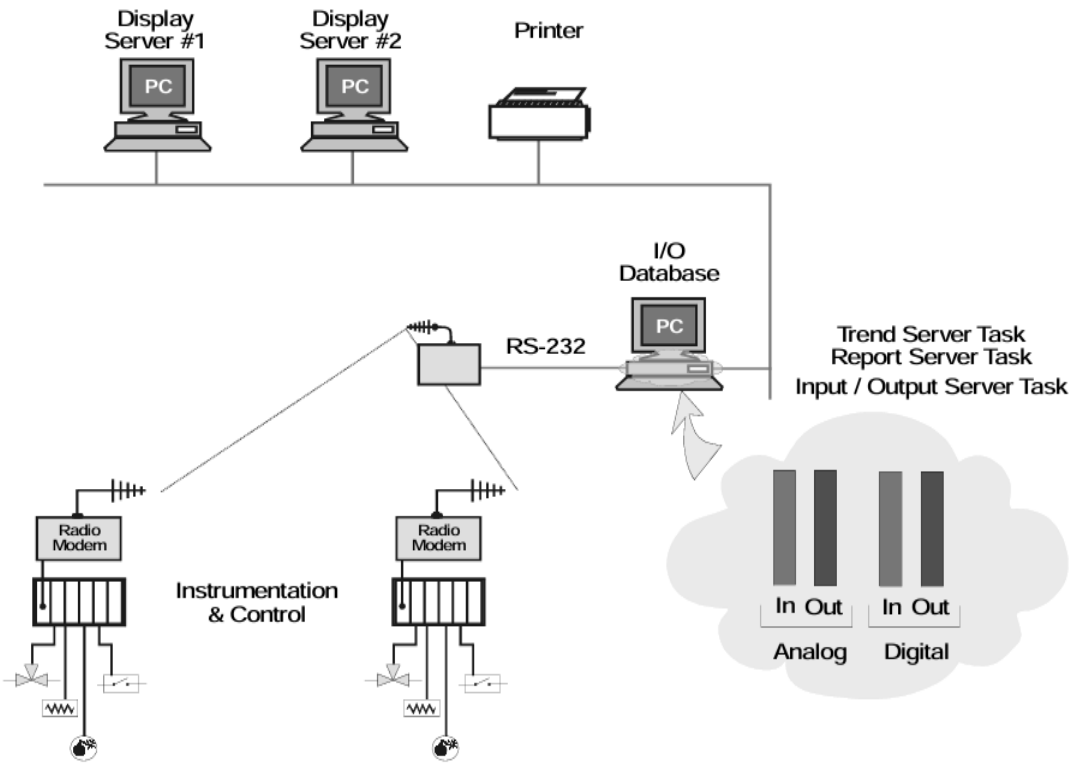

Fig 14.1 Components Of SCADA

X. Required Resources/Apparatus/Equipment:

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
01	Ellipse software		

XI. Precautions to be followed (Safety instructions/Rules/Standards)

1. Do not change system settings unless authorized by the instructor.
2. Handle software and simulation tools with care.
3. Avoid using incorrect tag addresses while configuring components.
4. Ensure all connections are secure if using hardware simulators.
5. Save the project frequently to avoid data loss.

XII. Procedure:

- Open the SCADA software.\
- Create a new project and define the name and process type (e.g., tank control).
- Navigate to the **Library** or **Wizard** section.
- Drag and drop components like pumps, valves, tanks, sensors from the library.

XIII. Observations:

Sr. No.	List out the industries work by using SCADA	List out the industries work by using PLC
1		
2		
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5		

XIV. Result:

XV. Interpretation of Results

XVI. Conclusions and Recommendation

XVII. Practical Related Questions

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

1. List out the purpose of the **Library** or **Wizard** in SCADA software?
2. List any **five components** you identified in the SCADA library during the practical?
3. Describe the steps to **configure a pump and a tank** using the SCADA wizard?
4. **State properties can you modify in a SCADA component like a valve or motor?**
5. **Compare the architecture of** SCADA and DCS **systems. Mention at least two key differences.**

Space for Answer]

XVIII. References / Suggestions for Further Reading:

https://s2.smu.edu/~nair/ftp/senior_design/scada/Practical_SCADA_for_Industry.pdf
https://www.studocu.com/in/document/aims-international-school/computer-science-sl/scada/100447026

	Performance Indicators	Weightage
	Process Related (15 Marks)	**(60%)**
1	Accuracy of hardware and software identification	20%
2	Quality of simulation implementation	20%
3	Presentation of findings/report clarity	12%
4	Answering viva questions / conceptual understanding	08%
	Product Related (10 Marks)	**(40%)**
1	Understanding of the practical objective	8%
2	Identification of correct hardware elements	12%
3	Identification of correct software tools	12%
4	Participation & lab procedure handling	8%
	Total	**100 %**

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

Practical No. 15

Identification Of hardware & software platform for DCS using virtual lab

I. Practical Significance:

A key component of industrial automation, distributed control systems (DCS) offer accurate, dependable control over intricate processes. Students that are familiar with DCS hardware and software platforms are better able to comprehend industrial control systems in the real world. For this identification, a "virtual lab" provides an economical, risk-free setting for simulating, testing, and assessing DCS capabilities and components.

II. Industry / Employer Expected Outcome:

Graduates with practical knowledge of DCS platforms and components.

Ability to interpret and interact with SCADA/DCS systems.

III. Course Level Learning Outcome (CO)

CO5 – Familiarize the SCADA and DCS architecture for process control and data acquisition from the field

IV. Laboratory Learning Outcome(s)

Identify hardware & software platform for DCS using virtual lab

V. Relative Affective Domain Related Outcome(s)

- When using automation software, exhibit discipline and a professional attitude.
- Recognize the value of virtual tools for teaching industrial systems in real time.
- Work as a team when interpreting data and running virtual simulations.

VI. Relevant Theoretical Background (with Diagram):

Definition: A Control system which is functionally as well as physically distributed is called Distributed Control System.

Working Of DCS:

Hardware Flow :

In any process the sensory organs of a process are sensors and /or transmitters through which the status of the process is known. The flow of signal passes from sensors/ transmitters to a local field junction box where number of wires comes. From field junction box through a multi core cable it goes to the main junction box. Again from main junction box it comes to a marshalling cabinet where the wires enter into the control panel. In the control panel, controller and I/O cards are placed. After signal entering the panel, the signal wire with or without a relay card goes into the input card connected to the controller. Controller thereby processes the data according to the logic created and gives output to the Final Control Element through output cards, following the same route.

Software. There is a scan cycle which needs to be completed for the execution of an instruction needed to control the process. The scan period is set by the user while configuring DCS and the following steps occur for each scan period:

- Firstly the status of inputs from the process through the input cards are checked.
- Then the values are updated in the program and according to the logic prepared by the programmer output values are decided.
- These outputs then go to the field through output cards.

- Moreover the status is updated in the SCADA as well as the changes are stored for future reference in the historian. Any alarms i.e. deviations in the process are there, then they are also noted and stored.

VII. **Experimental Setup:**

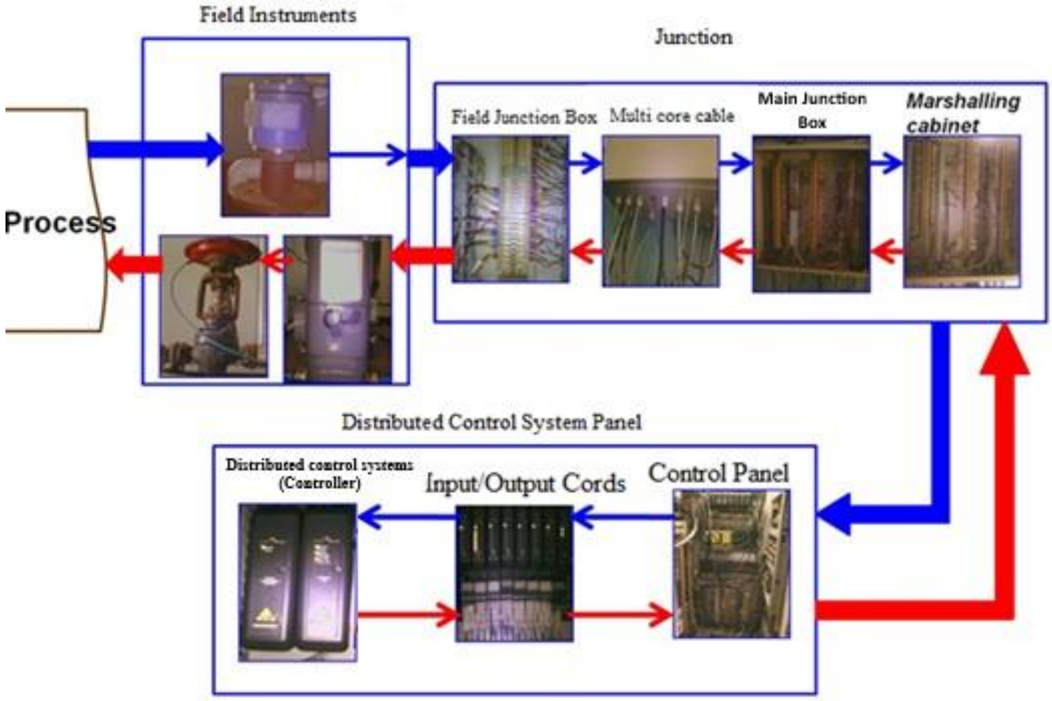

Figure 15.1 Hardware Flow Of DCS

VIII. **Required Resources/Apparatus/Equipment:**

Sr. No.	Name of Resource	Suggested Broad Specification	Quantity
01	Pc /Laptop	Windows 10	
02	Internet connectivity	Minimum 4 Mbps	
03	Virtual Lab Access	IIT Virtual Labs	

IX. **Precautions to be followed (Safety instructions/Rules/Standards):**

1. Do not change system settings unless authorized by the instructor.
2. Handle software and simulation tools with care.
3. Avoid using incorrect tag addresses while configuring components.
4. Ensure all connections are secure if using hardware simulators.
5. Save the project frequently to avoid data loss.

X. Procedure:

1. Launch the virtual lab or simulation software.
2. Select a module related to DCS/SCADA architecture.
3. ‘Navigate the interface to identify:
   * Hardware components (controllers, I/O modules, sensors, etc.)
   * Software components (HMI screens, data logging, control logic, etc.)

4. Interact with virtual devices to simulate a process.

XI. Observations:

Sr.No.	Component Type	Name / Label in Virtual Lab	Function
1	Hardware	Field Instruments (Transmitters, Control Valve, Actuator)	
2	Hardware	Field Junction Box (Field JB)	
3	Hardware	Main Junction Box (Main JB)	
4	Hardware	I/O Cards (AI, AO, DI, DO)	
5	Hardware	DCS Controller	
6	Software	SCADA Dashboard	
7	Communication	Field–DCS Signal Path (Blue & Red arrows)	

XII. Result:

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XIII. Interpretation of Results

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XIV. Conclusions and Recommendation:

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XV. Practical Related Questions:

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

1. Define is a DCS?
2. Give the role of the marshalling cabinet?
3. Explain the I/O modules?
4. State the difference between DCS and PLC?
5. State the role of the Human Machine Interface (HMI) in a DCS system. ?

Space for Answer]

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XVI. **References / Suggestions for Further Reading**:

- https://ial-coep.vlabs.ac.in/exp/software-platforms-dcs/
- https://ial-coep.vlabs.ac.in/exp/software-platforms-dcs/theory.html

	Performance Indicators	**Weightage**
	Process Related (15Marks)	**(60%)**
1	Accuracy of hardware and software identification	20%
2	Quality of simulation/virtual lab implementation	20%
3	Presentation of findings/report clarity	12%
4	Answering viva questions / conceptual understanding	08%
	Product Related (10 Marks)	**(40%)**
1	Understanding of the practical objective	8%
2	Identification of correct hardware elements	12%
3	Identification of correct software tools	12%
4	Participation & lab procedure handling	8%

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